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Jobs, investments, and exporting: the real effects of electricity crises in South Africa

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Abstract: South Africa's grid remains unstable and characterized by frequent power cuts. Employing a generalized difference-in-difference approach, this paper examines the implications of South Africa's electricity crises on jobs, capital investment, and exporting across manufacturing firms in the country. Our results show robust evidence that the electricity crises have destroyed jobs, lowered capital investments, and upended export activities of manufacturing firms, with this adverse effect severe for firms with higher energy vulnerability intensity. Furthermore, we find that differing sources of firm heterogeneity vis-à-vis ownership structure, age, size, and financial status modulate the impact of electricity crises on firm performance. Overall, these results indicate that policies aimed to help firms cope with the impact of the electricity crises must take into consideration the unique differences across and between manufacturing firms.

Key words: electricity crises; electricity vulnerability; jobs; export; investment; manufacturing firms; South Africa

JEL classification: L60, O14, Q404

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Note: tables and figures at the end of the paper, after the reference list

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1 Introduction

South Africa's grid remains unstable and characterized by severe cuts mostly due to the underperformance of Eskom's (the country's public utility company) power plants that generate about 95 per cent of the country's electricity (Ndubuisi et al. 2024). Hence, the country has resulted to daily enforced power cuts to minimize the electricity supply-demand imbalance and avoid national blackouts.[1] Between 2007 and 2020, for instance, the number of power outages in a typical month reported by firms in the country grew by 88.3 per cent.[2] At the same time, the share of firms experiencing electrical outages in the country increased from 45 per cent in 2007 to 92 per cent in 2020.[3] Given the importance of electricity to economic activities and performance (Jorgenson 1984; Stern and Kander 2012), South Africa's ongoing electricity crises pose a significant threat to the competitiveness of firms in the country. Despite this, we know little about how firms in the country are affected by the ongoing electricity crisis. This paper fills this gap by examining how jobs, capital investments, and export activities of manufacturing firms are affected by the ongoing electricity crises in the country.

Theoretically, electricity crises can affect firm activities and performance in two ways: intensive and extensive margins (Mensah 2024). Regarding the intensive margin, it disrupts business operations and plans and forces existing firms to either operate using suboptimal approaches or reallocate resources to provide alternative sources of electricity. This leads to inefficiency and a higher cost of production as well as reallocation of investments and profits to adapt to the electricity constraint with resources that would otherwise have been used to enhance productivity and create new jobs and employ new workers (Xu et al. 2022). On the other hand, electricity crises generally distort confidence in the economy and lead to a general increase in the cost of doing business. As a result, new firms looking to invest in the economy will be hesitant to invest and delay their investments while incumbents may exit or fold due to the high cost of doing business (Xu et al. 2022). This lack of or limited entry of new businesses due to deferred or foregone investments coupled with the exit of incumbents affect investments and lead to job losses, low international competitiveness, and loss of new jobs that would have otherwise been created (extensive margin) (Mensah 2024; Ndubuisi et al. 2024).

While the preceding discussion indicates a negative effect of electricity crises on firm activities and performance, the impact of electricity crises may be heterogenous, varying across firms and sectors. For instance, Xu et al. (2022), Abeberese (2020), Moyo (2013), and Fisher-Vanden et al. (2015) suggest that energy-intensive industries respond differently to electricity outages and shortages and, as a result, have differential outcomes compared with non-energy intensive industries. Guo et al. (2023) found that the negative effect of power shortages on research and development (R&D) investments and productivity were much pronounced for small-sized, non-export-oriented, and private-owned firms in China. Falentina and Resosudarmo (2019) found a negative impact of blackouts on the labour productivity of small and medium-sized enterprises (SMEs) in Indonesia. Evidence from related literature also highlights that smaller firms, for instance, are often more vulnerable as they may lack the necessary capital to invest compared with larger firms (Beck et al. 2005; Cissokho 2019). Mensah (2024) finds that electricity outages have a

[1] See Ndubuisi et al. (2024) for a detailed discussion of South Africa's electricity sector, crises, and landscape.
[2] See World Bank, Enterprise Survey: https://data.worldbank.org/indicator/IC.ELC.OUTG?locations=ZA
[3] See World Bank, Enterprise Survey: https://data.worldbank.org/indicator/IC.ELC.OUTG.ZS?locations=ZA

negative effect on employment, sales per worker, and value added per worker in African countries, with the effect most prevalent in non-agricultural sectors, skilled jobs, and in the private sector.

