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Lights Off, Lights On

The Effects of Electricity Shortages on Small Firms

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Abstract

Entrepreneurs in developing countries report that unreliable electricity imposes a serious constraint, yet little evidence exists on how blackouts impact the micro firms that account for the majority of employment. This paper estimates the effects of outages on small firms using original firm-level panel data and finds evidence of differential effects by firm size. Firms without employees experience large reductions in revenues and profits. Outages have no measurable effect on the output of firms with employees, where worker hours increase, weekly wages paid decrease, and the analysis fails to reject that blackouts have no effect on (average firm-level) worker hourly wages.

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LIGHTS OFF, LIGHTS ON:
THE EFFECTS OF ELECTRICITY SHORTAGES ON SMALL FIRMS

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1 Introduction

Small firms employ the vast majority of non-agricultural workers and dominate the firm size distribution in developing countries (?). Many of these firms are composed of a single person, the self-employed owner, for whom the profits of the firm are earned income. While single-person and other small firms face a variety of well-documented barriers to growth,[1] relatively little is known about how they cope with unreliable infrastructure. Power outages, in particular, are pervasive across the developing world and are oft-cited by entrepreneurs themselves as the most detrimental input shortage they face (??).[2]

This study is among the first to analyze the input and output effects of frequent blackouts among microenterprises. Existing studies of the direct firm-level consequences of electricity shortages estimate these effects primarily among large, formal firms, whose input composition differs dramatically from the modal single-person or very small firm. ? and ? find that large firms in China and India, respectively, avoid large productivity losses by shifting their input choices: outsourcing the production of intermediate inputs or storing raw materials during outages. The input composition of small firms, in contrast, is primarily labor, which is less substitutable than materials across firms and periods, leaving little reason to suppose that the evidence from large firms on coping strategies applies to microenterprises.

Microenterprises are also unlikely to shift away from grid electricity to costly generators, as many large firms do in Africa, though costs of running a generator often outweigh benefits even for large firms (?). Recent evidence from Ghana suggests that midsize firms (with an average of six workers) also invest in generators during power crises, though using a generator exacerbates productivity losses by diverting capital away from other inputs (?). In the sample studied in this paper, only 3% of firms report having access to a generator during the panel data collection period and only a single firm purchased a generator in the year during which the sample was surveyed.

This study also differs from the existing literature in the frequency of the labor input data it exploits. Using high-frequency (daily) data, this paper shows that microenterprises cope with power outages in the short term by shifting labor demand for workers and labor supply of firm owners. In this, it builds on ?, which presents indirect evidence that electrification enables self-employment in South Africa and ?, which show that place-based infrastructure grants increase employment in India.

This article studies a period of heavy load shedding and frequent, unpredictable blackouts in March and April of 2015, at the tail end of a three-year power crisis known as *Dumsor*, or the "Lights Off, Lights

[1]For example, ? consider access to capital, finding high rates of return to capital in microenterprises in Sri Lanka; ? show an impact of randomly offered consulting services on the productivity of small firms in Mexico; and ? present experimental evidence from Ghana that small firms in their context are labor constrained.

[2]The World Bank Enterprise Surveys in Ghana happen to have been collected during two periods of extreme power crisis, in 2007, during the 2006-07 power crisis and in 2013, near the beginning of the 2012-15 Dumsor crisis. As such, their estimates of the firm-level burden of lacking electricity may reflect that particular timing. In the 2013 survey, 61% of firms cite electricity as a major constraint to firm performance, as compared to 43% citing corruption and 62% citing access to finance. This figure is fairly constant across the three major firm size strata (61% for firms of size 5-19 workers, 61% for firms of size 20-99, and 63% for firms of size 100+). Firms in the World Bank sample estimated losses due to electricity outages to be 11.5% of annual revenues.

On" crisis. The sample consists of garment-making firms with access to electricity in Hohoe, Ghana, a mid-size district capital in the Volta Region. The study combines daily firm-level data on electricity outages and labor hours with weekly panel data on wages paid, revenues, and profits, to estimate the effects of blackouts on firm outputs and input choices. All specifications include time and firm fixed effects to control for blackout propensity variation across days and across firms, extracting plausibly exogenous variation in daily exposure to blackouts. High-frequency micro data on firm-level exposure to power outages, firm inputs, and firm outputs is rare, which is one reason why research on the impact of blackouts is so limited, despite the ubiquity of rolling blackouts in many developing countries. The panel dataset of small garment-making firms in Ghana analyzed in this paper offers an unusual opportunity to estimate direct effects.

Findings reveal that frequent power outages have disproportionately negative impacts on the profitability and productivity of single-person firms. Among single-person firms, *each* additional blackout day in a workweek is associated with a 10% decrease in weekly revenues and a 13% decrease in weekly profits. Point estimates are nearer to zero for firms that have access to workers during the period of the panel data collection, and the analysis is unable to reject that these firms experience no profit or revenue decreases in response to blackouts.

This heterogeneity in output effects suggests differential success in adapting production to cope with unreliable infrastructure, and that these coping strategies may center around labor inputs. One-person firm owners decrease their intensive and extensive labor supply on days with outages, without compensating for those lost hours on days when the power is restored. Aggregated to the weekly level, one-person firm owners reduce their weekly labor supply by 5% for each blackout weekday, utilizing labor as the primary input to contract production in response to changes in productivity. These productivity shifts, however, not only contract hours and outputs, they also have a statistically significant negative effect on profits per owner hour worked, which decrease by 16%. As is standard in the literature, these estimates of profits do not exclude income or wages paid to the owner; profit reductions are reductions in earned income for the owner-operators of single-person firms and reductions in profits per owner hour worked are reductions in hourly wages.

On a weekly basis, the analysis cannot reject that outages have no effect on the labor supply of firm owners in firms with workers. Rather, the study documents a dynamic reshuffling of firm owner labor supply across days, suggestive evidence of dynamic adjustments in the production process in response to blackouts. On days with lights following a blackout day, firm owners increase both intensive and extensive labor supply by about 5% each; on the second of two consecutive blackout days, firm owners decrease their intensive labor supply by about 20 minutes; on blackout days following a day with lights, there is no measurable effect on firm owner labor supply.[3]

[3]These intertemporal daily labor supply findings contribute to a debate in labor economics regarding labor supply elasticity across more and less productive work time, though this context is complicated by the fact that firm owners with

The central labor adjustment in microenterprises with workers is instead an upward shift in short term labor demand for workers in response to blackouts. Each additional blackout weekday is associated with 0.32 additional non-owner work days and 3.13 additional non-owner work hours in a workweek. On a daily basis, firms with workers statistically significantly increase the number of workers staffed and total worker hours on blackout days, on days that are the second of two consecutive blackout days, and on days with power that follow a blackout day. In addition, total weekly wages paid decrease by 20% for each blackout day in a workweek, but the analysis fails to reject that outages have no effect on within-firm worker hourly wages.

What rationalizes an increase in worker hours and a reduction in wages paid, without any measured effect on average hourly wages at the firm level? The evidence in this paper, though speculative, suggests that firms employing unskilled workers are increasing worker labor inputs and that firms employing skilled workers are driving the reductions in wages paid. The composition of the workforce in this industry is consistent with this interpretation; 91% of the workforce are unskilled (and poorly paid), while the tiny fraction of skilled workers take home 61% of total wages paid.

This paper is divided into six sections. Section 2 introduces the context of the study, providing background on Ghana's electricity crisis and the garment sector. Section 3 describes the sample and data. Section 4 discusses estimation. Section 5 presents the findings and discusses possible interpretations. Section 6 concludes.

2 Context

2.1 Dumsor

In Ghana, as in many low-income countries, electricity demand often outstrips supply, and power is erratic and frequently unavailable. A recent survey of electricity consumers in twelve African countries found that in all but Rwanda more than half of respondents reported at least one outage per day; in Ghana, that figure is 68% of electricity consumers (**?**). Despite both public and private efforts to develop new capacity, major power crises plagued Ghana in 1997-98, 2006-07, and 2012-15. Historically dominated by hydropower, from 2006 to 2016 generation capacity doubled, with thermal now accounting for nearly 60% of installed capacity. Still, the hydro/thermal power generation mix leaves Ghana susceptible to capacity reduction from drought and natural gas supply challenges, and the system suffers from massive distribution losses due to obsolete equipment, a tariff structure that is not cost-reflective, and pervasive non-payment by electricity consumers (including government ministries) (**?**).

Dumsor, or Dum So, derives from the words for off and on in the Asante Twi, Akuapim Twi, and

workers are working on a production process in conjunction with worker labor inputs. **?**, **?**, and **?** present evidence on the labor supply of vehicle and bicycle taxi drivers; **?** consider the labor supply of pear packers; **?** examine labor supply in fisheries; and **?** studies the labor supply of stadium vendors.

Fante languages. The term was first used during the electricity rationing program associated with a severe drought in 1997, and gained prominence again after the West Africa Gas Pipeline damage in 2012.[4] The Electricity Commission of Ghana (ECG) published official substation-level load shedding schedules from late 2012 to March 6th, 2015 which typically classified service areas in 6, 12, or 24 hour blocks as lights on, lights off, or standby. For two reasons, this study focuses on firm-owner self-reports, including time (and firm) fixed effects that extract plausibly exogenous variation not predicted by the official load shedding schedules. First, publicly-available load shedding schedules concluded on March 6th, 2015, only seven weekdays into the panel data collection period, and due to rolling entry into the weekly survey sample, only three days into the portion of the panel data collection period that includes all firms in the sample. Secondly, ECG load shedding schedules block together all firms in the sample under the Hohoe substation as a single service area. The authors, the research team, and the firm owners in the sample, however, can attest from experience that variation across firms within 12 hour blocks was the norm.[5] Anecdotally the load shedding schedules became less and less reliable as the crisis wore on into late 2014 and into the hot harmattan season of early 2015. Protests were widespread and though the study focuses on the tail-end of the 2012-15 crisis, it studies a period of long, erratic, and politically-salient blackouts.

