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The impact of blackouts on the performance of micro and small enterprises: Evidence from Indonesia

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Abstract

Reliability of electricity supply is one of pressing challenges to many micro and small enterprises (MSEs) in developing countries. MSEs play a pivotal role in employment generation in these countries, but productivity of MSEs is relatively low. Little is known about how blackouts affect performance of MSEs. This paper is the first study to estimate the impact of power blackouts on productivity of manufacturing MSEs and to discuss the role of the government in addressing problem. We employ a pseudo-panel dataset covering six firm cohorts within 21 Indonesian national electricity company working areas from 2010 to 2015. Our identification strategy involves first examining blackouts determinants and then using these determinants as instruments in an IV dynamic panel fixed effects estimation while controlling for factors potentially affect productivity and correlated with blackouts. We find that electricity blackouts reduce the average labor productivity and the resultant loss amounts to approximately IDR 71.5 billion (USD 4.91 million) per year in Indonesia. Therefore, it is crucial to improve electricity supply reliability in developing countries. We find that introducing a captive generator as a way to cope with power outages, is positively associated with productivity, and MSEs that have captive generators benefit more when the power supply is poor. Our findings will assist policy makers to prioritize addressing power blackouts relative to other constraints MSEs face.

Keywords: micro and small enterprises, power blackouts, productivity, captive generators, pseudo-panel data analysis

JEL Classifications: H54, L53, L94

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1 Introduction

Reliability of electricity supply, a key component of industrial development, has been considered one of the crucial problems to overcome in developing countries (Asian Development Bank [ADB], 2009). The electrification rate might be high but the connections might not functions well. For instance, in Nigeria the electrification rate reaches 96%, yet only 18% of these connections function for more than about half the time (Penar, 2016). Similarly, around 90% of Indonesians are connected to the grid, yet the average electricity customer experiences 19 hours of blackouts during 2017—equating to nearly 13 events (PLN, 2018). This poor power supply could affect enterprises since electricity is a crucial input for enterprise operation, for example, for lights, motors and machines (Allcott, Collard-wexler, & O'Connell, 2016). Likewise, electricity reliability might be as important as electricity provision (Andersen & Dalgaard, 2013) because outages cause economic losses (Pricewaterhouse Cooper [PwC], 2016) and could diminish output considerably. Reliable power supply is also mentioned as a necessary condition for flourishing micro and small enterprises (MSEs) (Masato, Troilo, Juneja, & Narain, 2012).

Although some researchers are pessimistic about the role of MSEs in the economy, for example, Martin, Nataraj, & Harrison (2017), an extensive body of work shows that MSEs play a crucial role in many developing countries (Berry & Mazumdar, 1991; Resosudarmo, Sugiyanto, & Kuncoro, 2012; Sjöholm & Lundin, 2010; Tambunan, 2009). MSEs generate at least 60% of employment in the manufacturing sector and produce up to 50% of the sector's output in most countries (Hill, 2001; Little, Mazumdar, & Page, 1989). Nonetheless, the productivity of MSEs remains low (Mead & Liedholm, 1998; Tybout, 2000) and is, as expected, lower than that of larger firms (Little et al., 1989; Organisation for Economic Co-operation and

Development [OECD], 2015). Labor productivity is a key element for assessing the standard of living of those engaged in production processes in which labor remains the single most important input (OECD, 2001).

While larger firms might be able to substitute other electricity resources (Foster & Steinbuks, 2009), this choice would be limited for smaller firms since providing small-scale electricity is generally costly (Burke, Stern & Bruns, 2018). Further, MSEs are more financially constrained compared with larger firms, thus it is less likely that MSEs have their own captive generators. Data show only 8.2% of small firms had or shared a generator in 2016 (World Bank, 2016).

Relying on data from Indonesia, we examine the causal impact of power supply interruptions on MSEs' performance. Indonesia, home to 3.5 million MSEs in the manufacturing sector, is struggling to provide reliable power in some regions. MSEs are essential, mainly because they generate significant employment, and they are among the government's priorities; however, the productivity of MSEs is relatively low.

In this study, we employ a pseudo-panel dataset covering six cohorts and 21 Indonesian national electricity company (*Perusahaan Listrik Negara* or PLN) working areas for the period 2010–2015. PLN is the major provider of all public electricity and electricity infrastructure in Indonesia. The pseudo-panel data are constructed from repeated cross-sectional surveys on MSEs by grouping enterprises into cohorts based on factor intensity (labor, capital, resource) and size (micro, small), then tracking them over time. Appendix 1 provides the grouping of 2-digit Indonesian Standard Industrial Classification (KBLI) based on factor intensity. Micro enterprises is defined as enterprises with 1–4 workers, while small enterprises are those with 5–19 workers.

We use under-investment in the power sector and poor PLN governance as instruments for blackouts. Using IV dynamic panel fixed effect estimations while controlling for factors that potentially affect productivity and are potentially correlated with blackouts, we find that blackouts reduce average labor productivity. Our results are robust to a battery of robustness checks. Our findings provide evidences for policy makers to prioritize improving electricity reliability to support development and sustainability of MSEs in developing countries.

To our knowledge, this is the first study that links power supply reliability and MSE performance in developing countries using rich MSE national survey data. The existing studies on electrification and industrialization have largely focused on the relationship of electricity provision and larger firm performance.

We begin with a brief review of the existing research on electricity reliability and firm performance. Next, we provide an overview of MSEs and the electricity sector in Indonesia. The following section sets out our models and data, then we present the results and robustness checks. The paper concludes by discussing the boarder implications of our findings for scholars and development practitioners.

2 Electricity reliability and firm performance

Infrastructure, such as electricity supply, is a crucial component needed for the economy, community, and industrial development (Calderón, Moral-benito, & Servén, 2015; Urrunaga & Aparicio, 2012). There are two means by which infrastructure leads to progression in firm production. First, infrastructure like electricity represents an intermediate input, and a decline in input costs increases profitability, hence allowing greater output, revenue, and/or employment. Second, infrastructure boosts the productivity of other factors, such as labor and other capital (Kessides, 1993). In the case of electricity, it enables the firm to use electrical equipment. Further, electricity facilitates the use of information and communication technologies, and more productive organization of manufacturing (Kander, Malanima, & Warde, 2014).

It is not only infrastructure provision but also its quality that matters. Two costs emerge from power outages. The first is the direct cost of production interruptions, loss of unpreserved raw materials or outputs, and impairment of sensitive electronic equipment. Such costs might cause underutilization of current productive capacity and limit short-run productive efficiency and output growth. The second cost is caused by the unreliability or lack of access to electricity, which leads to firms investing in alternative sources, such as the adoption of a captive generator, thus raising capital costs (Kesedes, 1993). This additional cost adds another burden for MSEs, which notably, compared with larger firms, face many disadvantages, such as lack of finance, lack of technology, and lack of scale economies (ADB, 2009; Harvie, 2015).

Research on the impact of electricity on firm performance has been conducted largely into medium to large firms using firm level data. Among others, Allcott, Collard-wexler, & O'Connell (2016) investigate the impact of power shortages on the Indian manufacturing sector between 1992 and 2010, whereas Fisher-Vanden, Mansur, and Wang (2015) quantify the impacts of electricity shortages in Chinese manufacturing firms from 1999 to 2004. Chakravorty, Pelli, and Marchand (2014) explore the effects of electricity grid expansion and quality of electricity on household income in rural India, while Alby, Dethier, and Straub (2012) study firms' generator investment decisions across countries over the period of 2002 to 2006. Further, Rud (2012a) investigates the effect of electrification provision on industrialization in India.

Nevertheless, only a few studies explore the impact of electricity on MSE performance. For instance, Grimm, Hartwig, and Lay (2013) investigate the importance of electricity access among informal firms in seven African cities. They find that electricity access is not statistically significant for good performance. However, the study finds a significant positive influence on tailor industry performance. This demonstrates that a certain type of informal industry might benefit from electricity access. Neelsen and Peters (2011) examine electricity usage in microenterprises in rural Southern Uganda. They find weak evidence of the benefits of electrification for firm profits or worker remuneration. A study on infrastructure deficiency, including electricity, among small and medium enterprises (SMEs) in Nigeria conducted by Obokoh and Goldman (2016) indicates that electricity interruptions are associated with reduced profitability and productivity. Meanwhile, Alby, Dethier, and Straub (2012) find that in countries with frequent power failures, the proportion of small firms in electricity-intensive sectors is lower as investing in an electric generator is unaffordable for small firms.