Motivated by the preceding discussion, this paper considers the effects of electricity crises in South Africa on jobs, capital investments, and exports and how the observed relation varies by firm size, age, financial status, and foreign ownership structure. In this way, our study provides not only an impact assessment of the electricity crisis but also considers its distributional effect across different firm characteristics, which can help policymakers make informed decisions on how to prioritize firms when rolling out policies and initiatives that help firms cope with the crisis. To address our research objective, we combine firm-level panel data across 41 unique manufacturing subsectors from the South African Revenue Service and National Treasury (SARS-NT) with self-computed country-level indicators of electricity crises for the period spanning 2008 to 2021.

As our empirical strategy, we employ the generalized difference-in-difference (DiD), which provides a flexible framework to identify the causal effect of the electricity crisis by comparing the outcomes of firms across sectors expected to be affected differentially by the crisis. To capture each sector's innate source of heterogeneous reaction to the crisis, we rely on the sector energy vulnerability index developed and computed by Ndubuisi et al. (2024) using South Africa's input-output table that covers the universe of the sectors in the economy. The index measures the intensity of each sector's forward and backward linkages to the energy sector, such that a sector having a higher energy vulnerability intensity level is considered more dependent on the energy sector and therefore more vulnerable to any electricity supply or demand shock.

Our results show that the ongoing electricity crisis has led to significant job losses, reduced capital investments, and disrupted export activities across manufacturing firms in the country, with the adverse effect being particularly severe for manufacturing firms with higher energy vulnerability intensity. Our results are robust to several alternative model specifications and measurement of the electricity crisis. Furthermore, our analysis on the role of the firm's ownership structure, age, size, and financial status further show that they interact with sector energy vulnerability to determine how the ongoing electricity crisis affects firm outcomes. We found that domestic firms and financially constrained firms with high electricity vulnerability were significantly more affected than their foreign and financially unconstrained counterparts, for whom no adverse effects were evident. However, the results concerning firm size and age are more nuanced, with the results varying across the considered firm-level outcomes. Overall, our findings corroborate the nascent evidence that suggest that the ongoing electricity crises have upended economic activities in the country (see, for instance, Ndubuisi et al. 2024; Bhorat and Köhler 2024). At the same time, it highlights that firms are not uniformly affected by the crises. In this case, policies aimed at helping manufacturing firms cope with the crises must account for this heterogeneity.

The paper relates to the broader literature on the economic effects of electricity in South Africa. This literature can be broadly categorized into two: those that broadly consider the implications of electricity consumption (e.g., see Odhiambo 2009; Lin and Wesseh 2014; Bah and Azam 2017) and those that specifically consider the implications of the ongoing electricity crisis. The latter, which our study relates more to, has to date examined the effect of the crisis on economic growth (Mabugu and Inglesi-Lotz 2022), consumer emotions and behaviour (Wiese and van der Westhuizen 2024), carbon emissions (Pretorius et al. 2015), manufacturing jobs (Ndubuisi et al. 2024), and labour market outcomes including employment rates, working hours, and earnings (Bhorat and Köhler 2024). Our main contribution to this literature is to provide firm-level evidence on how manufacturing firms in the country are affected by the ongoing crisis. To our knowledge, our paper is the first to do this using comprehensive firm-level data.

Because of our empirical approach and focus on manufacturing, our work also comes close to Ndubuisi et al.'s (2024) work, which shows that the ongoing electricity crises in the country are associated with significant manufacturing job destruction, and this adverse effect is severe for sectors with higher energy vulnerability intensity. The current paper deviates from Ndubuisi et al. (2024) in two important ways. First, we provide firm-level evidence as opposed to sector-level evidence, as done by Ndubuisi et al. (2024). Second, in addition to the manufacturing job effects of the electricity crises, we provide novel evidence on how the electricity crises affect export activities and capital investments, areas not covered in the previous study. Third, we provide additional analyses and insights on how the effects of the electricity crises vary by firm size, age, financial status, and foreign ownership structure. In this way, the current paper provides further insights on how policymakers can prioritize firms based on the combination of sector-firm characteristics.

Our study also relates to the broader literature examining the firm-level effects of electricity shortages or energy crises, especially in Africa (see, for instance, Moyo 2013; Cole et al. 2018; Amadu and Samuel 2020; Abeberese et al. 2021; Mensah 2024). Our innovation to this literature is twofold. First, rather than merely examining the average effect of the electricity crisis on firms, we provide evidence on how the firm-level effect varies across firms based on a novel energy vulnerability index. Along this line, we provide evidence on the causal pathway where negative electricity supply shocks are passed down to manufacturing firms. Second, we provide evidence on how firms' heterogenous characteristics—vis-à-vis age, size, foreign ownership, and financial status—further determine the implications of any electricity shortages or energy crises on firm-level activities and outcomes. To our knowledge, the available evidence on the heterogeneous impact of electricity crises on firm outcomes in South Africa also remains scant. We add to this literature.