2.2 Garment Making

Bespoke garment making firms are ubiquitous in many parts of Africa and the developing world. Ghana is no exception. Nearly all garments produced by these small firms are made-to-order, for special occasions like funerals and weddings, as dress attire for church, for work in government offices on African-wear Fridays, or simply as everyday clothing. A fraction of shops also produce ready-made garments or supply larger school uniform contracts, but exporting or selling to large distributors is rare. In the study sample, the best selling product in about 70% of firms was bespoke womenswear, another 25% of firms reported bespoke menswear as the most commonly produced item, and less than 5% of the sample reported specializing in some other type of garment (e.g. wedding dresses, school uniforms, hand-made bags). The product mix is fairly gender segregated, though there is no difference in the product mix between firms with and without workers.

Production of bespoke garments can be undertaken via a combination of three different production technologies: by hand using a needle and thread, using a manual hand or foot crank sewing machine, or using an electric sewing machine, in order of increasing productivity. 97% of the firms in the sample have

[4] The West Africa Gas Pipeline, the first of its kind in Africa, transports natural gas from Nigeria to Benin, Togo, and Ghana, and began service in 2009. The pipeline was damaged by pirates trying to board an oil tanker off the coast of Togo in 2012. Interruption in the supply of natural gas continued through 2013.

[5] In this paper's appendix, we present the official load shedding schedule for the relevant dates, discuss variation over time and across firms in the sample, provide information on some unofficial ex-post load shedding records the research team was able to obtain, and document the relationship between the official and unofficial schedules and the self-reported blackout data exploited in the paper.

either a manual or an electric sewing machine or both. 86% of both firms with and without workers have at least one manual sewing machine, making a shift to this less productive technology possible for most firms in the event of a power outage. About 75% of one-person firms and 88% of firms with workers have either an electric sewing machine or some other type of auxiliary electric equipment, such as an electric iron or embroidery machine, undergirding the potential productivity importance of power outages for electrified firms in this industry.

All firms in the analysis sample and most firms in the industry utilize the labor of the firm owner, who is typically a skilled garment maker who has completed apprenticeship training in the trade. About half of the firms in the sample also employ non-owner labor. To shed light on the composition of the workforce in the Ghanaian garment making industry, the analysis turns to the baseline dataset from **?**, which includes worker-level information from 752 garment making firms in Ghana.[6] In that sample, 630 firms employ 197 workers who have already completed an apprenticeship, 72 family workers, and 1,908 apprentices, for a workforce composition that is 91% apprentices and family workers. Although there is skill heterogeneity among apprentices (and family workers) driven by progression in the apprenticeship (among other things), for the purposes of this paper family workers and apprentices are conceptualized as unskilled labor and what are colloquially referred to as "paid workers" (who have completed an apprenticeship) as skilled labor.

Firm owners and skilled workers are generally able to utilize any of the three production technologies, and often also possess specialized skills in fashion design, embroidery, and the use of other specialized machines. Capital utilization by apprentices varies according to the capital available in their training firm and their progression in the apprenticeship, and they generally learn each production technology in order of ascending productivity. In the **?** data, over 95% of apprentices can effectively use at least one type of sewing machine six months into their training. The pay structure for skilled and unskilled workers differs dramatically in this context. Apprentices are paid low weekly or monthly wages that are tied to the overall revenues of the firm, while skilled workers are much better paid piece rate employees. In the **?** baseline dataset, though skilled workers constitute only 9% of the workforce, they earn 61% of all the wages reported in the data.

Many features of the garment making industry mirror other small-scale manufacturing trades in Ghana. Apprenticeships are widespread in skilled construction, cosmetology, auto repair, cobblery, and artisan crafts. Variation in reliance on manual and electric equipment is also common in these trades. Perhaps not surprisingly, the profit distribution of the garment making firms in the sample studied in this paper is statistically indistinguishable from the distribution of incomes among all self-employed Ghanaians in the Ghana Living Standards Survey (**?**).

[6] This dataset includes other industries as well; here the study draws on descriptive statistics from the garment making portion of the sample and from the 2013 firm baseline survey before any experimental intervention.

3 Data

3.1 Sample

This paper makes use of data from the Hohoe Garment Makers Project, collected in Hohoe Municipal District, a mountainous part of the Volta Region in Eastern Ghana near the border with Togo. In February of 2014, the research team conducted a census of all garment making firm owners in the district in preparation for this and other projects, a listing which uncovered 445 active garment making firm owners in Hohoe Town and its outlying suburbs. The activity began with existing lists of firms provided by the leadership of the local chapter of the Ghana National Tailors and Dressmakers Association (GNTDA) and other local trade associations, and continued through snowball sampling until all leads were exhausted. The field team then conducted a final stage of geographic road-by-road canvassing.[7]

Of the firms identified in the census, 416 were still operational at the time of the weekly monitoring surveys in March and April of 2015.[8] Of these, 342 firms were verified by the field team to have an electricity connection to their shop or place of business at the time of the weekly surveys.[9] These 342 firms make up the analysis sample.

3.2 Data Sources

In addition to the February 2014 census, supplementary baseline data was collected in the summer of 2014 and recall information in June of 2015 on machinery and equipment in use as of June 2014. Together, these three data sources make up the baseline dataset.

The primary analysis dataset was generated by a weekly panel survey conducted over seven weeks in March and April of 2015. All 445 firms in the Hohoe town census sample were cluster randomly assigned by neighborhood to weekdays for the weekly surveys, in an effort to spread daily recall randomly across days (if, for example, the weekend interlude makes it easier or harder to recall certain information). Data collection began on Thursday, March 5th, 2015, referencing daily blackouts and hours worked recall for Thursday, February 26th through Wednesday, March 4th, and weekly sales, orders, and expenses recall for that same seven day period. The four other weekday survey groups were started on Friday, March 6th, Monday, March 9th, Tuesday, March 10th, and Wednesday, March 11th. Data collection continued in this weekly manner through to Wednesday, April 22nd, 2015. Field staff conducted make-up surveys

[7]Individuals were included in the original census sample if they met three criteria. First, they had to report the ability to produce at least one of three commonly sold bespoke garment products: a man's shirt, a woman's slit and kabbah (a fitted top and long skirt), or a caftan (the attire traditionally worn by Ghanaians from the Northern part of the country). Second, they had to report owning a garment making business, though the business need not have a permanent physical location. Third, they had to report that the business was currently operational or was planned to be in operation over the next year.

[8]Appendix Table 1 compares baseline firm characteristics between the full census sample and those surviving to the panel survey. There are few observable predictors of survivorship, with the exception that older firms owners and older firms are less likely to exit.

[9]Appendix Table 2 compares baseline firm characteristics between all survivors and those survivors with electricity access (the analysis sample). Firms with access to electricity are, unsurprisingly, larger, more formal, and more likely to be owned by a man.

for missed days where possible, though these referenced the originally intended seven day period for that survey. The final make-up survey was conducted on May 8th, 2015.[10]

Due to the overlapping seven day structure, there are a total of 55 possible days covered in the daily panel, with 49 fully overlapping days. Date fixed effects in daily regressions correspond to the actual date. Week level specifications control for week-by-day fixed effects, a combination of the ordered weeks one through seven, and the day of the week that the firm was randomized to for survey purposes (ensuring controls for the exact same seven day period across firms).

In auxiliary analysis, the study utilizes two additional data sources: information on machinery and equipment as of June 2015 to study capital adjustments, and the baseline dataset from **?**, which includes worker-level information on 752 garment making firms in Ghana to provide contextual information on worker skill levels and wages in the industry.

Baseline data measures of profits and revenues use single question monthly self-reports as recommended by **?**. In piloting the weekly panel survey, the research team found summary profit questions difficult on a weekly basis cleaved by the weekday on which survey administration was randomly assigned. It was instead more efficient to recall weekly revenues by garment type and weekly expenses by expense type. One advantage of this measurement strategy is that self-reported profits are frequently de facto censored at zero, as firm owners rarely report negative profits. Using reported sales and expenses to ex-post calculate profits allows for the entire distribution of possible profit levels. On the other hand, many expenses are paid on a monthly, biannual, or annual basis, making weekly measures including them noisy, and other work on measuring profits has recommended summary questions as potentially more accurate noisy measures (**?**).

Expenses reported in the weekly monitoring surveys were as follows: wages, outsourcing fees, inventory, rent, taxes, electricity bills, furniture, machinery, tools, repairs, and other. In the specifications presented in this paper, profits are calculated as total sales less wages, outsourcing fees, and inventory costs, each of which are recurrent variables operating expenses. Rent, taxes, and bills (including electricity bills)[11] are lump-sum costs that it would be inappropriate to include in weekly measures (in Ghana, these are most often paid on an annual or biannual basis). The study categorizes the purchasing and repairing of equipment as investment, and thus does not deduct furniture, machinery, tools, and repair expenses from sales in the profit calculations.

[10] In the analysis sample of 342 firms, the panel survey targeted a total of 2,394 surveys (342 by 7 weeks). 32 of these are missing, primarily due to travel by firm owners towards the end of the data collection period (near Easter).

[11] At the time of the survey Hohoe electricity consumers were on a post-pay meter system with intermittent billing. Most ECG consumers have since been transitioned to a pre-pay metering system that uses scratch cards and smart phone apps to purchase power piecemeal.

3.3 Sample Characteristics by Firm Type

All analysis splits the sample into firms with and without workers during the weekly panel data period of March and April, 2015. Of the 342 firms in the analysis sample, 184 report no worker activity during any week in that seven week period. The remaining 158 firms, categorized as with workers, reported non-owner working hours for at least one of the seven weeks in the weekly monitoring data. Note that this measure of firms with and without workers is time-invariant, as it is defined as employing non-owner labor inputs at any time during the seven week panel.[12]

Baseline characteristic comparisons between one-person and with-worker firms are presented in Table 1.[13] Firms with workers are predictably larger as measured by revenues, profits, and capital assets. They are also more likely to do things like keep formal business records (as measured by the adoption of management practices), register with the municipal government, and become a member of a trade association, evidence that these are more formal firms. Readers should interpret the findings with caution in light of these gravity differences between firms with and without workers; firms with workers are almost tautologically larger than firms without workers.