Research focusing specifically on Indonesian power supply and firm performance is rare. Blalock and Veloso (2007) discover that their dummy coefficient for electrical connection positively and significantly affects the production of Indonesian medium and large manufacturing establishments. A similar result was also found for small enterprises (Hill & Kalirajan, 1993). Our study uses extensive data from MSE surveys, which are rarely explored by researchers, and is among the first to explore MSEs and electricity in Indonesia.

3 Micro and small enterprises and the electricity sector in Indonesia

Like in other developing countries, MSEs play a significant role in the Indonesian economy as a source of employment and income. Table 1 provides some statistics for manufacturing MSEs in Indonesia. In the last 15 years, the number of MSEs in the manufacturing sector has grown significantly from 2.6 million in 2005 to more than 3.6 million in 2015. Similarly, the number of people engaged in manufacturing MSEs rocketed from 6.6 million to 8.7 million in 2005 and 2015, respectively. Nevertheless, the MSEs share of total manufacturing value added is relatively constant at around 10%.

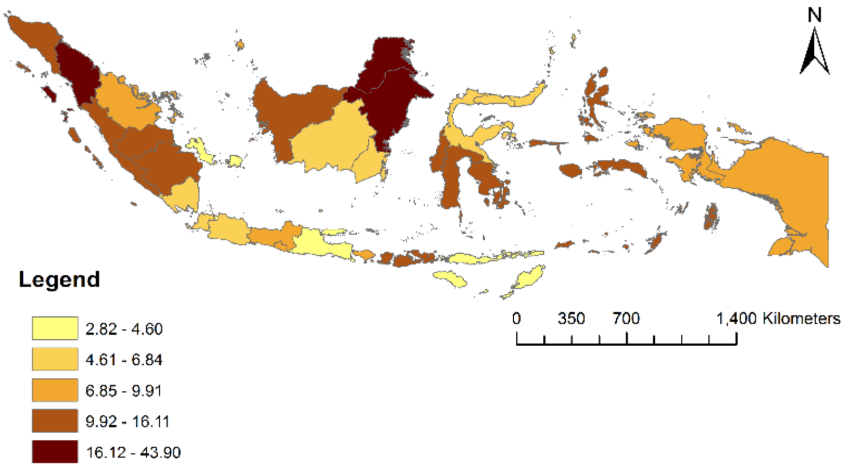
Table 1. Statistics of manufacturing MSEs in Indonesia

	2005	2010	2015
Number of manufacturing MSEs (unit)	2,682,810	2,732,724	3,668,873
Number of employment (workers)	6,681,243	6,447,260	8,735,781
Value added (million IDR)	40,642,830	77,624,573	220,740,544
Contribution to manufacturing value added	9%	8%	10%

Note: Data for 2005 are based on Integrated Survey (SUSI), while 2010 and 2015 are based on Survey IMK. Value added is at market price. Source: Annual Statistics Indonesia from Statistics Indonesia (BPS).

MSEs might not use electricity as intensively as bigger firms in the production process. However, when the number of MSEs is enormous, the impact of electricity interruptions could correspondingly be substantial.

There were relatively large variations of power quality among regions during 2004–2015, as shown in Figure 1. Regarding power blackout frequency, East Java and East Nusa Tenggara consistently experienced the fewest power blackout events, with 2.8 and 3.8 occasions per customer per year, respectively, while Jakarta and Bangka Belitung experienced slightly more frequent blackouts (4.5). Banten and West Java experienced 5.4 occasions without electricity, while Gorontalo, Central Sulawesi, and North Sulawesi had six events of power failure, South Kalimantan and Central Kalimantan 6.2 events, and Lampung 6.8 events.



Source: PLN (2004–2015)

Figure 1. Frequency of electricity failure, 2004–2015

During 2004–2015, people in Central Java and Yogyakarta lived without power supply for 8.2 events, and those in Bali experienced slightly more frequent events, at 9.2, while Riau had 9.5, and the Papua and West Papua region had 9.9 occasions. The West Kalimantan region, and the Bengkulu, Jambi, and South Sumatera region experienced 11 blackout events; West Nusa Tenggara, West, South and Southeast Sulawesi region had 12 events; West

Sumatera had 12.6 events; while Aceh experienced 16 events. The regions of East and North Kalimantan, and North Sumatera experienced the most frequent electricity failures at more than 27 and 44 events per year.

The improvement of electricity reliability varies greatly across regions during 2004-2015. While some regions experienced more than 70% reduction in power interruptions, such as Aceh and North Sumatera, other regions experienced around 30% reduction, such as Riau and Kepulauan Riau. Nonetheless, blackout events in Central Java and Yogyakarta, and South, South East and West Sulawesi regions more than doubled in 2015 compared with 2004.

4 Empirical framework

The main labor productivity outcomes in this paper concern gross output– and value added–based labour productivity. Gross output–based productivity measures capture disembodied technical change, while value-based productivity measures reflect an industry's capacity to contribute to economy-wide income and final demand. We use number of workers to quantify labor input in the production process.

We examine the impact of blackouts on labor productivity at the firm cohort level. Cohorts are groups of firms with similar characteristics. We conduct the analysis at the firm cohort level because MSE data from BPS are available for multiple cross-section surveys rather than for a panel. The pseudo-panel data are constructed by grouping observations into cohorts on the basis of invariant shared characteristics (Deaton, 1985). The cohort variables are formed as the mean values of the observations in each cohort. For the dummy variable, the "share" variable is equivalent to mean values of the continuous variable. The cohorts are then tracked over time in each of the annual surveys, forming a panel. Compared with a genuine panel, the pseudo-panel suffers from fewer problems of attrition and nonresponse, since cohorts are followed over time (Verbeek, 2008).

We developed a first-difference dynamic panel fixed effects estimations to estimate the impact of power blackouts on labor productivity; as seen in the equation (1)[1]. It is a dynamic panel model since firms might learn from previous labor productivity and might expect current outcome based on previous experience.

$$\Delta \ln y_{c,r,t} = \alpha + \beta \Delta \ln E_{r,t} + \Delta \ln y_{c,r,t-1} \gamma + \Delta X'_{c,r,t} \lambda + \Delta W'_{r,t} \delta + \theta_c + \theta_r + \theta_t + \varepsilon_{c,r,t} \qquad (1)$$

where $y_{c,r,t}$ is output per labor, of cohort *c* in region *r* in year *t*. $E_{r,t}$ is power blackouts. We use the system average interruption frequency index (SAIFI) as the measurement of power blackouts. Output per labor at (t-1) is also included in the specification. Our X vector is time-varying firm cohort characteristics including logarithmic form (ln) of average fixed assets per worker as a proxy of capital, share of cooperative member enterprise, share of privately owned enterprise, share of licensed enterprise, share of female-owned enterprise, and share of enterprise of which the owner has no education. We also control for infrastructure (road density and electrification rate) and weather factors (ln precipitation and temperature) *W* at the regional level. Δ is the first-difference operator.

Our labor productivity is in terms of per labor, thus we do not include the average number of workers as a control. θ_c and θ_r are cohort and region fixed effects to allow for different underlying average productivity levels for each cohort and each region, respectively. θ_t is a set of year fixed effects to eliminate the effects of time-specific factors that might affect average productivity, such as macroeconomic shocks. $\varepsilon_{c,r,t}$ is an idiosyncratic error.

Negative estimates of β are expected, because power blackouts interrupt the production process. The interpretation of our blackout frequency measurement is that the

[1] Before applying an empirical form, we examine the presence of unit root in our data from the log productivity, log blackout frequency, and log blackout duration. Using national figures, we could not reject the hypothesis that these variables contain unit roots. Accordingly, we apply models in first-differences.

more frequent the blackout events, the more unreliable the power supply. We cluster the standard errors by cohorts-regions, which are robust to cross-sectional dependence and heteroskedasticity (Cameron & Miller, 2015).

5 Identification Strategy

The estimation results of equation (1) might suffer from endogeneity problems. First, our blackouts might be not naturally exogenous. Second, our power blackout variable and labor productivity might have a reverse causality relationship. Third, there could be measurement errors in the electricity blackout measurement and cohort variables. Last, there is a possibility of omitted variables.