The rest of this paper is organized as follows. The next section presents the research design, where we specified our econometric model and estimation approach. Section 3 discusses the data sources and the computation of all key variables. The results from the empirical analysis are presented as well as discussed in Section 4, while Section 5 concludes the paper.

2 Research design: model specification and estimation

Our empirical approach relies on the generalized DiD method. The method provides a flexible framework to identify how firm- or industry-level outcomes are affected by country-level characteristics—by leveraging country-industry or country-firm interactions. Originally developed by Rajan and Zingales (1998), this method has been widely applied in the literature to determine the causal impact of various country characteristics on firm-level and industry-level outcomes (see Dutta and Sharma 2008; Ma et al. 2010; Chen 2017; Turco et al. 2019; Alimov 2019; Maskus et al. 2019; Ndubuisi and Owusu 2022).

Employing the generalized DiD method, our empirical framework relates a firm-level outcome to an interaction variable comprising a country-level indicator (i.e. electricity crisis) and industry-level indicator (i.e. sector energy vulnerability intensity). Therefore, rather than evaluating the average effect of the electricity crisis on a firm-level outcome, which in the absence of a good external instrument(s) suffers from severe identification problems, we examine the differential effect of the electricity crisis on the outcomes of firms across sectors expected to be affected differentially by the crisis. Our identification assumption is then that if firms in the country are truly impacted by the ongoing electricity crisis, this impact should be more pronounced in sectors that are inherently more vulnerable to electricity shocks.

In line with the preceding discussion, the baseline empirical model that guides our analysis is formulated as:

$$\hat{A}_{ijt} = \delta(EC_t * EV_j) + \theta X'ijt + D_i + D_j + D_t + n_{ijt} \qquad (1)$$

From Equation 1, $\hat{A} \in \{\text{export, investment, job}\}$. The subscript i denotes firm, j denotes sector, t is the year index, and n_{ijt} is the error term. X'_{ijt} is a vector of time-varying firm characteristics such as age, size, labour productivity, financial status, working capital, foreign ownership status, and foreign connection. The inclusion of these controls is informed and guided by data availability and the extant literature on drivers of firm performance (see Yasar et al. 2006; Ding et al. 2013; Lipsey et al. 2013; Konte and Ndubuisi 2021). D_i is a firm-specific time-invariant dummy, D_j is a sector-specific time-invariant dummy, and D_t is a time-specific dummy. We include full sets of firm-specific dummies to account for unobserved firm heterogeneities and sector-specific dummies to account for differences across sector such as the level of competition, technology use, and market demand. The time dummies account for time-specific technological shocks that are common across firms but differ across time.

$EC_t * EV_j$ is the variable of interest. It is an interaction term comprising a country-level indicator of electricity crisis (EC_t) and a sector-specific electricity vulnerability intensity (EV_j). We consider EV_j to be an inherent technological component of a sector such that when it interacts with EC_t it allows us to identify how firms with varying levels of EV_j respond to variation in EC_t. Note that as EC_t is constant across firms and varies uniformly across time, its direct effect is subsumed by the time effect (D_t). Also, the direct effect of EV_j is subsumed in the sector fixed effect as it is time-invariant (D_j). For these reasons, Equation 1 excludes the direct effects of EV_j and EC_t in the specification. Moving on, δ is the coefficient of interest, which measures how the effect of EC_t on $\hat{A}_{ijt}$ varies according to the intensity level of EV_j. We expect the coefficient to be negative and statistically significant, implying that firms experience poorer performance due to the ongoing electricity crisis with the effect being severe in sectors with higher EV_j.

The estimation of Equation 1 only allows us to address our first research objective that focuses on firms' heterogenous response to the electricity crisis based on their energy vulnerability intensity. The second objective of our study is to unpack how firm characteristics such as ownership structure, age, size, and financial status further interact with the firm's energy vulnerability intensity to determine the effect of the ongoing electricity crisis on firm outcome. To examine this relationship, we follow Maskus et al. (2019) to perform a split sample analysis.[4] This particularly entails re-estimating Equation 1 for various subsamples along the lines of the firm characteristics of interest.