Perhaps reassuringly, there is no statistical difference between access to any manual or electric sewing machine across firms with and without workers, though firms with workers predictably have more of both. Firms with workers are more likely to report having any electric equipment (including electric sewing machines, but also other electric equipment like electric irons or embroidery machines), though this difference would tend against the finding that one-person firms are differentially negatively affected by unreliable electricity. It is also reassuring that most of the demographics are balanced across the two firm types, including gender, age, ethnicity, educational background, and Ravens (a measure of abstract cognitive ability).

During the panel data collection period, firm owners in one-person firms and in firms with workers both reported blackouts on 31% of days.[14] Among firms with workers, 44% reported at most a single worker reporting to work in a given week, another 22% reported at most two workers in a week, and the remaining 34% reported at least some weeks with at least three workers.

[12]The study defines firms with and without workers using this measure contemporaneous to the main analysis data collection because the labor information in the baseline data (from the February 2014 census) occurs more than a year before the weekly monitoring surveys. Given normal churn in the labor market, defining the firms with workers as those employing non-owner labor in February 2014 adds unnecessary noise to estimates of short term staffing adjustments that the paper argues firms use to cope with blackouts. 20% of firms with workers in March and April of 2015 had no employees as of the February 2014 census and 25% of firms without workers in March and April of 2015 had at least one worker besides the owner in February 2014. Appendix Table 8 estimates the relationship between these annual changes and outages and Section 5 discusses this analysis in more detail.

[13]Appendix Figure 1 shows the location of all sample firms by firm type. The entire sample is within an 11 square kilometer radius.

[14]Firm owners were given the option to report daily power access as blackout, partial blackout, or no blackout. In all specifications partial blackout is coded as a blackout, though the conclusions are robust to classifying partial blackouts as non-blackout days. Unfortunately, the data do not have any more direct measures of blackout duration.

4 Estimating Equations

Estimates of blackout effects on weekly sales, profits, expenses, and labor use the following specification:

$$Y_{it} = \beta_0 + \beta_1 * \#b_{it} + r_{it} + \gamma_i + \eta_{sd} + \epsilon_{it} \tag{1}$$

where $\#b_{it}$ is the number of blackouts (of five) reported for firm owner i during five week days t, r_{it} is a vector of dummies indicating the number of days for which a response about blackout status is recorded for firm owner i in time period t, γ_i are firm fixed effects, and η_{sd} are week by survey day code fixed effects (a combination of the ordered weeks one through seven, and the day of the week that the firm was randomized to for survey purposes, to ensure controls for the exact same five day period).[15] The identifying assumption is that conditional on time and firm fixed effects, the number of blackout days reported by the firm is as good as random. To allow for spatial correlation in the error term, and because the day of the survey randomization was clustered by neighborhood, all errors in these specifications are clustered at the neighborhood level. There are 23 neighborhood clusters in the sample.

Extensive and intensive labor supply for both firm owners and workers are recorded on a daily basis over the seven day recall period preceding the date of each weekly survey. Estimates of the dynamic labor supply response to blackouts use the following:

$$Y_{it} = \beta_0 + \beta_1 * b_{it} + \beta_2 * b_{it-1} + \beta_3 * b_{iboth} + \gamma_i + \eta_t + \epsilon_{it} \tag{2}$$

where b_{it} indicates a self-reported blackout on date t, but not $t-1$, for firm i, b_{it-1} indicates a self-reported blackout on date $t-1$, but not t, for firm i, and b_{iboth} indicates self-reported blackouts on both t and $t-1$ for firm i. The omitted category is no reported blackout on either t or $t-1$ for firm i. Missing blackout observation pairs are dropped and Fridays and Mondays are paired as t and $t-1$ over weekends. γ_i are firm fixed effects, and η_t are day fixed effects. Again, the identifying assumption is that conditional on date and firm fixed effects, the assignment of firm i to one of these four exposure categories for date t is as good as random. As in the week-level specifications, all errors in the daily specifications are clustered at the neighborhood level.

[15] All primary specifications restrict data to weekdays Monday through Friday because these businesses are rarely operational on the weekends. Appendix Tables 3 through 7 replicate these estimates using the full 7 day period and find qualitatively similar results.

5 Findings

5.1 Revenues and Profits

Each additional blackout weekday is associated with a reduction of 4.40 GhC in firm revenues and 4.15 GhC in firm profits for one-person firms (Table 2 Panel A). These effects are both highly statistically significant and economically significant at approximately 10% and 13% of weekly average revenues and profits, respectively. In contrast, there is no statistically significant effect of blackouts on the revenues and profits of firms that had access to workers during the period of the panel data collection (Table 2 Panel B). Point estimates are near zero, at 1% and 4% of weekly revenues and profits, respectively.[16] There is also no evidence of measurable impacts on the sum of all variable expenses (wages, outsourcing fees, and inventory costs) for either one-person firms or firms with workers, though point estimates are negative for both firm types.

5.2 Labor Inputs

To understand the source of these differences in weekly revenue and profit effects between with-worker and one-person firms, the paper turns in this section to an exploration of labor-based coping strategies.

The effects of each additional blackout day (of the five working days Monday through Friday) on owner days worked, total owner hours, and the owner's effective wage (profits per hour) for one-person firm owners (Panel A), and firm owners with workers (Panel B) are presented in Table 3. One-person firm owners significantly decrease labor by around 1 hour and 20 minutes per blackout day. Even with this decrease in hours by one-person firm owners, owner effective wages (profits per hour) fall by 0.17 GhC per blackout day. This drop in the effective wage paid is statistically and economically significant at 16% of an already low hourly wage, implying potentially sizable welfare losses for the owner-operators of the smallest and most common firm type among the self-employed in Ghana. Firm owners with workers show no overall weekly owner labor supply response and experience no fall in owner effective wage as a result of blackouts.

Daily labor input effects are presented dynamically in two day pairs, with Fridays and Mondays paired together (Table 4). One-person firm owners decrease both intensive and extensive labor supply on blackout days following a day with lights, and on the second of two consecutive blackout days. These firm owners are 4% and 8% less likely to work on the first and second day of outages. In terms of total hours, one-person firm owners work around 30 fewer minutes on the first day of a blackout and almost an hour less on a blackout day preceded by another blackout day, without compensating for these lost hours by increasing their likelihood of working or number of hours supplied on days on which power is restored. For firms with workers, dynamic firm owner labor supply may suggest changes in the production model

[16] Though all specifications use raw levels, results are robust to winsorizing the data at 1% or 5%.

in response to outages. These firm owners increase their labor supply on days with lights immediately following a blackout day and decrease their labor supply on the second of two consecutive blackout days.

For each blackout day in a workweek, firms with workers increase the probability of staffing a worker by 3%, increase the number of worker days staffed by 4%, and increase total worker hours by 4%, small but meaningful changes in an environment with nearly two blackouts in each five day workweek (Table 5). Worker labor inputs are increased dynamically on blackout days, on the second of two consecutive blackout days, and on days with lights following blackout days, across the board working more relative to paired days with lights (Table 4).

While the analysis finds no evidence of input changes (beyond firm owner labor supply) for one-person firms, as proxied by expenses, firms with workers exhibit significant drops in weekly wages paid (Table 6).[17] Each additional blackout day is associated with a reduction of 1.29 GhC in weekly wages paid. This figure amounts to a dramatic 20% reduction. The final labor input finding comes from Table 5, which shows that despite increases in worker hours and decreases in total wages paid, the data fail to reject no effect of outages on within-firm worker hourly wages.

5.3 Interpretation

This study has shown that one-person firms suffer larger profit and revenue losses than firms with workers, suggesting that labor input adjustments in microenterprises ameliorate the negative effects of unreliable electricity. The prior section then outlines three comparative statics on worker labor inputs, which can be used as a basis to examine *how* labor input adjustments in microenterprises ameliorate the negative effects of outages: worker hours increase in response to blackouts, weekly wages paid by firms decrease in response to blackouts, and the data fail to reject that blackouts have no effect on (average firm-level) worker hourly wages. The context discussion in Section 2 suggests that the key to rationalizing this set of findings may be found in exploring the skill composition of these labor input adjustments.

Ideal data for identifying differential effects on the labor inputs of skilled and unskilled workers would individually classify workers by skill level and wages by individual worker. Worker-level data of this type would allow for direct tests of both the skill composition of labor input adjustments, and the effects of blackouts on the total and hourly earnings of workers by skill level. Unfortunately, the firm-level panel data enumerates workers 1 through n, but does not differentiate them by skill level. A related data limitation is that the wage data in the firm-level panel is lumped together as all wages paid by the firm in a given week and thus cannot be attributed to individual workers.

Given these data limitations, the study uses information on the composition of the workforce in the garment making industry in Ghana to draw speculative conclusions about the mechanisms behind the

[17]Note that inventory costs in Ghanaian garment-making firms tend to be relatively small. As with other skilled small businesses in Ghana, garment making customers typically supply the raw materials (fabric), leaving little in the way of materials inputs from the firm's perspective.

observed comparative statics. As noted in the context section, worker-level data from the 752 garment making firms in the **?** baseline dataset reveals that 91% of the workforce in that baseline sample are unskilled workers. Though skilled workers comprise only 9% of the labor force, they earn 61% of all wages paid by firms in the baseline data. Skilled and unskilled workers average similar hours of work per week and skilled workers earn many multiples the hourly and weekly wage of an unskilled worker.