Regarding the first concern, we would like to know whether blackouts could be treated as naturally exogenous. Thus, we regress blackouts frequency on possible factors, as in equation (2):

$$\Delta \ln E_{\mathrm{r,t}} = \alpha + \theta \Delta \ln \mathrm{X}'_{\mathrm{r,t}} + \nu \Delta M'_{r,t} + \eta_r + \varphi_t + \varepsilon_{r,t} \quad (2)$$

where *X* is a set of time-varying PLN characteristics in region *r* at time *t,* which include ln energy produced, ln energy losses, ln length of medium voltage transmission lines, ln length of low voltage transmission lines, ln electricity price in real terms, ln accounts receivable (A/R) collection period; demand side of electricity (ln proportion of residential, of commercial customer, ln GRDP regional); and *M* weather factors (temperature and ln precipitation). η_r is region fixed effects to allow for different underlying electricity interruptions trajectories for each region. φ_t is year fixed effects to eliminate the effects of common time-specific factors that might affect blackout frequency and ε_{rt} is an idiosyncratic error.

World Bank (2017) reports that adequacy of energy production, power system infrastructure, financial and operational performance, and weather are factors that may affect electricity reliability. We include energy produced to indicate energy production, while the length of medium voltage transmission lines represents infrastructure. Variables of financial and operational performance are energy losses, A/R collection period, and electricity price (at constant price), whereas factors of weather are precipitation and temperature. The variables of energy produced, and length of medium and low voltage transmission lines are weighted by area of region to incorporate size of region.

We also examine whether our main estimation in equation (1) is driven by reverse causality. For instance, regional small firms' development might cause increases in demand for electricity, thus leading to increasing power blackouts. We conduct tests to explore whether past productivity has a significant effect on current blackouts. Our specification is similar to that in equation (2), but now we add ln average productivity of region *r* in year (t−1*)* on the right-hand-side and estimate its coefficient. However, in this test we do not include Regional Gross Domestic Product (RGDP) as a control since it is very likely that GRDP correlates with labor productivity. The result is shown in the appendix 3. It appears that past productivity does not affect current power failure.

Regarding omitted variable bias, in equation (1), as much as possible we include variables, such as cohort and regional fixed effects that will capture time-invariant firm cohort and regional average difference levels. In addition, we include year fixed effects to capture unobservable time-variants.

Knowing what factors affect power interruptions, we use those factors as instruments for blackouts. They could act as valid instruments that affect blackouts but affect MSEs only through blackouts. To verify the validity of the instruments, we also conduct an informal test to examine exclusion restriction of the instruments.

6 Data

We have collected data from 2004–2015 on the power sector, infrastructure, weather, and MSEs, excluding 2006–2008 for which data on MSEs are not available. Our dataset covers six cohorts, which vary by 21 regions. First differencing means our sample covers 2005 and 2010–2015, while the first-lag of the first-difference means our sample covers 2011–2015. All monetary amounts are deflated to real 2010 IDR using the gross domestic product deflator for the manufacturing sector (2010 = 100), while electricity price is deflated using consumer price index for electricity price (2012 = 100). Throughout the paper, we use the word "region" to refer to PLN working areas. The appendix 2 provides details on variable constructions and the PLN working regions.

All power sector data are at the region level. We obtain data of PLN characteristics from PLN statistics publications available online through the PLN website (PLN, 2005, 2006, 2010, 2011, 2012, 2013, 2014, 2015, 2016). Data on electricity blackouts per region are gathered from the PLN Research and Development Center through communication. Panel A in Table 2 summarizes the region-by-year observations of power sector data, weather, and infrastructure, while Panel B shows our MSE cohort data.

Table 2. Summary of descriptive statistics

Variables	Obs	Mean	Std deviation
Panel A. Power sector, weather & infrastructure data (region-by-year) 2004–2005, 2009–2015			
Blackout frequency (event/customer/year)	189	9.92	11.32
Blackout duration (hour/customer/year)	189	10.99	20.73
Energy produced (gigawatt hour)	189	8,240.27	12,811.51
Energy losses (%)	189	9.74	2.46
Length of medium voltage transmission lines (circuit km)	189	13,854.72	12,220.73
Length of low voltage transmission lines (circuit km)	189	20,290.41	23,663.75
Electricity price (IDR/kilowatt hour)	189	698.82	95.94
A/R collection (days)	189	55.12	461.62
Proportion of residential customer (%)	189	91.53	2.86
Proportion of commercial customer (%)	189	5.59	2.53
GRDP region (IDR billion)	189	340,663.20	379,259.60
Temperature (^{o}C)	189	26.69	1.20
Precipitation (mm)	189	2,249.84	789.21
Road density (per km)	189	0.89	2.12
Electrification rate (%)	189	17.74	7.40
Panel B. MSE data (cohort-by-year) 2004–2005, 2009–2015			
Output per worker (million IDR/year)	1,076	22.85	14.83
Value added per worker (million IDR/year)	1,075	9.28	6.70
Number of worker	1,076	4.16	3.04
Fixed asset per worker (million IDR)	1,076	12.40	10.63
Share of cooperative member enterprise	1,076	0.04	0.09
Share of privately owned enterprise	1,076	0.82	0.18
Share of licensed enterprise	1,076	0.25	0.39
Share of female-owned enterprise	1,076	0.31	0.28
Share of without education–owned enterprise	1,076	0.21	0.16

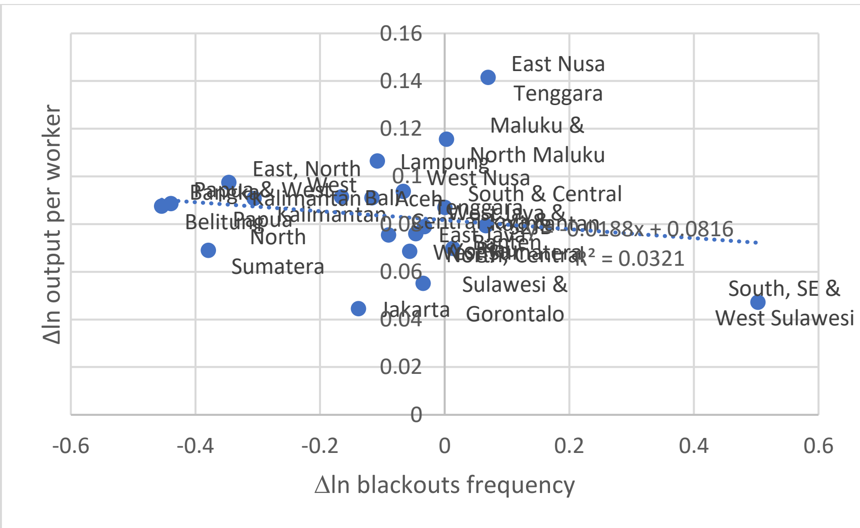
Source: PLN R&D Center, PLN annual report, Delaware University, Statistik Indonesia, MSE Survey 2004–2005 and 2009–2015, author's calculation

PLN reports the SAIFI and the system average interruption duration index (SAIDI) as the metrics of electricity reliability in its annual report. SAIFI is the average number of service interruptions experienced by a customer in a year, while SAIDI is the average total duration of outages over the course of a year for each customer served. SAIFI and SAIDI are calculated based on the following formula:

$$\text{SAIFI} = \frac{\sum F}{\text{M}} \qquad (3) \qquad \text{, and} \qquad \text{SAIDI} = \frac{\sum (\text{H} \times \text{N})}{\text{M}} \qquad (4)$$

where *F* is the number of blackout events, *H* is blackout duration, *N* is the number of customers who experienced blackout, and *M* is the total customers. Following PLN's definition, the coverage of blackouts are blackouts at distribution lines that are experienced by customers because of interruption or maintenance at generation as well as transmission lines (Circular of PLN BOD No. SE.031.E/471/PST/1993).

We collect data on road density and electrification rates from the Statistical Yearbook of Indonesia (*Statistik Indonesia* [SI]). Data on provincial temperatures and precipitation for 2011–2015 are obtained from SI, while data on temperature and precipitation before 2011 are obtained from Matsuura & Willmott (2011). We use Indonesia's annual survey of MSEs for 2004–2015, excluding 2006–2008 since there are no data available for those years. Data on MSEs are representative at the province level for one digit KBLI or at the national level for two-digit KBLI.