Though it is not possible to categorize workers as skilled or unskilled in the analysis panel dataset, the labor information in the February 2014 census differentiates workers by skill level. At that time, the sample employed 256 apprentices, 76 family workers, and 27 skilled workers, a workforce composition that was 92% unskilled workers, remarkably similar to the ratios in the national-level **?** data. The preponderance of unskilled workers in this setting implies that the first of the key comparative statics, that worker hours increase in response to outages, is likely explained by firms employing this type of worker. Likewise, the contextual similarities between this study and **?** (and the experience of the research team in the field) imply that skilled workers in this sample are also much better paid than their unskilled counterparts, suggestive evidence that large changes in firm-level weekly wages paid (the second key comparative static) are driven by firms employing skilled workers.

An alternative explanation of rising hours and falling earnings could be that in the presence of falling productivity, skilled workers being paid at a piece rate simply experience a reduction in hourly wages.[18] Though it is not possible to test for this directly given data limitations in the firm-level panel, in the third key comparative static of the paper the analysis fails to reject that outages have no effect on within-firm worker hourly wages, consistent with reductions in both wages and hours for skilled workers and inconsistent with the simplest version of this alternative interpretation. **?** provides complementary evidence in this regard, using the World Bank Enterprise and Afrobarometer surveys to show that unreliable electricity supplies reduce both employment and the share of high-skilled jobs in the local labor market.

Another interpretation issue to consider is whether increases in worker labor inputs result from hiring or from shift changes among unskilled labor in the existing workforce. Again, data limitations in the firm-level panel preclude a direct test. However, total blackout exposure reported by each firm owner during the panel does not predict the changes in employment seen between February 2014 and March and April 2015, limited but suggestive evidence that extensive margin labor may be less important in the short-term than intensive margin staffing changes.[19] This preliminary conclusion is also consistent with evidence from **?** that small firms in Ghanaian artisan manufacturing are labor constrained.

Finally, although the data includes no direct information on capital utilization by firm owners and skilled and unskilled workers, evidence from Table 1 on available production technologies shows that the vast majority of firms with and without workers have access to manual sewing machines that can

[18]We thank two anonymous referees for this insight.
[19]See Appendix Table 8.

be used in the event of a blackout. Recall as well that all firms have access to the simplest production technology: sewing by hand using a needle and thread. This paper finds no evidence of changes in capital composition in response to outages,[20] but supposes rather naturally that firms of both types shift, at least partially, to (existing) functional manual production technologies when blackouts render electric sewing machines obsolete. Though this study is limited in its ability to directly describe differential changes in production processes in firms with workers, it shows that these firms are able to more flexibly shift labor inputs to cope with outages. As seen in Table 4, paired days with any blackout are associated with additional worker hours relative to paired days with lights. Firms owners in firms with workers also significantly increase their own hours on days with electricity following a blackout day, suggestive evidence of potentially complex dynamic shifts in production processes and in the matching between capital inputs and labor inputs in firms with workers.

6 Conclusion

Unreliable power supplies are a well-known obstacle to doing business across much of the developing world, yet surprisingly little is known about how frequent blackouts affect firms of different sizes, or workers of different skill levels. Previous analyses have focused on larger firms and capital-based coping strategies, uncovering interesting patterns using annual data, but leaving a space in the literature to explore how outages impact microenterprises which comprise the overwhelming majority of firms in low-income countries and are a vital source of employment and income for poor and vulnerable households. This study begins to fill that gap by using high-frequency blackout, profit, and labor input data to estimate the effects of blackouts on microenterprises.

The analysis finds that single-person firms experience large reductions in revenues and profits, but fails to reject no effect of outages on the revenues and profits of firms with employees. Turning to labor-based coping strategies, the study documents that one-person firm owners reduce their labor supply in response to outages. Firms with employees adjust labor in several ways, increasing worker labor hours on blackout days, increasing firm owner labor hours on days on which lights are restored, and decreasing dramatically total wages paid. Leveraging descriptive evidence on the composition of the workforce in the garment making industry in Ghana, this paper argues that firms employing unskilled workers drive the observed increases in worker labor hours while firms employing skilled workers drive the observed decreases in wages paid.

Taken together, these findings suggest that the economic costs of blackouts fall most heavily on single-person firm owners, who experience large reductions in their effective wage, and on skilled workers, who experience large reductions in earnings. More detailed analysis of the distributional consequences of

[20] Appendix Table 8 estimates changes in capital from June 2014 to June 2015 using the retrospective follow-up data and fails to reject no effect on capital or capital composition. Point estimates are very near zero for both one-person firms and firms with workers.

unreliable power supplies are left to future research. Finally, consistent with earlier evidence from **?**, the findings of this paper suggest that policies and programs designed to promote entrepreneurship and support microenterprise development (e.g. microfinance, management training) may be less effective in the likely presence of constant rolling blackouts.

Table 1: **2014 Summary Statistics by 2015 Firm Type**

Panel A variables were collected during the February 2014 census. Panel B variables were collected during the summer 2014 baseline survey. Panel C variables were collected retrospectively, during a June 2015 follow-up survey. The sample is split into "one-person" and "has workers" firms using information from the weekly panel data collected in March and April 2015, consistent with the remainder of the analysis. *** p<0.01, ** p<0.05, * p<0.1.

	Full Sample	One-Person	Has Workers	Diff	
	mean	*mean*	*mean*	*diff*	*p-val*
Panel A: Source - Census					
Male	0.26	0.26	0.26	0.00	0.98
Years of schooling	8.90	8.91	8.89	0.02	0.95
Owner age	35.67	35.95	35.31	0.64	0.52
Firm age	9.66	9.21	10.24	-1.03	0.26
Has any worker(s) besides owner	0.49	0.25	0.79	-0.54	0.00***
Firm size (including owner)	2.12	1.40	3.04	-1.64	0.00***
Revenues Last Month (GHC)	215	149.77	290.50	-140.74	0.00***
Profits Last Month (GHC)	151	106.92	203.22	-96.30	0.00***
Registered w/any govt agency	0.19	0.11	0.29	-0.18	0.00***
Trade association member	0.24	0.15	0.35	-0.19	0.00***
Panel B: Source - Baseline					
Ewe ethnicity	0.77	0.79	0.75	0.03	0.44
Ravens	5.73	5.52	5.96	-0.44	0.14
Management practices (of 5)	2.57	2.34	2.84	-0.49	0.00***
Assets excl land/building (GHC)	1349	999.39	1756.38	-756.99	0.00***
Panel C: Source - Retrospective Follow-up					
Has Manual Sewing Machine	0.86	0.86	0.86	-0.00	0.92
# Manual Sewing Machines	1.57	1.23	1.93	-0.69	0.00***
Has Electric Sewing Machine	0.43	0.40	0.45	-0.05	0.35
# Electric Sewing Machines	0.57	0.48	0.68	-0.20	0.04***
Has Any Electric Machine	0.82	0.75	0.88	-0.13	0.00***
# Any Electric Machine	1.74	1.40	2.10	-0.70	0.00***
Has Generator	0.03	0.01	0.04	-0.03	0.13
Number of Firms	342	184	158		

Source: Author calculations from The Hohoe Garment Makers Project Data

Table 2: **The Effect of Blackouts on Weekly Sales, Profits, and Expenses**

All specifications include time fixed effects, firm fixed effects, and a vector of dummies indicating the number of days (of 5) for which a response about blackout status was reported by the firm owner. Standard errors are clustered at the neighborhood level. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Revenues (GhC)	(2) Profits (GhC)	(3) Expenses (GhC)
Panel A: One-Person Firms			
# Blackout days reported (out of 5 days)	-4.40***	-4.15***	-0.25
	(1.24)	(1.27)	(0.39)
Outcome Variable Average	44.74	31.42	13.32
Observations	1,265	1,265	1,265
Panel B: Firms With Workers			
# Blackout days reported (out of 5 days)	0.76	2.07	-1.31
	(2.33)	(2.09)	(1.35)
Outcome Variable Average	77.75	48.71	29.04
Observations	1,097	1,097	1,097

Source: Author calculations from The Hohoe Garment Makers Project Data

Table 3: **The Effect of Blackouts on Owner Labor and Wages (Profit/Hour)**

All specifications include time fixed effects, firm fixed effects, and a vector of dummies indicating the number of days (of 5) for which a response about blackout status was reported by the firm owner. Standard errors are clustered at the neighborhood level. *** p<0.01, ** p<0.05, * p<0.1.

	(1) # Days Worked	(2) Total Hours Worked	(3) Profits/Hours (GhC)
Panel A: One-Person Firms			
# Blackout days reported (out of 5 days)	-0.10	-1.33**	-0.17**
	(0.06)	(0.60)	(0.06)
Outcome Variable Average	3.20	27.12	1.05
Observations	1,265	1,265	1,010
Panel B: Firms With Workers			
# Blackout days reported (out of 5 days)	0.02	0.11	0.08
	(0.05)	(0.47)	(0.06)
Outcome Variable Average	4.01	36.84	1.33
Observations	1,097	1,097	1,010

Source: Author calculations from The Hohoe Garment Makers Project Data

Table 4: **The Dynamic Effect of Blackouts Owner and Worker Labor**

All specifications include time fixed effects and firm fixed effects. Day pairs for which one or both blackout responses are missing are dropped. Standard errors are clustered at the neighborhood level. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Owner Worked	(2) Owner Hours	(3) # Workers	(4) Worker Hours
Panel A: One-Person Firms				
Blackout Today Only	-0.04**	-0.59***	x	x
	(0.02)	(0.16)	x	x
Lagged Blackout Only	-0.01	-0.12	x	x
	(0.01)	(0.15)	x	x
Blackout Both Today and Lagged	-0.08***	-0.89***	x	x
	(0.03)	(0.24)	x	x
Outcome Variable Average	0.68	5.80	x	x
Observations	5,226	5,226	x	x
Panel B: Firms With Workers				
Blackout Today Only	-0.01	-0.20	0.07**	0.72*
	(0.02)	(0.17)	(0.03)	(0.36)
Lagged Blackout Only	0.04***	0.35***	0.09***	0.98**
	(0.01)	(0.11)	(0.03)	(0.37)
Blackout Both Today and Lagged	-0.03	-0.39*	0.08**	0.73*
	(0.03)	(0.21)	(0.04)	(0.40)
Outcome Variable Average	0.84	7.76	1.67	15.52
Observations	4,711	4,711	4,711	4,711