Notes: A fitted line is shown. The line has a slope of −0.019 and an R^2 of 0.032. Source: PLN R&D Center and BPS (2011–2015)

Figure 2. Scatter plot of differenced log blackout frequency and output per worker, 2011–2015

Figure 2 shows the plot of the differenced log output per worker and the differenced log blackout frequency, using average cohort data. It appears that there is a negative association between the two variables. The regions with a higher blackout frequency experience lower outputs per worker.

7 Factors affecting blackouts

As previously explained, we need to know whether blackouts could be treated as naturally exogenous. The results indicate that underinvestment in the power sector and poor PLN governance might be among the reasons that Indonesia experiences blackouts.

Table 3. Factors affecting blackout frequency

	DV: ∆blackout frequency (∆lnSAIFI)			
Variables	(1)	(2)	(3)	(4)
∆ln length of medium voltage transmission lines	−0.306*	−0.312*	−0.332	−0.335
	(0.165)	(0.174)	(0.231)	(0.223)
∆ln electricity price	−0.694*	−0.745	0.842	0.729
	(0.397)	(0.449)	(0.729)	(0.721)
∆ln A/R collection	0.137**	0.140*	0.181*	0.179*
	(0.0593)	(0.0670)	(0.0951)	(0.0965)
∆ln GRDP regional				−1.406
				(1.105)
Region FE	N	Y	Y	Y
Year FE	N	N	Y	Y
Observations	147	147	147	147
R squared	0.108	0.111	0.159	0.164

Notes: Other variables included in the estimations are electricity price, energy produced, energy losses, length of low voltage transmission lines, share of residential, share of commercial customer, temperature and precipitation. However, these variables are statistically not significant. ***, **, and * indicate statistical significance at 1, 5, and percent. Robust standard errors clustered by region are in parentheses

In Column 1 of Table 3 we obtain the length of medium voltage transmission lines coefficient and electricity price coefficient, which are negative and significant at the 10% level, while the A/R collection coefficient is positive and significant at the 1% level. The remaining columns control for region fixed effects. Column 2 adds region fixed effects; we find electricity price is no longer statistically significant. Adding year fixed effects in Column 3, the significance of transmission lines disappears while the A/R collection period coefficient is significant at the 10% level. Similar results are found when we add GRDP in Column 4.

The medium voltage transmission line is among the infrastructure that PLN requires to deliver electricity to customers (World Bank, 2017), while A/R collection reflects the ability of PLN to collect revenue from customers and transform it into profit or investment. In this sense, A/R collection could be seen as PLN governance. Knowing that medium voltage transmission lines and A/R collection determine blackouts, we then use these factors as instruments for blackouts.

8 The impact of power blackouts on micro and small enterprises' performance

We run a IV dynamic panel fixed effects model, instrumenting blackouts using medium voltage transmission lines and A/R collection. Table 4 presents the main results. There are two panels of estimates, corresponding to two groups of outcomes: Δln output and Δln value added. The IV estimates show that a 1% increase in blackout frequency causes lower output per worker by 0.055%. The effect is slightly higher on value added per worker (0.061%). The FE point estimates differ from the IV estimates, and the directions are consistent, as expected. The fact that the FE panel point estimates are smaller than the IV estimates suggests that instrumenting helps to address endogeneity problems. Without instrumenting for blackouts, one might incorrectly conclude that the effect of blackouts is very small.

The OLS estimates in Column 1 on output per worker show a small (−0.007) and statistically significant negative effect at the 10% level, rising to −0.006 in Column 2. Column 3 of Panel A controls for cohort, region, and year fixed effects; we obtain a negative coefficient for blackouts, which is statistically significant at the 5% level (−0.054). Column 4 adds cohort and region characteristics (infrastructure and weather factors), for which we find a slightly higher negative coefficient for blackouts (−0.055), significant at the 10% level.

The OLS coefficient in Column 5 is negative and statistically significant at the 10% level, while that in Column 6 is statistically not significant. Similar to the estimates on output per worker, the IV estimation results on value added per worker are negative and statistically significantly different from zero at the 5% level. The IV estimates show that a 1% increase in blackout frequency causes a 0.061% decrease in valued added per worker. Column 7 controls for cohort, region, and year fixed effects; the coefficient for blackouts is −0.059. When we add cohort and region characteristics in Column 8, the estimate is slightly higher and negative (−0.061).

In addition, another variable vital in explaining labor productivity is fixed asset, a proxy of capital. In all specifications for all outcomes, we obtain positive and significant coefficients for fixed asset. It appears that fixed asset is a channel through which MSEs cope with unreliable electricity by, for instance, adopting a captive generator. However, because of data unavailability, we are only able to examine whether adopting a captive generator helps MSEs manage poor power supply using a cross-sectional estimation, as explained in the next section.

The first-stage results of our main estimation show that medium voltage transmission lines and A/R collections are valid instruments for blackouts. The signs for these two variables are as expected and statistically significantly different from zero. Column 3 controls for cohort, region, and year fixed effects; the coefficient for length of medium voltage lines is −0.383, while that of A/R collection is 0.249, and both are significant at the 1% level. The longer the length of medium voltage transmission lines, the less frequent are the blackouts, and the longer the period of A/R collection the more frequent are the blackouts. Column 4 adds cohort and region characteristics; we obtained a slightly smaller coefficient for medium voltage transmission line and of A/R collection, −0.387 and 0.239, respectively.

While the exact coefficient estimates differ slightly because of the different controls, we find that the coefficients for instruments are the same for both output (Column 3–4) and value added (Column 7–8). The instruments are powerful, as seen in the heteroskedasticity-robust Kleibergen-Paap *F*-statistics range from 16.56 to 17. For comparison, the Stock and Yogo (2005) critical values for two instruments and one endogenous regressor are 11.59 and 19.93 for maximum 15% and 10% bias, respectively.

Since we use two instruments for blackouts, we also conduct an over-identification test of all instruments. The Hansen J statistic is consistent in the presence of heteroskedasticity and autocorrelation. A rejection casts doubt on the validity of the instruments. The results show that we cannot reject the joint null hypothesis that the instruments are valid instruments. This means that our instruments are uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation (1).

By inputting the average value added per worker per year of approximately IDR9.28 million, it can be roughly estimated that with an average of four workers per enterprise, unreliable electricity supply lowers labor productivity by approximately IDR20.500 per enterprise per year. Further, if this number can be interpreted as the average cost of experiencing unreliable electricity supply, and assuming there are around 3.5 million manufacturing MSEs in Indonesia, this paper estimates that the cost of unreliable power supply is approximately IDR71.5 billion (USD 4.91 million) per year for the country.

Table 4. Effects of blackouts on productivity

	A. ∆ln output per worker				B. ∆ln value added per worker			
	Dynamic panel FE		**IV dynamic panel FE**		**Dynamic panel FE**		**IV dynamic panel FE**	
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
∆ln blackout frequency	−0.007*	−0.006*	−0.054**	−0.055*	−0.007*	−0.006	−0.059**	−0.061**
	(0.004)	(0.004)	(0.026)	(0.028)	(0.004)	(0.004)	(0.027)	(0.030)
∆ln output per worker (t–1)	0.0682	0.0803	0.083	0.091				
	(0.0726)	(0.0627)	(0.057)	(0.055)				
∆ln value added per worker (t–1)					0.0773	0.0903	0.0943*	0.102*
					(0.0695)	(0.0597)	(0.0559)	(0.0544)
∆ln fixed assets per worker	0.0777**	0.0769**	0.080***	0.079***	0.0790**	0.0779**	0.081***	0.080***
	(0.0311)	(0.0329)	(0.025)	(0.025)	(0.0315)	(0.0333)	(0.026)	(0.025)
<u>Coefficients for instruments:</u>								
∆ln length of medium voltage transmission lines (meter)			−0.383***	−0.387***			−0.383***	−0.387***
			(0.077)	(0.078)			(0.077)	(0.078)
∆ln A/R collection period (days)			0.249***	0.239***			0.249***	0.239***
			(0.068)	(0.069)			(0.068)	(0.069)
F-statistic on instrument			17.00	16.58			16.97	16.56
Hansen J statistic			2.325	2.429			2.341	2.378
Cohort characteristics	N	Y	N	Y	N	Y	N	Y
Region characteristics	N	Y	N	Y	N	Y	N	Y
Cohort FE	Y	Y	Y	Y	Y	Y	Y	Y
Region FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	547	547	547	547	547	547	547	547
R squared	0.299	0.309	0.219	0.225	0.288	0.299	0.191	0.196

Notes: ***, **, and * indicate statistical significance at 1, 5, and percent. Robust standard errors are in parentheses

9 Robustness tests

To evaluate sensitivity of our estimation results, we conduct a battery of robustness checks by using blackout duration as the measurement of blackouts, omitting cohort fixed effects, and clustering standard errors by cohort region.