Source: Author calculations from The Hohoe Garment Makers Project Data

Table 5: **The Effect of Blackouts on Worker Labor and Wages**

All specifications include time fixed effects, firm fixed effects, and a vector of dummies indicating the number of days (of 5) for which a response about blackout status was reported by the firm owner. Standard errors are clustered at the neighborhood level. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Any Worker Present	(2) Total Worker Days	(3) Total Worker Hours	(4) Wages/ Worker Hours (GhC)
Firms With Workers, Only				
# Blackout days reported (out of 5 days)	0.03***	0.32***	3.13***	-0.02
	(0.01)	(0.10)	(0.96)	(0.02)
Outcome Variable Average	0.84	8.32	77.51	0.10
Observations	1,097	1,097	1,097	917

Source: Author calculations from The Hohoe Garment Makers Project Data

Table 6: **The Effect of Blackouts on Expenses by Category**

All specifications include time fixed effects, firm fixed effects, and a vector of dummies indicating the number of days (of 5) for which a response about blackout status was reported by the firm owner. Standard errors are clustered at the neighborhood level. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Wages (GhC)	(2) Inputs (GhC)	(3) Outsourcing (GhC)
Panel A: One-Person Firms			
# Blackout days reported (out of 7 days)	x	-0.43	0.18
	x	(0.50)	(0.24)
Outcome Variable Average	0.00	10.75	2.57
Observations	1,265	1,265	1,265
Panel B: Firms With Workers			
# Blackout days reported (out of 7 days)	-1.29**	0.61	-0.62
	(0.56)	(0.77)	(0.40)
Outcome Variable Average	5.80	17.68	5.60
Observations	1,097	1,097	1,097

Source: Author calculations from The Hohoe Garment Makers Project Data

A Appendix

A.1 Sample Selection

Appendix Tables 1 and 2 explore sample selection into the main analysis sample. Appendix Table 1 compares baseline firm characteristics between the full February 2014 census sample and the sample of firms surviving to the March/April 2015 panel survey. The study finds few observable predictors of survivorship, with the exception that older firms owners and older firms are less likely to exit. Appendix Table 2 compares baseline firm characteristics between all survivors and those survivors with electricity access (the analysis sample). Firms with access to electricity are, unsurprisingly, larger, more formal, and more likely to be owned by a man. The findings should be interpreted with this sample selection in mind.

Appendix Figure 1 plots the location of firms by firm type (with and without workers). Both types are observed throughout the geospatial distribution of firm location in the sample.

A.2 Five Day Workweek

Appendix Figure 2 presents owner (and total business) hours by date. As the figure shows, in this area of Ghana, businesses very rarely open on Sundays. Only a small fraction of observed Saturdays include any positive business hours, and typically in these cases only the owner works for a fraction of the day on Saturday. For this reason, the study includes only weekdays (Monday through Friday) in the main specifications. Including weekends adds noise, as business is not normally conducted during the weekends. All results using the full seven day period are shown in Appendix Tables 3 through 7, producing findings qualitatively robust to this decision.

A.3 Blackouts

A.3.1 Variation in Self Reported Blackout Data

Appendix Figure 3 presents average self-reported exposure to blackouts by date for the samples of firms with and without workers. The analysis finds no difference in blackout propensity by firm type, though there are large differences in blackout propensity over time. Ghanaian Independence Day (March 6th, 2015) and Easter (April 6th, 2015) are both associated with lower than average blackout self-reports, suggesting that Electricity Commission of Ghana (ECG) service delivery varied systematically over time.[1] The specifications control for endogeneity of this type by including time fixed effects in all specifications.

In addition to endogeneity over time, the study also finds that some firm owners in the sample reported more frequent outages than others. For example, better educated firm owners and older firms report

[1]For example, the authors and the research team can attest that power was nearly universally available on February 8th, 2015, when Ghana played Ivory Coast in the African Cup of Nations final.

slightly fewer blackouts. However, using the set of baseline characteristics in Table 1 to predict total reported blackouts generates an F-stat of 0.1469, indicating that taken together these characteristics do not jointly predict blackout exposure. Given the spatial component of power delivery and the fact that these firms are too politically inconsequential to be directly targeted by ECG service delivery targeting, perhaps the most important cross-sectional predictor of blackouts is geospatial variation. Appendix Figure 4 plots percentiles of outage exposure across the physical space of the sample, uncovering greater blackout exposure for firms located farther from the central market area of town.[2] This cross-sectional exposure pattern is consistent with lower quality grid lines and transformer connections in more rural parts of town as well as with weaker and more unstable voltage further out in the network.[3] To control for this remaining cross-sectional endogeneity, all specifications include firm fixed effects.

The remaining variation is idiosyncratic to the firm and controls for both market-wide date-specific endogeneity and time-invariant observable and unobservable firm characteristics that may be related to both blackout propensity and outcomes of interest.

A.3.2 Official Load Shedding Schedules

ECG publicly released official load shedding schedules through March 6th, 2015, only seven weekdays into the 55 day panel data collection, and due to rolling entry into the weekly survey sample, only three weekdays into the portion of the panel data collection period that includes all firms in the sample. Appendix Figure 5 displays the load shedding schedule for February 6th, 2015 through March 6th, 2015 (Hohoe is Block A). Though the exercise is limited by the limited availability of this official load shedding schedule, it is possible check whether a large(r) fraction of the sample reported a blackout on days marked as load shedding or standby than on the average day. From February 26th, 2015 (the first date covered by the data collection) to March 6th, 2015, an average of 36% of firms report a blackout on a given day. On the three days marked load shedding in this schedule, 33% of reporting firms reported a blackout. On the three days marked standby, 47% of reporting firms reported a blackout. These figures are underwhelming, and consistent with observations by the authors and the research team that by this period of the Dumsor crisis, the load shedding schedules were quite unreliable.

A.3.3 Unofficial Ex-Post Load Shedding Data

The research team was also able to obtain unofficial ex-post load shedding records for the Hohoe substation for 75% of the 55 day panel data collection period, including the first nine days covered by the public-release load shedding schedules. During this time, Dumsor was extremely politically sensitive, so the access to these records is only a function of a personal connection, and these records were never released to the public. Comparing the ex-post schedules to the public-release load shedding schedules

[2] For privacy reasons, random noise has been added to the gps coordinate values.

[3] A more detailed discussion of the technical foundations of this type of idiosyncratic variation can be found in **?** and **?**.

for the nine-day overlap, it can be seen that the ex-post records indicate daytime load shedding only on March 2nd, a date listed in the official load shedding schedules as standy. 48% of the sample reported experiencing a blackout on the 2nd. Unfortunately, the unofficial records appear also to be not particularly reliable.

A.3.4 Mismatch Between Self-Reports and Government Records

The final and most important source of mismatch between the government records (both the public-release logs and the unofficial ex-post records) and the self-reported data is that the ECG schedules and records block together all firms in the sample under the Hohoe substation as a single service area. The authors, the research team, and the firm owners in the sample can attest from experience that variation across firms within a day was the norm. It was not uncommon during the period of the panel data collection to experience an outage and observe (non-generator) lights on directly across the street or in a neighbor's shop.

Regressing the self-reports on the official schedules yields at R-squared of 0.03. Regressing the self-reports on the ex-post records yields an R-squared of 0.08. Ultimately, neither government source does a competent job of predicting the self-reported data, and the paper relies on blackout self-reports and idiosyncratic variation that remains after controlling for time and firm fixed effects.

A.4 Annual Input Adjustments

Throughout the paper, firms with and without workers are defined using a measure contemporaneous to the main analysis data collection because the labor information in the baseline data (from the February 2014 census) occurs more than a year before the weekly monitoring surveys that make up the bulk of the analysis. Looking just at the descriptive statistics, normal churn in the labor market results in 25% of firms with employees in February 2014 reporting no worker activity during any of the seven weeks of the panel data collection and 20% of firms without employees in February 2014 reporting positive worker hours for at least one of the seven weeks in the panel. Though one of the key strengths of the data is its high-frequency, the descriptive annual labor adjustment estimate presented in Appendix Table 8 allows us to compare the setting more directly to the analyses in the existing literature on the coping strategies of firms experiencing frequent outages. The reader should note that the measurement of labor was quite different in February 2014, which simply asked how many workers of each type a firm employed and in the March and April 2015 panel, which asked about daily worker hours enumerated by worker. An additional caution to the reader: the measure of number of workers in the panel data is the maximum number of workers observed in any of the seven weeks of the panel, as the data do not individually identify workers.

Similarly, the literature to date has focused more directly on capital-based coping strategies, which are longer-term coping mechanisms abstracted from in the primary high-frequency analysis in this paper. In addition, Table 1 of the paper shows that the vast majority of firms with and without workers in the sample have access to manual sewing machines and thus can shift production in the short term to the extent that labor is available to pair with manual machinery. Still, the descriptive annual capital adjustment estimate in Appendix Table 8 likewise allows us to compare the setting more directly to the analyses in the existing literature.