In addition to blackout frequency, PLN also reported blackout duration (hours per customer per year), which is known as SAIDI. As a reliability measurement, SAIDI means the longer the duration of blackouts, the more unreliable is the power supply. Omitting cohort fixed effects allows us to evaluate whether our results are driven by cohort effects. Further, clustering the standard error by cohort-region will enable us to evaluate whether there is serial correlation among errors in cluster.

Table 5. Robustness checks

Change from base specification:	Use blackout duration (lnSAIDI) (1)	Without cohort fixed effects (2)	Cluster by cohort-region (3)
		∆ln(output per worker)	
∆ln blackouts	−0.065**	−0.057**	−0.055**
	(0.032)	(0.028)	(0.027)
Number of observations	547	547	547
First-stage *F*-stat	12.354	16.840	11.417
		∆ln(value added per worker)	
∆ln blackouts	−0.071**	−0.062**	−0.060**
	(0.033)	(0.030)	(0.029)
Number of observations	547	547	547
First-stage *F*-stat	12.354	16.840	11.417

Notes: This table presents alternative estimates for Table 4, instrumenting for blackouts using length of medium voltage transmission lines, and A/R collection period. All specifications include fixed assets per worker, cohort characteristics, region characteristics, cohort FE, region FE, year FE. *F*-statistic is for the heteroskedasticity and cluster-robust Kleibergen-Paap weak instrument test. Robust standard errors are in parenthesis. ***, **, and * indicate statistical significance at 1, 5, and percent.

We find that the IV results are robust to a set of robustness checks, as depicted in Table 5. The estimates are similar and statistically indistinguishable when using the difference estimator, omitting cohort fixed effects θ_c, or using duration of blackouts instead of blackout frequency as the endogenous right-hand-side variable. Clustering by cohort-region-year instead of robust standard error only mildly changes the standard errors; no discrete significance levels change, and no first-stage *F*-statistic drops below 10.

Table 6 evaluates the exclusion restriction of our instruments informally. For an instrument to be valid, it must affect blackouts without affecting MSEs other than through blackouts. We regress a dependent variable (∆ln output per worker or ∆ln value added per worker) on the instruments of medium voltage transmission lines and A/R collection period, controlling for region and year fixed effects. We find that regardless of the dependent variables, the coefficients for medium voltage transmission lines as well as those of the A/R collection period are statistically insignificant. These might confirm that our instruments have no direct effect on productivity, thus fulfilling the exclusion restrictions.

Table 6. Exclusion restriction checking

	DV: ∆ln output per worker			**DV: ∆ln value added per worker**		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
∆ln length of medium voltage	0.048	0.043	0.076	0.049	0.044	0.082
transmission lines (meter)	(0.043)	(0.040)	(0.046)	(0.044)	(0.042)	(0.049)
∆ln A/R collection (days)	0.005	−0.029	−0.022	0.004	−0.030	−0.024
	(0.028)	(0.024)	(0.016)	(0.028)	(0.024)	(0.016)
∆ln output per worker (t-1)	N	Y	Y			
∆ln value added per worker (t-1)				N	Y	Y
Controls	N	N	Y	N	N	Y
Region FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Observations	146	105	105	146	105	105
R squared	0.225	0.398	0.635	0.228	0.405	0.661

Controls include fixed assets per worker, share female, share without education, share cooperative member, share licensed, share privately owned, electrification rate, road density, precipitation, temperature. Notes: ***, **, and * indicate statistical significance at 1, 5, and percent. Robust standard errors clustered by region are in parentheses

10 The effect of adopting a captive generator

A potential behavioral response to higher electricity interruptions is to self-generate electricity by adopting captive generation (Alby, Dethier, and Straub, 2012 ; Rud, 2012b). Our main results indicate that capital might be an avenue through which MSEs secure their activities against unreliable electricity. In this section, we specifically examine the impact on labor productivity of possessing a captive generator. We also explore the interraction of owning a captive generator and blackout frequency. Using equation (5), we conduct cross-section estimations since data on captive generation are available only for 2010. The estimation results indicate that those MSEs adopting a captive generator are benefited more when electricity supply is poor:

$$\ln y_{\mathrm{ir}} = \alpha + \beta \ln E_{\mathrm{r}} + \mathrm{Generator}_{\mathrm{ir}} + \gamma \ln E_{\mathrm{r}} * \mathrm{Generator}_{\mathrm{ir}} + \ln X'_{\mathrm{ir}}\varphi + M'_r\chi + \mathrm{I}_{\mathrm{ir}} + \mathrm{S}_{\mathrm{ir}} + \eta_r + \varepsilon_{ir} \quad (5)$$

where $\ln y_{ir}$ is output per labor of firm *i* in region *r*, in million IDR. Generator is the dummy for owning a captive generator. X is a set of time-varying controls (ln fixed asset per worker, cooperative membership dummy, ln of percentage privately owned capital, a set dummy for owner education level, female-owned dummy) and M is a vector of infrastructure (road density, electrification rate) and weather factors (temperature and ln precipitation) at the region level. I_{ir} is a two-digit KBLI dummy to represent industry effect. S_{ir} is a small-sized dummy, which equals 1 if a firm employs 5–19 workers, and 0 otherwise. η_r is the island dummy to allow for different underlying productivity trajectories for each island. ε_{ir} is an idiosyncratic error.

Table 7. The impact on labor productivity of owning a generator

	Dependent variable: ln output per worker			
	(1)	(2)	(3)	(4)
Blackout frequency (lnSAIFI)	0.089	−0.021	−0.062	−0.043
	(0.112)	(0.099)	(0.123)	(0.103)
Owned a captive generator = 1	0.487***	0.118	0.059	−0.126
	(0.156)	(0.142)	(0.147)	(0.116)
Owned a captive generator* blackout	0.168*	0.195**	0.224**	0.235***
frequency	(0.090)	(0.080)	(0.082)	(0.067)
ln fixed asset per worker	0.287***	0.229***	0.227***	0.195***
	(0.0148)	(0.010)	(0.010)	(0.008)
Island dummy	N	Y	Y	Y
KBLI dummy	N	Y	Y	Y
Small-sized dummy	N	Y	Y	Y
Region characteristics	N	N	Y	Y
Firm controls	N	N	N	Y
Observations	52,428	52,428	52,428	49,984
R squared	0.215	0.358	0.367	0.423

Notes: ***, **, and * indicate statistical significance at 1, 5, and percent. Robust standard errors clustered by region are in parentheses.

As shown in Table 7, in all our specifications, we find that blackout frequency coefficients are statistically not different from zero. Once we add controls, the signs for blackouts coefficients are negative, as expected. Column 1 does not add a control; we obtain a positive and insignificant coefficient for blackouts. The remaining columns control for island, KBLI and size dummy. In Column 2, we find that the coefficient for blackouts is negative yet statistically not different from zero. Column 3 adds region characteristics (road density, electrification rate, temperature, and precipitation); we obtain much higher coefficients for blackouts. In Column 4 we add firm controls; a lower negative and insignificant blackout frequency is obtained.

We also find that the coefficients for possessing a captive generator are statistically insignificant, except when we add no control. Column 1 does not add a control; we obtain a positive and significant coefficient for owning a captive generator at 1%. However, once we add island, KBLI and size dummies in Column 2, the significance disappears. Similar results are also obtained when we add region characteristics in Column 3. Column 4 adds firm controls; we find a negative and insignificant coefficient for owning a captive generator.