Estimates of annual adjustments in labor and capital as predicted by number of self-reported blackouts use the following ANCOVA specification:

$$Y_{2015,i} = \beta_0 + \beta_1 * \#b_i + \beta_2 * \#r_i + \beta_3 * Y_{2014,i} + \epsilon_{it} \tag{3}$$

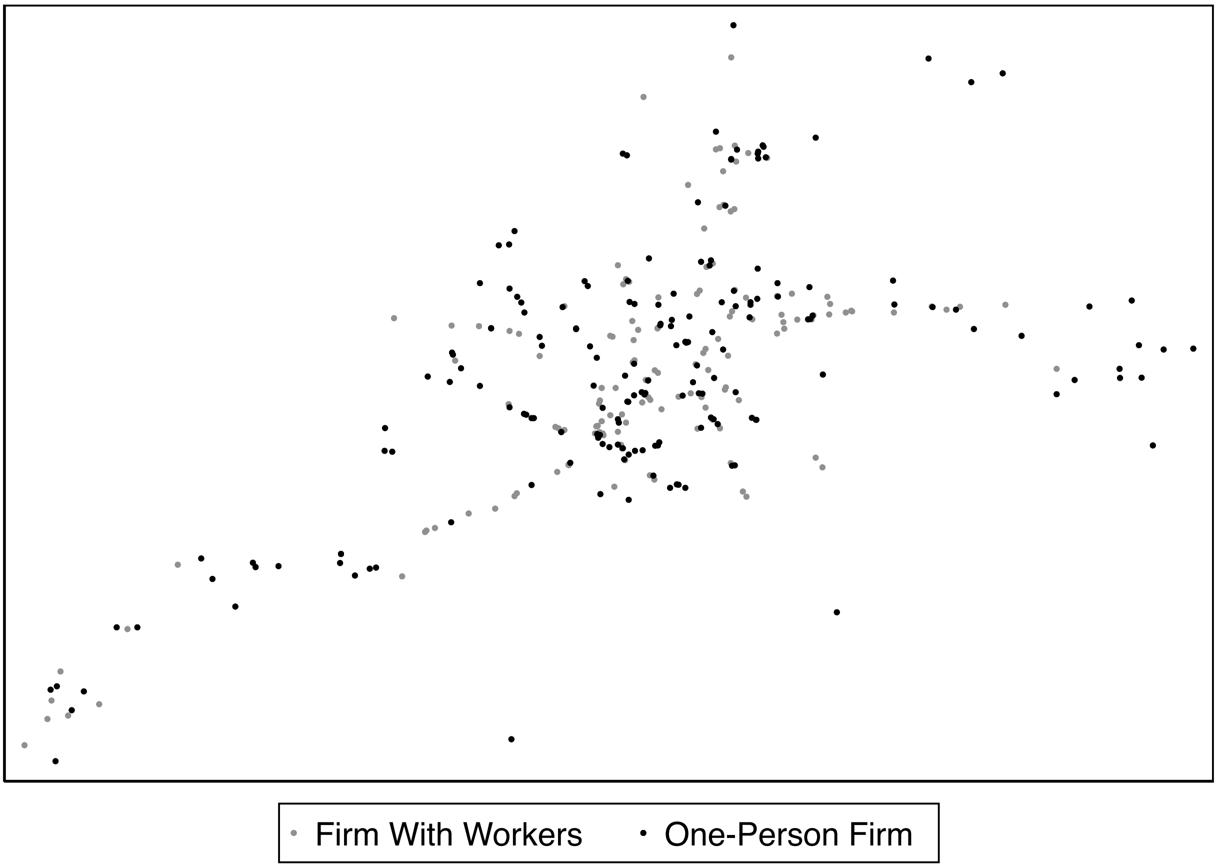
where $\#b_i$ is the number of blackouts (of a possible 49 days) reported by firm owner i during the seven week panel, $\#r_i$ is a the number of days for which a response about blackout status is recorded for firm i (again, of a possible 49), and $Y_{2014,i}$ is the baseline value of the outcome variable.[4] As in all the main specifications, errors are clustered at the neighborhood level. The identifying assumption in this specification is that conditional on the baseline value of the outcome variable and the overall number of days reporting, the number of blackouts reported is orthogonal to the error term.

The analysis finds no significant relationship between the number of blackouts reported in total over the panel data collection period and worker or machine composition. Though this is limited to two measures during the 2012-2015 crisis, the capital results are suggestive evidence that at least over this period, neither one-person firms nor firms with workers made lumpy capital investments or disinvestments.

[4]The baseline values of the labor outcome variables are missing for 22 firms in the February 2014 census due to surveyor error. These values are replaced with zeros and controlled for using an indicator equal to one for all firms missing this data in Columns 1 and 2 of Appendix Table 8.

Figure A.1: **Geospatial Firm Type**

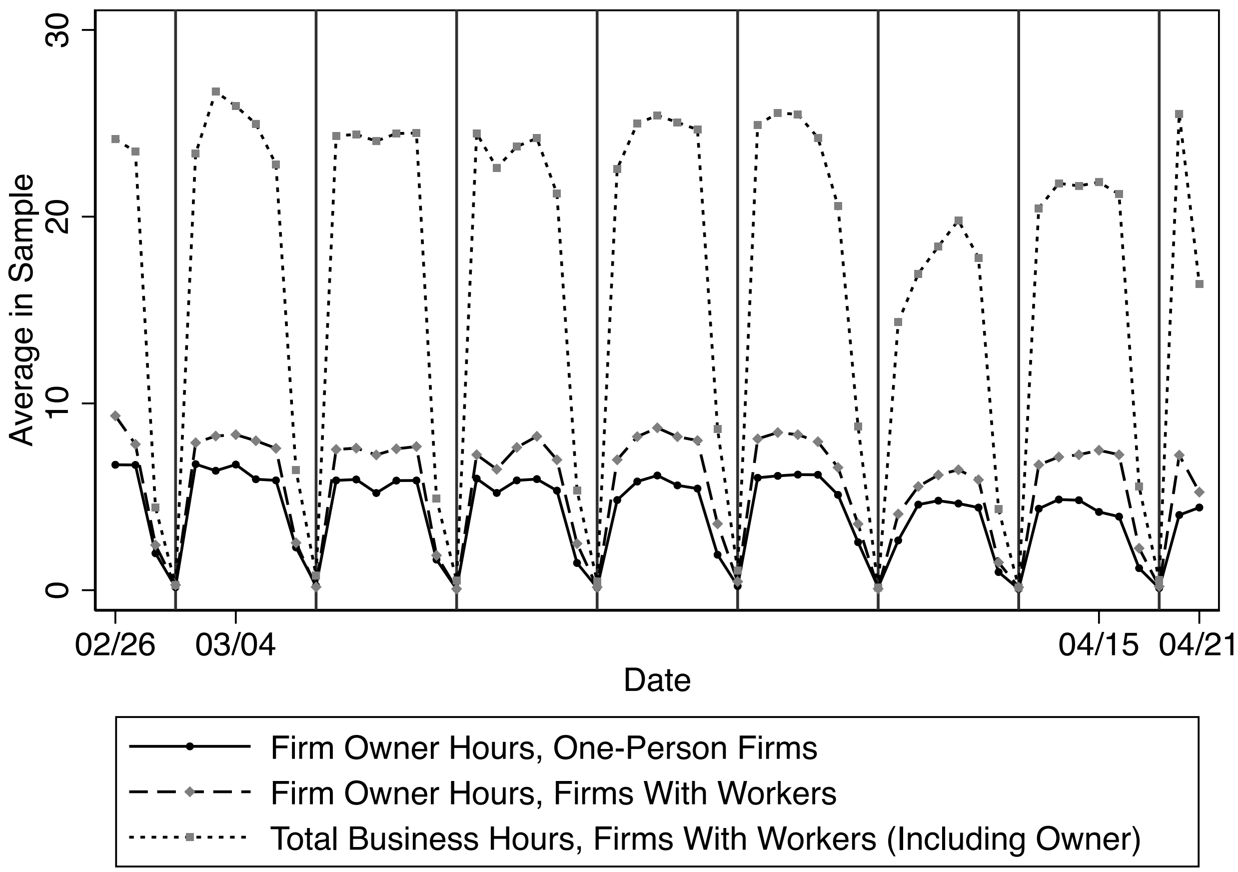
This figure depicts geospatial firm location by firm type (one-person vs. with workers). For privacy reasons, coordinate values have been slightly adjusted and axis labels have been removed.



Source: Author calculations from The Hohoe Garment Makers Project Data

Figure A.2: **Labor Hours Over Time**

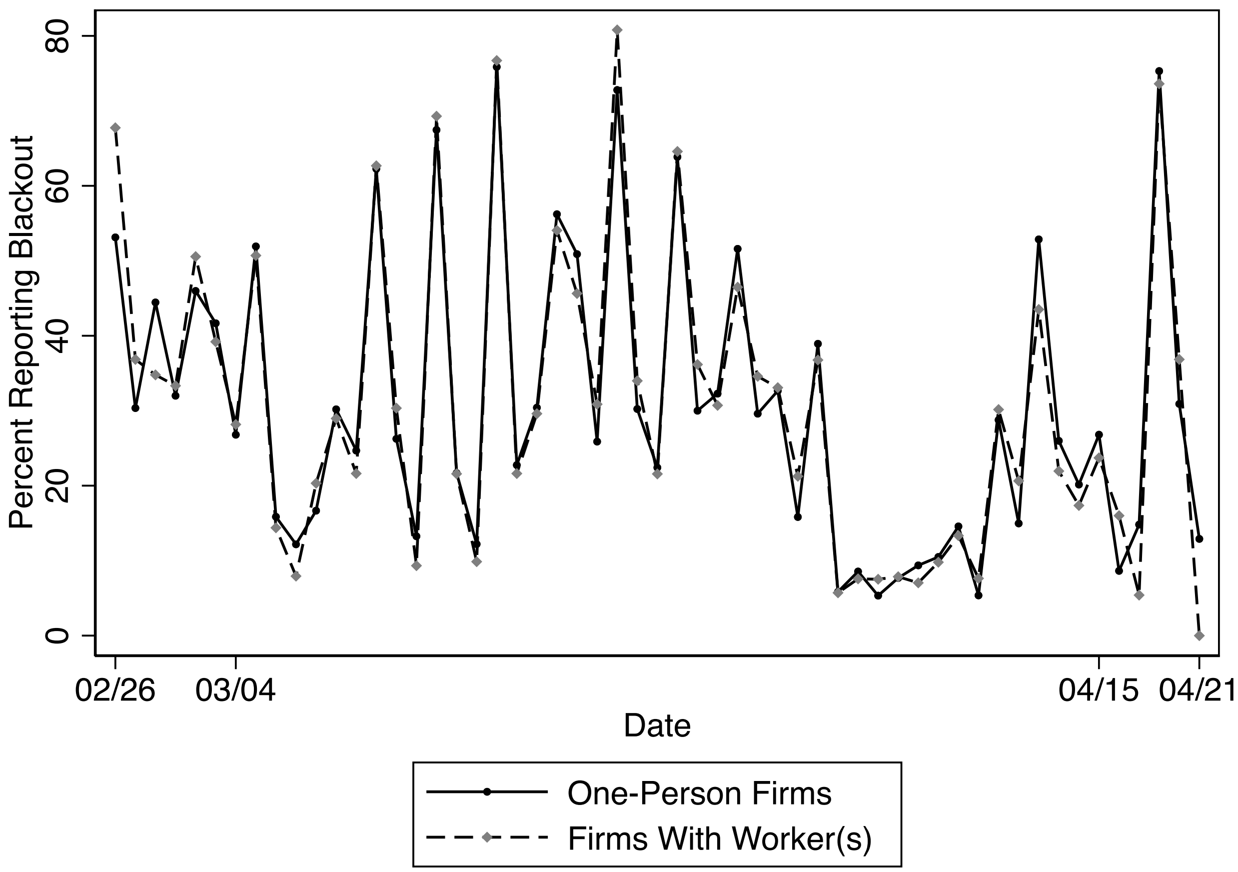
This figure depicts sample average firm owner daily hours (and all labor daily hours for firms with workers) by date from February 26, 2015 to April 21, 2015. Due to the rolling nature of data collection, sample sizes decrease daily before March 4, 2015, and after April 15, 2015. Vertical lines mark Sundays.



Source: Author calculations from The Hohoe Garment Makers Project Data

Figure A.3: **Blackouts Over Time**

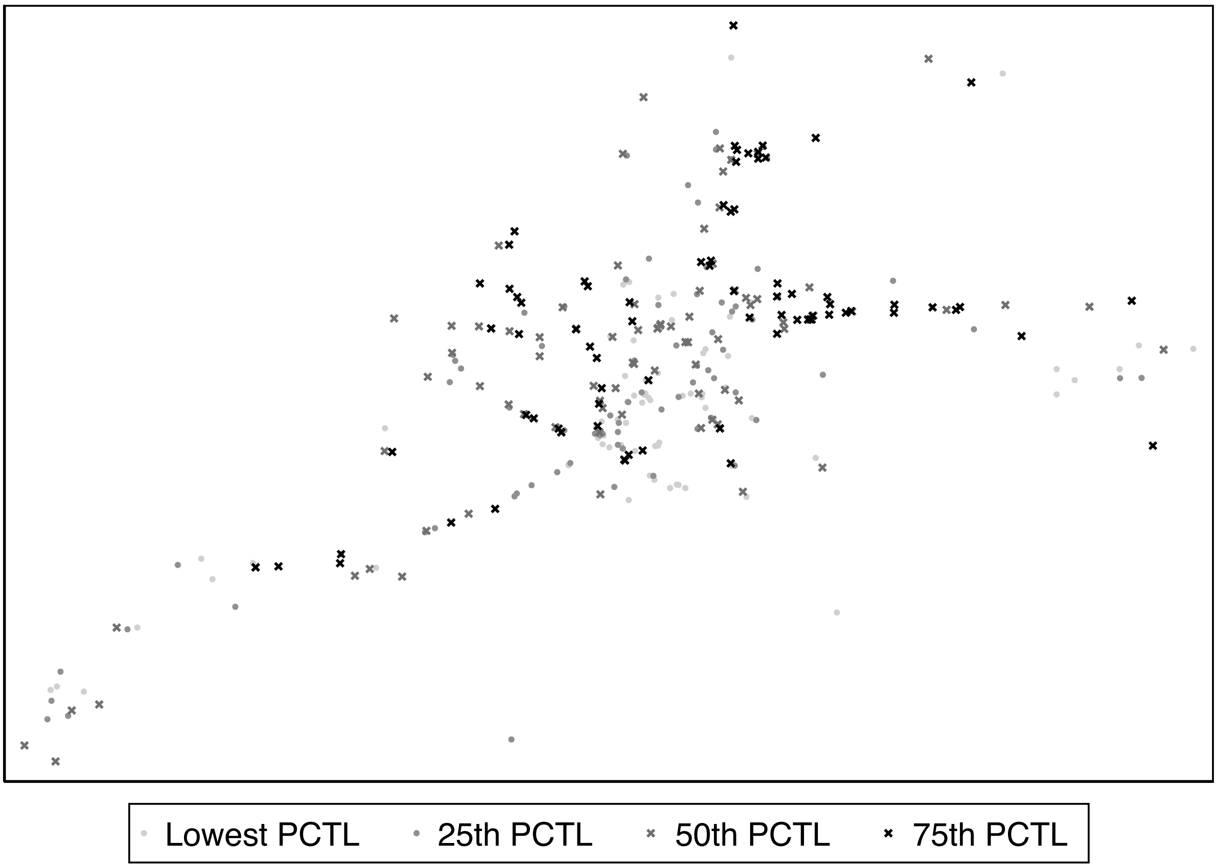
This figure depicts the fraction of firm owners reporting a blackout by date from February 26, 2015 to April 21, 2015. Due to the rolling nature of data collection, sample sizes decrease daily before March 4, 2015, and after April 15, 2015.



Source: Author calculations from The Hohoe Garment Makers Project Data

Figure A.4: **Geospatial Exposure to Blackouts**

This figure depicts blackout exposure by firm location. The figure indicates a pattern in which extreme blackout exposure is reduced toward the center of town (center of the grid). For privacy reasons, coordinate values have been slightly adjusted and axis labels have been removed.



Source: Author calculations from The Hohoe Garment Makers Project Data

Figure A.5: **Last-Released Official Load Shedding Schedule**

Hohoe is Block A. A non-bracketed A signifies that Hohoe was scheduled for load shedding in that time slot. A bracketed A signifies that Hohoe was on load shedding standby for that time slot. The absence of an A in a cell signifies that Hohoe was scheduled to have lights on during that time slot. the primary self-reported blackout data begins on February 26th for the first batch of firms with rolling entry into the weekly firm-level panel dataset. The ex-post unofficial government logs begin also begin on February 26th, 2015.

LOAD-SHEDDING GUIDE

The Electricity Company of Ghana wishes to inform its cherished customers that due to generation shortfall it has become necessary to publish this load shedding guide.

All Communities in the bracket are on loadshedding, but all or some may not go off depending on the quantum of power to be shed.

	FRIDAY 06/02/2015	SATURDAY 07/02/2015	SUNDAY 08/02/2015	MONDAY 09/02/2015	TUESDAY 10/02/2015	WEDNESDAY 11/01/2015	THURSDAY 12/02/2015
DAY 6AM TO 7PM	B; (A)	C; (B)	A; (C)	B; (A)	C; (B)	A; (C)	B; (A)
NIGHT 6PM TO 6AM	A; (C)	B; (A)	C; (B)	A; (C)	B; (A)	C; (B)	A; (C)
	FRIDAY 13/02/2015	**SATURDAY 14/02/2015**	**SUNDAY 15/02/2015**	**MONDAY 16/02/2015**	**TUESDAY 17/02/2015**	**WEDNESDAY 18/01/2015**	**THURSDAY 19/02/2015**
DAY 6AM TO 7PM	C; (B)	A; (C)	B; (A)	C; (B)	A; (C)	B; (A)	C; (B)
NIGHT 6PM TO 6AM	B; (A)	C; (B)	A; (C)	B; (A)	C; (B)	A; (C)	B; (A)
	FRIDAY 20/02/2015	**SATURDAY 21/02/2015**	**SUNDAY 22/02/2015**	**MONDAY 23/02/2015**	**TUESDAY 24/02/2015**	**WEDNESDAY 25/01/2015**	**THURSDAY 26/02/2015**
DAY 6AM TO 7PM	A; (C)	B; (A)	C; (B)	A; (C)	B; (A)	C; (B)	A; (C)
NIGHT 6PM TO 6AM	C; (B)	A; (C)	B; (A)	C; (B)	A; (C)	B; (A)	C; (B)
	FRIDAY 27/02/2015	**SATURDAY 28/02/2015**	**SUNDAY 01/03/2015**	**MONDAY 02/03/2015**	**TUESDAY 03/03/2015**	**WEDNESDAY 04/03/2015**	**THURSDAY 05/03/2015**
DAY 6AM TO 7PM	B; (A)	C; (B)	A; (C)	B; (A)	C; (B)	A; (C)	B; (A)
NIGHT 6PM TO 6AM	A; (C)	B; (A)	C; (B)	A; (C)	B; (A)	C; (B)	A; (C)
	FRIDAY 06/03/2015						
DAY 6AM TO 7PM	C; (B)						
NIGHT 6PM TO 6AM	B; (A)						

Source: Downloaded by authors from the Electronic Commission of Ghana website during the crisis of 2015

Table A.1: **2014 Summary Statistics by 2015 Firm Exit**

Panel A variables were collected during the February 2014 Census. Panel B variables were collected during the summer 2014 Baseline. *** p<0.01, ** p<0.05, * p<0.1.