In all specifications, we find that the coefficients for the interaction of possessing a captive generator and blackout frequency are positive and statistically significantly different from zero. Column 1 adds no control; we obtain a positive and significant coefficient for interaction at 10% (0.168). When we control for island, KBLI and size dummy in Column 2, we obtain a slightly higher coefficient. Columns 3 and 4 add region characteristics and firm control, respectively; still we obtain positive and significant coefficients for interaction, 0.224 and 0.235, respectively. The results point out that MSEs who adopt a captive generator are benefited, specifically when power supply is unreliable. We also find in all specifications that fixed asset coefficients are positive and statistically significantly different form zero.

11 Conclusion

In this paper, we examine the impact of electricity outages on labor productivity of MSEs using constructed pseudo-panel data for Indonesia over the period from 2010 to 2015. Our identification strategy involves using factors affecting blackouts as instruments for blackouts in IV dynamic panel fixed effects estimation, while controlling for factors that potentially affect productivity and are correlated with blackouts. We find a negative and significant impact of electricity interruptions on labor productivity: power blackouts reduce average productivity. The results are qualitatively similar under different approaches to calculating productivity. The monetary loss associated with unreliable power supply for Indonesia is approximately IDR 71.5 billion (USD 4.91 million) per year. The results provide support for a growing body of work linking reliable power supply and firm performance (Alby, Dethier, and Straub, 2012 ; Allcott, Collard-wexler, and O'Connell, 2016; Fisher-Vanden, Mansur, and Wang, 2015)).

We also find that a way for firms to secure their production under poor power supply conditions is adoption of captive generators. Our estimations suggest that using captive generators is associated with higher productivity and MSEs that own captive generators are benefited more when the power supply is poor.

Bearing these results in mind, we argue that it is crucial that developing countries' government put priorities in improving electricity reliability. This priority would help MSEs that commonly face economic disadvantage, including financial constraints, to improve their productivities; hence increase their profitability as well as the welfare of those participating in this sector. What policies and how developing countries should do to effectively improve electricity reliability in their countries, unfortunately, is not within the scope of this paper. Further research might want to focus their question on this issue.

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Appendix 1: The grouping of two-digit Indonesian Standard Industrial Classification Codes (KBLI) based on factor intensity

KBLI 2000 & 2005	KBLI 2009	Factor intensity
		Labor intensive
17	13	Manufacture of textiles
18	14	Manufacture of clothing
19	15	Manufacture of leather and related products
20	16	Manufacture of wood and products of wood and cork, except furniture
36	31	Manufacture of furniture
37	32	Other manufacturing
	33	Maintenance and repair of machinery and equipment
		Resource intensive
15	10	Manufacture of food products
15	11	Manufacture of beverages
16	12	Manufacture of tobacco products
21	17	Manufacture of paper and paper products
22	18	Printing and reproduction of recorded media
23	19	Manufacture of coke and refined petroleum products
24	20	Manufacture of chemicals and chemical products
	21	Manufacture of basic pharmaceutical products and pharmaceutical medicine
25	22	Manufacture of rubber and plastics products
		Capital intensive
26	23	Manufacture of other non-metallic mineral products
27	24	Manufacture of basic metals
28	25	Manufacture of fabricated metal products, except machine
30, 32, 33	26	Manufacture of computer, electronic, and optical products
31	27	Manufacture of electrical equipment
29	28	Manufacture of machinery and equipment not elsewhere classified
34	29	Manufacture of motor vehicles, trailer and semi-trailers
35	30	Manufacture of other transport equipment

Source: Aswicahyono, Hill & Narjoko (2011), updated for KBLI 2000 & 2005 by the author

Appendix 2: Variable descriptions and list of regions

Enterprise characteristics. Source BPS (2004–2005, 2009–2015)

Cohort variables are constructed as the mean of variables for firms within the same cohort.

The following variables are calculated for each cohort:

1. Output per labor, calculated for each enterprise by dividing total output (2010-real term) by number of worker, then for each cohort we calculate the average labor productivity per month. Average labor productivity per year = average labor productivity per month*12 months.
2. Value added per labor, calculated for each enterprise by dividing value added (= output minus input) (2010-real term) by number of worker, then for each cohort we calculate the average value added per month. Average labor productivity per year = average labor productivity/month*12 months.
3. Fixed assets per worker, calculated for each enterprise by dividing fixed asset by number of worker. Then, for each cohort we calculate the average fixed assets per worker.

   We interpolate the fixed assets for 2011 since there was no question on this in the questionnaire.
4. Share of privately owned enterprise = summation of privately owned enterprise dummy, divided by total cohort member.
5. Share of cooperative member = summation of cooperative member enterprise dummy, divided by total cohort member.
6. Share of licensed enterprises = summation of licensed enterprise dummy, divided by total cohort member.
7. Share of female-owned enterprise = summation of female-owned enterprise dummy, divided by total cohort member
8. Share of without education–owned enterprise = summation of dummy of enterprise that is owned by entrepreneur without education, divided by total cohort member.

Energy sector. Source PLN annual report (2004–2005, 2009–2015):

9. SAIDI and SAIFI are at the region level, source PLN Research and Development Center.
10. Net energy production (GWh) = Purchased from outside PLN + received from other unit (GWh) + own production (Gwh) − own use central (GWh) region-by-year, except 2004–2005 national figure proportional to 2009 distribution.
11. Length of medium voltage transmission lines (kmc) region-by-year, except 2004–2005 national figure proportional to 2009 distribution.
12. Length of low voltage transmission lines (kmc) region-by-year, except 2004–2005 national figure proportional to 2009 distribution.
13. Electricity price (IDR/kWh) = average price (region-by-year), except 2004–2005 = income/#sales (national figures), in nominal terms.
14. Energy losses (%) = transmission + distribution losses, region-by-year, except 2004–2005 = national figures.
15. A/R collection = average duration of A/R collection, in days.
16. Proportion of residential and of commercial (business and industry) calculated as share of number of residential and of commercial customer to total customers, region-by-year, except 2004–2005 national figure proportional to 2009 distribution.

Weather, infrastructure. Source: University of Delaware (2004–2005), Statistik Indonesia (2009–2015), PLN annual report (2004–2005, 2009–2015):

17. Temperature = average temperature of province(s) in the same region, in ^{o}C.
18. Precipitation = average precipitation of province(s) in the same region, in mm.
19. Road density = proportion of total road length to region area (km^2). Total road length is the summation of state, provincial, and regency/municipality road length (km).
20. Electrification rate = ratio of total PLN customer to region population.
21. GRDP region: summation of GRDP of province(s) in the same region, constant price 2010. Source: BPS Statistik Indonesia 2004–2015

22. Regions: Aceh; North Sumatera; West Sumatera, Riau and Kepulauan Riau; South Sumatera, Jambi, Bengkulu; Bangka Belitung; Lampung; West Kalimantan; South Kalimantan and Central Kalimantan; North Sulawesi, Central Sulawesi and Gorontalo; South Sulawesi, South East Sulawesi, and West Sulawesi; Maluku and North Maluku; Papua and West Papua; Bali; West Nusa Tenggara; East Nusa Tenggara; East Java; Central Java and Yogyakarta; West Java and Banten; Jakarta Raya and Tangerang.

Appendix 3: Reverse causality checks

	DV: ∆blackout frequency (∆lnSAIFI)		
VARIABLES	(1)	(2)	(3)
∆ output per worker (t-1)	0.384	0.482	0.505
	(0.514)	(0.542)	(0.544)
Region FE	N	Y	Y
Year FE	N	N	Y
PLN characteristics	Y	Y	Y
Weather factors	Y	Y	Y
Observations	105	105	105
R squared	0.158	0.157	0.235

Notes: ***, **, and * indicate statistical significance at 1, 5, and percent. Robust standard errors clustered by region are in parentheses. PLN characteristics includes ∆ln energy produced, ∆ln energy losses, ∆ln electricity price, ∆ln A/R collection period, ∆ln length of mv trans lines, ∆ln length of lv trans lines, ∆share of residential, ∆share of commercial customer, excluding RGDP region. Weather factors (∆temperature, ∆ln precipitation)

SUPPLEMENTS

Supplement 1: MSEs in Indonesia

In terms of production, in general, MSEs produce labor-intensive products. In 2015, 46% of MSEs produced food, beverages, and tobacco, while 23% of MSEs produced wood and furniture, and 15% of MSEs were engaged in textiles and clothing. Non-metallic mineral products, basic metals and fabricated metal products, and other types of manufacturing accounted for 7%, 4%, and 2%, respectively. The remaining products constituted 1% of the total.

In addition to firm characteristics, surveys on MSEs collect data about entrepreneur characteristics. When there is more than one entrepreneur in an enterprise, data are collected for only the entrepreneur who possesses the biggest share. Our data show that most MSE entrepreneurs are male (59%), while women account for 41%. Further, 23% of owners have not attained primary education. While 39% of owners attained primary education (39%), those with secondary education and tertiary education account for 34% and 2%, respectively. This low level of education indicates that the skill level of the owners might be limited.

MSEs in Indonesia are able to survive for a relatively long time because, on average, an MSE is 14 years old. Nonetheless, only around 3% of MSEs become a member of a cooperation. Whereas 3% of MSEs have a license to operate, most MSEs do not (97%). More than 59% derive capital from their own private sources, and approximately 40% received capital from external sources. Around 6% of MSEs distribute their product partially or entirely to other provinces and abroad, while 94% distribute their output within the same province.

The development of MSEs is among the top priorities of both the central and local governments of Indonesia. Since the 1970s the Indonesian government has been paying close attention to small firms, as reflected in several small and medium enterprise (SME) development policies. These policies range from general, technology, finance, and marketing initiatives (Anas, Mangunsong, & Panjaitan, 2017).

Table S1. SMEs policy in Indonesia, 1969-2000, 2008-current

Year	**Technology Initiatives**
1969	Establishment of Metal Industry Development Centre (MIDC)
1974	Establishment of BIPIK (Small Industries Development Program)
1979	As part of BIPIK, LIK (Small-Scale Industry Area), and PIK (Small Industry Estates) were established and technical assistance to SMEs was intensified through the UPT (Technical Services Units), staffed by TPL (Extension Field Officers)
1994	BIPIK was replaced by PIKIM (Small-scale Enterprises Development Project)
2012	Ministry of Research and Technology Regulation No.1/2012 concerns research and development technical assistance for business entities
2013	Presidential Regulation No.27/2013 concerns the development of an entrepreneurship incubator. The entrepreneurship incubator is an intermediary institution that performs the incubation process for business, especially start-up company.
2014	Minister of Industrial Regulation No. 11/2014 concerns reorganization of small and medium enterprise machinery and/or equipment
	Finance Initiative
1971	PT. ASKRINDO was established as a state-owned credit insurance company
1973	KIK (Small Investment Credits) and KMKP (Working Capital Credits) were introduced to provide subsidized credit for SMEs
1973	PT. BAHANA, a state-owned venture capital company, was established
1974	KK (Small Credits), administered by Bank Rakyat Indonesia, was launched; subsequently (1984) it was changed to the KUPEDES (general Rural Saving Program) scheme, aimed at promoting small business
1989	SME loans from state-owned enterprises were mandated
1990	The subsidized credit programmes (KIK, KMKP) were abolished and the unsubsidized KUK (Small Business Credits) was introduced
1999	Directed credit programmes were transferred from the Central Bank to PT PNM (a state-owned corporation got SMEs) and Bank Ekspor Indonesia
2000	All government credit programmes for SMEs are to be abolished
2009	Law No. 2/2009 concerns LPEI (Indonesia Exporting Fund Agency). One of the focus is to stimulate MSMEs and cooperatives to develop export-oriented products by providing funding. LPEI also may provide assistance and consultancy for MSMEs
2015	Bank central regulation No. 17/12/PBI/2015, in 2018 banks have to allocate minimum 20% of their lending to SMEs
2015	Economic package: the government subsidized interest rates from 22% to 12%. Through LPEI, the government also increase support for export oriented SMEs or those involved in the production of export products through loans or working capital loans with interest rates lower than commercial interest rates
	General initiatives
1978	A Directorate General for Small-scale Industry was established in the Ministry of Industry

1984	The Bapak Angkat (foster parent) scheme was introduced to support SMEs. It was extended nationally in 1991.
1991	SENTRAs (groups of SMEs) in industrial clusters were organized under the KOPINKRA (Small-scale Handicraft Cooperatives)
1993	The Ministry of Cooperatives was assigned responsibility for small business development
1995	The Basic law for promoting small-scale enterprises was enacted
1997	The Bapak Angkat programme was changed to become a Partnership (Kemitraan) programme
1998	The Ministry of Cooperatives and Small Business added medium-scale business to its responsibilities
2008	Law No.20/2008 concerns micro, small, and medium enterprises (MSMEs)
2009	Government regulation No.24/2009 concerns the Industrial Park. The industrial park company is obliged to provide land for activities of MSMEs
2013	Law No.1/2013 concerns microfinance institutions was launched
2013	Government regulation No.17/2013 regards the implementation of Law No.20/2008 was enacted
2014	Government regulation No.98/2014 concerns licensing for micro and small enterprises (MSEs)
2014	Law No.23/2014 concerns local government role in the empowering and upgrading MSMEs
	Marketing initiatives
1977	A reservation scheme was introduced to protect certain markets for SMEs
1999	The anti-monopoly law included explicit provisions in support to SMEs
2008	Ministry of Trade Regulation No. 53/2008 focuses on partnership between MSMEs and shopping centre/modern markets including the provision of areas and product marketing/MSMEs as supplier
2010	Presidential Regulation No. 54/2010 concerns procurement of goods/services for the government. Government procurement needs to expand opportunities for micro and small enterprises as well as small cooperatives
2013	Ministry of Trade Regulation No. 53/2008 was replaced by Ministry if Trade Regulation No. 70/2013. Encourages MSMEs development through product marketing, provision of areas, for MSMEs suppliers.
2014	Presidential Regulation No. 39/2014 concerns the Investment Reservation List • 93 business activities reserved for MSMEs and cooperatives • 51 business activities opened for investment which requires partnership with MSMEs and cooperatives
2014	Asephi (Asosiasi Eksportir dan Produsen Handicraft Indonesia/ Indonesia Handicraft Producer and Exporter Association) established INACRAFT Mall (http://inacraft-mall.com/) as online site as market place for SMEs product

However, Hill (2001) notes that until 1998 these policies were ineffective for several reasons. First, limited resources were allocated. Second, there was a lack of a clear policy rationale as well as a supply-driven orientation. Last, there was a lack of large firms and commercial services that engaged in supporting SME development programs. Moreover, Anas et al. (2017) reveal that after the Asian Financial Crisis in 1997–1998, the policies continued to be framed in a social welfare approach and reflected excessive protectionism methods to shield SMEs from competition, for instance, partnerships with SMEs, reservation of the business sector for SMEs.

Economic Research Institute for ASEAN and East Asia [ERIA] (2014) evaluates the SME development policies and actions implemented by 10 countries of the Association of Southeast Asian Nations (ASEAN), including Indonesia. Using surveys and in-depth interviews, an independent research team assessed the policy implementation in each country. There are eight factors of assessment: institutional framework, access to support services, the cost and speed to start a business, access to finance, technology and technology transfer, international market expansion, promotion of entrepreneurial education, and representation of SME's interests. The index was constructed through a peer-review process, and Indonesia scored 4.1 out of 6.0 (good practice).

Supplement 2: Electricity sector

PLN is the major provider of all public electricity and electricity infrastructure in Indonesia, including power generation, transmission, distribution, and retail sales (Tharakan, 2015). Electricity demand in Indonesia increased significantly during 2002–2015. In 2015, the total electricity production of Indonesia was 225.7 TWh, more than double that of 2002 (108.3 TWh). Indonesia's total power generating capacity (including captive and off-grid generation) was about 52,859 MW in 2015, of which 64% was from Java. Of this capacity, PLN owned more than 73%. Independent power producers (IPPs) owned the remainder of the electricity.

Indonesia's electricity production in 2015 was dominated by fossil power (89.3%), which consists of coal-based, natural gas–based, and oil-based power, with shares of 55.8%, 25.3%, and 8.2%, respectively. The portion of renewable energy–based power enterprises was relatively small (10.7%), consisting of hydroelectric (5.9%), and geothermal and other (4.8%). Existing power capacity contributes a yearly average per capita electricity consumption of approximately 794 kWh, which is among the lowest in ASEAN (Tharakan, 2015).