	All Firms	Exits	Remain	Diff	
	mean	*mean*	*mean*	*diff*	*p-val*
Panel A: Source - Census					
Male	0.22	0.13	0.23	-0.09	0.26
Years of schooling	8.86	8.93	8.85	0.08	0.85
Owner age	35.25	31.41	35.53	-4.12	0.02**
Firm age	9.24	5.86	9.49	-3.62	0.02**
Has any worker(s) besides owner	0.43	0.34	0.44	-0.10	0.31
Firm size (including owner)	1.98	1.93	1.98	-0.05	0.88
Revenues Last Month (GHC)	194	157	196	-39	0.34
Profits Last Month (GHC)	136	113	138	-25	0.40
Registered w/any govt agency	0.16	.07	.17	-0.10	0.17
Trade association member	0.21	0.10	0.22	-0.11	0.15
Panel B: Source - Baseline					
Ewe ethnicity	0.76	0.76	0.76	0.00	0.99
Ravens	5.63	5.66	5.63	0.03	0.96
Management practices (of 5)	2.54	2.55	2.54	0.02	0.95
Assets excl land/building (GHC)	1186	904	1206	-302	0.34
Number of Firms	445	29	416		

Source: Author calculations from The Hohoe Garment Makers Project Data

Table A.2: **2014 Summary Statistics by 2015 Electricity Access**

Panel A variables were collected during the February 2014 Census. Panel B variables were collected during the summer 2014 Baseline. Panel C variables were collected, retrospectively, during a June 2015 follow-up survey. *** p<0.01, ** p<0.05, * p<0.1.

	All Remain	No Access	Access (Sample)	Diff	
	mean	*mean*	*mean*	*diff*	*p-val*
Panel A: Source - Census					
Male	0.23	0.08	0.26	-0.18	0.00***
Years of schooling	8.85	8.65	8.90	-0.25	0.40
Owner age	35.53	34.93	35.67	-0.73	0.54
Firm age	9.49	8.72	9.66	-0.95	0.37
Has any worker(s) besides owner	0.44	0.23	0.49	-0.26	0.00***
Firm size (including owner)	1.98	1.38	2.12	-0.74	0.00***
Revenues Last Month (GHC)	196	112	215	-103	0.00***
Profits Last Month (GHC)	138	75	151	-77	0.00***
Registered w/any govt agency	0.17	0.05	0.19	-0.14	0.00***
Trade association member	0.22	0.11	0.24	-0.13	0.01**
Panel B: Source - Baseline					
Ewe ethnicity	0.76	0.69	0.77	-0.08	0.13
Ravens	5.63	5.19	5.73	-0.54	0.11
Management practices (of 5)	2.54	2.38	2.57	-0.19	0.21
Assets excl land/building (GHC)	1206	544	1349	-805	0.00***
Panel C: Source - Retrospective Follow-up					
Has Manual Sewing Machine	0.88	0.97	0.86	0.11	0.01***
# Manual Sewing Machines	1.57	1.57	1.57	-0.00	0.97
Has Electric Sewing Machine	0.38	0.15	0.43	-0.28	0.00***
# Electric Sewing Machines	0.50	0.16	0.57	-0.41	0.00***
Has Any Electric Machine	0.72	0.29	0.82	-0.53	0.00***
# Any Electric Machine	1.49	0.38	1.74	-1.36	0.00***
Has Generator	0.02	0.01	0.03	-0.01	0.58
Number of Firms	416	74	342		

Source: Author calculations from The Hohoe Garment Makers Project Data

Table A.3: **The Effect of Blackouts on Weekly Sales, Profits, and Expenses - 7 Days**

All specifications include time fixed effects, firm fixed effects, and a vector of dummies indicating the number of days (of 7) for which a response about blackout status was reported by the firm owner. Standard errors are clustered at the neighborhood level. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Revenues (GhC)	(2) Profits (GhC)	(3) Expenses (GhC)
Panel A: One-Person Firms			
# Blackout days reported (out of 7 days)	-4.45**	-4.11**	-0.34
	(1.64)	(1.49)	(0.32)
Outcome Variable Average	44.74	31.42	13.32
Observations	1,265	1,265	1,265
Panel B: Firms With Workers			
# Blackout days reported (out of 7 days)	0.16	0.32	-0.16
	(1.75)	(1.81)	(0.86)
Outcome Variable Average	77.75	48.71	29.04
Observations	1,097	1,097	1,097

Source: Author calculations from The Hohoe Garment Makers Project Data

Table A.4: **The Effect of Blackouts on Owner Labor and Wages (Profit/Hour) - 7 Days**

All specifications include time fixed effects, firm fixed effects, and a vector of dummies indicating the number of days (of 7) for which a response about blackout status was reported by the firm owner. Standard errors are clustered at the neighborhood level. *** p<0.01, ** p<0.05, * p<0.1.

	(1) # Days Worked	(2) Total Hours Worked	(3) Profits/Hours (GhC)
Panel A: One-Person Firms			
# Blackout days reported (out of 7 days)	-0.07	-0.90	-0.13**
	(0.07)	(0.64)	(0.05)
Outcome Variable Average	3.46	29.02	0.97
Observations	1,265	1,265	1,015
Panel B: Firms With Workers			
# Blackout days reported (out of 7 days)	0.03	0.25	0.04
	(0.04)	(0.40)	(0.04)
Outcome Variable Average	4.33	39.57	1.22
Observations	1,097	1,097	1,012

Source: Author calculations from The Hohoe Garment Makers Project Data

Table A.5: **The Dynamic Effect of Blackouts Owner and Worker Labor - 7 Days**

All specifications include time fixed effects and firm fixed effects. Day pairs for which one or both blackout responses are missing are dropped. Standard errors are clustered at the neighborhood level. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Owner Worked	(2) Owner Hours	(3) # Workers	(4) Worker Hours
Panel A: One-Person Firms				
Blackout Today Only	-0.04**	-0.46***	x	x
	(0.01)	(0.13)	x	x
Lagged Blackout Only	0.00	0.02	x	x
	(0.01)	(0.07)	x	x
Blackout Both Today and Lagged	-0.05**	-0.65***	x	x
	(0.02)	(0.20)	x	x
Outcome Variable Average	0.53	4.43	x	x
Observations	7,329	7,329	x	x
Panel B: Firms With Workers				
Blackout Today Only	-0.01	-0.18	0.04	0.47
	(0.01)	(0.13)	(0.04)	(0.37)
Lagged Blackout Only	0.03***	0.28**	0.05	0.51
	(0.01)	(0.10)	(0.03)	(0.36)
Blackout Both Today and Lagged	-0.03	-0.32	0.06	0.47
	(0.02)	(0.20)	(0.05)	(0.53)
Outcome Variable Average	0.65	6.00	1.25	11.67
Observations	6,477	6,477	6,477	6,477

Source: Author calculations from The Hohoe Garment Makers Project Data

Table A.6: **The Effect of Blackouts on Worker Labor and Wages - 7 Days**

All specifications include time fixed effects, firm fixed effects, and a vector of dummies indicating the number of days (of 7) for which a response about blackout status was reported by the firm owner. Standard errors are clustered at the neighborhood level. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Any Worker Present	(2) Total Worker Days	(3) Total Worker Hours	(4) Wages/ Worker Hours (GhC)
Firms With Workers, Only				
# Blackout days reported (out of 7 days)	0.02	0.29**	2.92**	-0.01
	(0.01)	(0.11)	(1.30)	(0.01)
Outcome Variable Average	0.84	8.75	81.51	0.09
Observations	1,097	1,097	1,097	919

Source: Author calculations from The Hohoe Garment Makers Project Data

Table A.7: **The Effect of Blackouts on Expenses by Category - 7 Days**

All specifications include time fixed effects, firm fixed effects, and a vector of dummies indicating the number of days (of 7) for which a response about blackout status was reported by the firm owner. Standard errors are clustered at the neighborhood level. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Wages (GhC)	(2) Inputs (GhC)	(3) Outsourcing (GhC)
Panel A: One-Person Firms			
# Blackout days reported (out of 7 days)	x	-0.42	0.08
	x	(0.43)	(0.22)
Outcome Variable Average	0.00	10.75	2.57
Observations	1,265	1,265	1,265
Panel B: Firms With Workers			
# Blackout days reported (out of 7 days)	-0.82**	0.67	-0.01
	(0.36)	(0.54)	(0.41)
Outcome Variable Average	5.80	17.68	5.60
Observations	1,097	1,097	1,097

Source: Author calculations from The Hohoe Garment Makers Project Data

Table A.8: **Yearly Shifts in Workers and Equipment as Predicted by Blackouts**

All specifications control for number of responses given (out of 49 days) and dummies indicating missing values for 2014 data. Where 2014 data are missing, the value is set to 0. Standard errors are clustered at the neighborhood level. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Has Workers	(2) # Workers	(3) Has Manual Sewing	(4) # Manual Sewing Machine	(5) Has Electric Sewing	(6) # Electric Sewing Machine	(7) Has Any Electric Machine	(8) # Any Electric Machine	(9) Has Generator
Panel A: One-Person Firms									
# Blackout days reported (out of 49 days)	0.00	0.00	-0.00	-0.03	0.01	0.00	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.00)
Outcome Variable in 2014	0.00	0.00	0.56***	0.37***	0.76***	0.80***	0.83***	0.76***	0.50
	(0.00)	(0.00)	(0.14)	(0.08)	(0.05)	(0.05)	(0.04)	(0.04)	(0.37)
Outcome Variable Average	0.00	0.00	0.79	1.04	0.36	0.41	0.66	1.22	0.01
Observations	184	184	162	162	162	162	162	162	162
Panel B: Firms With Workers									
# Blackout days reported (out of 49 days)	0.00	0.02	-0.01	-0.02	-0.00	-0.00	-0.00	-0.02	0.01
	(0.00)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)
Outcome Variable in 2014	0.00	1.88***	0.76***	0.90***	0.78***	0.95***	0.77***	0.96***	0.64**
	(0.00)	(0.20)	(0.10)	(0.07)	(0.09)	(0.03)	(0.12)	(0.02)	(0.27)
Outcome Variable Average	1.00	2.40	0.79	1.82	0.41	0.64	0.84	2.01	0.03
Observations	158	158	152	152	152	152	152	152	152

Source: Author calculations from The Hohoe Garment Makers Project Data