As an archipelago, the Indonesian transmission network is segregated into many power grids—8 interconnected networks and 600 separate grids that are all operated by PLN. PLN currently owns and operates about 41,682 circuit km of transmission lines and 92,651 megavolt ampere (MVA) of main transformer capacity. In 2015, PLN operated about 890,099 circuit km of distribution lines and 50,151 MVA of distributor transformer capacity.

Despite under-supply of electricity to some regions, such as Papua, East Nusa Tenggara, and West Sulawesi (Sambodo, 2016), where around 65% of 12,000 villages without electricity are located (World Bank, 2017), electricity reliability is improving. Data on the level of improvement or deterioration of power quality in each region for the last decade show that most regions experienced a decreasing trend of blackout frequency and duration. In 2008, PLN consumers experienced 81 hours or 13 occasions without electricity (PLN, 2010), whereas electricity outages declined to an average of 5 hours or 6 events in 2015 (PLN, 2016).

PLN holds a de facto monopoly over distribution, and is, therefore, the primary agency responsible for the network's required expansion. It is reported that a stable power supply in Indonesia has been achieved over the past decades, mostly by supply-side initiatives, for instance, gradually implementing structural changes to its energy sector, boosting investment in infrastructure, and introducing a regulatory initiative to improve overall power reliability (World Bank, 2017).

In 1999, the Government of Indonesia (GoI) started to invite the private sector to enter the electricity sector. Consequently, Indonesia's power capacity expanded dramatically. In 2015, IPPs and private utilities accounted for 26% of Indonesia's installed generation capacity. The GoI has announced two fast-track programs to meet the fast-growing electricity demand to accelerate the expansion of power capacity. The first fast-track program was launched in 2004 and aimed to construct new coal-based electricity generation with a total capacity of 10,000 MW. In 2006, the second fast-track program began to install another 10,000 MW of new power capacity by 2014, including 5,000 MW from geothermal enterprises and 1,250 MW from hydropower.

In 2015, Indonesia's president launched the 35 gigawatts electricity project. Based on PLN's Electricity Business Plan (RUPTL) 2017–2026, electricity demand growth is projected to be approximately 8.3% per year. The additional capacity of power generation that will be developed up to 2026 is approximately 77,873 MW or 7,787 MW per year on average. However, actual demand has grown at a much slower rate compared with the projections, leading to uncertainties about the government's projection of 35 gigawatts by 2019 (Singgih & Sundaryani, 2017). Further, PLN might have overestimated demand and that this project put PLN and customers at risk of paying of unneeded power (Chung, 2017). In 2011, the GoI enacted a policy stating that customers have the right to receive compensation from PLN when they experience a certain level of blackouts. As a deterrent, this policy helps the improvement of power supply reliability (World Bank, 2017).

On the demand side, Indonesia has not sought to limit consumption through tariffs. The pricing policy pursued by the government aims to balance the financial standing of the utility with the affordability of electricity tariffs. Tariffs are set below market levels, but PLN is compensated through subsidies that allow for a profit margin of 7%. Tariffs are also routinely reviewed by the regulator. End-use tariffs were raised by 15% in 2013, for example, to help improve PLN's financial performance in the wake of rising energy prices (World Bank, 2017).

Supplement 3: Exogeneity of A/R collection period

It might be argued that A/R collection might have a correlation with productivity. Those MSEs with low productivity might not be able to pay electricity bills on time, causing PLN to implement a longer A/R collection period. However, there are no data available on A/R collection for MSE-type customers. PLN provides A/R collection data by region or by customer, which could be differentiated into the public sector and the government sector. The public sector includes household, industry, and (larger) firms. In Indonesia, an MSE is an inseparable entity from the household such that the MSE does not have a separate electricity account from the household. It is very common that electricity accounts are registered under the household name instead of the enterprise name. From the A/R collection data available we could not untangle the information for MSEs only.

Based on PLN regulation, customers must pay fines if they are late paying the electricity bill by one month. Further, if they still do not pay the bill plus the fines in the second month, PLN will stop the power supply temporarily. Finally, PLN will disconnect the power supply permanently if customers fail to pay the bill in the third month (PLN, 2011). Moreover, in 2008, PLN released a prepaid system, in which those customers who choose this system buy the electricity upfront. Any post-paid customers who would like to increase their installed capacity, or whoever has experienced a disconnection previously and would like to re-install electricity, will have to adopt the prepaid system. Similarly, new customers will be registered under the prepaid system.

Our data show that public sector accounted for around 90% of PLN's A/R amount, and the rest belongs to the government sector (armed forces, non-armed forces, local government, and state owned enterprises). In practice, power disconnection actions were taken for the public sector, but not for the government sector. This might suggest that in general PLN governance is relatively poor. Therefore, we argue that A/R collection is relatively exogenous to productivity.

Supplement 4: Measurement errors

There are at least two concerns regarding measurement errors. First is the cohort variable as the representation of firm. By construction, the cohort variable equals the average value of variables within the cohort. On average, our cohort size is 1,701 enterprises. The number of cohorts is predetermined as the interaction of factor intensity and firm size, which varies by region. Moffitt (1993) shows that when the number of cohorts is fixed and the cohort size increases with the number of observation, the error-in-variable problem, which appears as we construct the mean variable, would disappear. Therefore, we argue that the measurement error in the cohort variable is minimal.

The second concern regarding measurement errors is the blackout measurement from PLN. Data on power failure frequency and duration indicate that PLN tends to meet its annual target of blackout frequency and duration. If this observation is true, then there might be underreported bias since PLN might wish to be viewed as providing a reliable power supply. However, we should also keep in mind that electricity blackout frequency and duration are observed by customers who might be eligible to claim compensation when they experience a certain degree of electricity interruptions per month based on the PLN target (PLN, 2015). Consequently, it is PLN who will be disadvantaged if PLN wrongly measures the power failure.

Supplement 5: Data explanation

There are two different sources of MSEs from BPS. Before 2006, BPS collected data for non-directory/household enterprises, including the manufacturing industry, with less than 20 workers, known as Survei Terintegrasi (SUSI). We extract data from SUSI only for the manufacturing sector. Starting in 2009, BPS regularly conducted a designated survey to specifically collect data on MSEs, known as Survei Industri Mikro Kecil (Survei IMK). Data from SUSI 2004 uses KBLI 2000, while data from SUSI 2005 uses KBLI 2004, and data from Survei IMK 2009–2015 uses KBLI 2009.

The reason for grouping KBLI into factor intensity is that the number of firms at two-digit KBLI per region is very limited, as indicated by the level of representativeness of the MSE surveys. Moreover, if we split the samples for two size categories of MSEs, the observations per category become smaller. Province Nanggroe Aceh Darussalam was not covered by MSE survey in 2005 because of the tsunami that occurred in December 2004. Further, some categories consist of no observations. Thus, there are 1,076 cohorts created overall. The PLN working areas consist of 23 regions. However, we merge Tarakan and Batam regions into their main provinces of East Kalimantan and Kepulauan Riau since these two regions constitute a tiny number of MSE samples; thus, we have 21 regions in total.

While SAIFI and SAIDI are available at the regional level for all periods of observation, other power sector data, such as energy produced and energy loss, are available at the regional level starting from 2009. Therefore, to obtain regional power sector data for 2004–2005, we disaggregate national figures proportionally based on the 2009 regional power sector data. Those variables are energy produced, energy losses, length of medium voltage transmission lines, electricity price, accounts receivable (A/R) collection period, total number of customer, and number of customers based on the categories of residential and commercial.

We have two measurements for infrastructure: road density and electrification rate. Road density is the proportion of total road length to region area (km^2). Total road length is the summation of state, provincial, and regency/municipality road length (km). Following the PLN definition, electrification rate is constructed as the ratio of total PLN customers to region population. We collect data on road length and population number from the Statistical Yearbook of Indonesia (*Statistik Indonesia*, SI). SI provides provincial total road length, population and area; then we sum the provincial figures into regional ones.

Data on provincial temperature and precipitation for 2011–2015 are obtained from SI, while data on temperature and precipitation before 2011 are obtained from Matsuura & Willmott (2011). Matsuura & Willmott provide monthly precipitation for geographic grid points spaced at half-degree intervals. We sum the total annual precipitation by grid point, then calculate district-by-year average temperature by averaging across all grid points within each district. Finally, we calculate the provincial data as the average of district level data within each province. There are some missing temperature data from SI; in this case, we input the data using the previous year's data, assuming that the level of temperature is the same as that in earlier year.