Following past studies that adopt the generalized DiD approach (see Dutta and Sharma 2008; Alimov 2019; Maskus et al. 2019; Ndubuisi and Owusu 2022), we estimate Equation 1 using the ordinary least square (OLS) conditional on a battery of firm characteristics as well as year and sector fixed effects. Under the identifying assumption that other factors affecting $\hat{A}_{ijt}$ are uncorrelated with $EC_t * EV_j$, this would indicate a causal influence of electricity crisis on the firm-level outcome. It suffices to say that our empirical framework associates a firm-level outcome to a combination of sector- and country-level characteristics, thereby minimizing concerns of reverse

[4] The authors examine how patent protection interacts with sector patent intensities to determine sectoral R&D intensities and how this relationship differs across countries at different levels of financial development.

causality. This assumption breaks down only if a single firm is able to drive changes in $EC_t * EV_j$, which is an exception rather than a norm.

3 Data sources and variable computation

3.1 Firm-level outcomes and characteristics

We source data on firm-level outcomes and characteristics from the South African Revenue Service and National Treasury (SARS-NT). We particularly use the CIT-IRP5 dataset from this source, spanning the period 2008–21 (National Treasury and UNU-WIDER 2023). The dataset is a panel containing detailed information about the activities and performance of formal firms in South Africa. Firms in the dataset are also grouped into sectors using the SIC classification. We are particularly able to identify and distinguish firms in the dataset based on either the one-, two-, or three-digit SIC classification. We restrict our sample to only firms in the manufacturing sector, exploring mostly the three-digit SIC classification. We also dropped observations with missing or negative values of sales, capital, and employment.

Our study seeks to explain three outcomes including jobs, capital investment, and exports. From the cleaned dataset, therefore, we define jobs as the log transformation of a firm's total number of employees. Following Den et al. (2020), we define a firm's investment as capital expenditure divided by total assets. To capture the export activity of a firm, we focus on the extensive margin defined herewith as a dummy variable that takes the value of one in a period if a firm reports positive export value and zero otherwise.[5] Table 1 provides a description of the firm-level characteristics included in our analysis. The variables on foreign connection and ownership structure are directly sourced from the database. The rest of the variables (age, size, labour productivity, financial status, working capital, ownership structure, and foreign connection) were computed using data series that were retrieved from the database.

3.2 Energy vulnerability

We source the sector energy vulnerability index from Ndubuisi et al. (2024). The original data used by the authors to compute the index rely on the input-output (IO) table from the Quantec statistical database. The data cover IO linkages across 91 sectors at the three-digit SIC code in South Africa.[6] The authors proceeded in three steps to compute the index. First, they computed indicators of each of the 91 sectors' forward and backward linkages to the energy sector.[7] Second, they sum the backward and forward indicators to generate a sector-specific energy vulnerability index. Third, they normalize the resulting index to have a minimum value of zero and a maximum value of one. Ultimately, higher values of the resulting index imply higher energy vulnerability intensity—i.e. the higher, the more vulnerable the sector is to shocks in the energy sector. Our analysis relies on an extracted sample comprising only manufacturing sectors. We rely on the gross energy vulnerability measure (which includes both the backward and forward component) of each

[5] Nonetheless, in the Appendix, we show results using the intensive margin, which entails estimating the differential effect of the electricity crisis on the actual export values using the Poisson pseudo maximum likelihood (PPML).
[6] Note that the 91 sectors include non-manufacturing sectors.
[7] The authors computed forward linkage as the relative share of the energy subsector in the total inputs used in other subsectors, while they computed backward linkage as the relative dependence of the electricity and gas subsector on the domestic output of other subsectors for its production.

of these sectors in our analysis. For completeness, however, we show results using the subcomponents in the baseline estimate.

Intuitively, the core idea behind the energy vulnerability index is that a sector's susceptibility to energy supply and demand shocks stems from its degree of backward and forward dependence on the electricity sector. In this case, the more electricity serves as an intermediate input to a sector's output, the more vulnerable that sector is to any shock in the electricity sector. Similarly, the more the electricity sector consumes a sector's output, the more vulnerable that sector is to any shock in the electricity sector. Overall, the index therefore captures the strength of a sector's linkages to the electricity sector, with higher values indicating a stronger linkage and, consequently, greater susceptibility to electricity supply or demand shocks.

Using the three-digit sector description in the Quantec dataset, we manually map the sector energy vulnerability index to the three-digit sectors with comparable names in the CIT-IRP5 datasets. To maximize the mapping, we aggregated some of the sectors in the Quantec database to match the three-digit SIC classification in the CIT-IRP5 datasets (see Table A1 in the Appendix). We successfully mapped the energy vulnerability index to 80 per cent of the three-digit manufacturing SIC sectors in the CIT-IRP5 datasets. About 51 per cent of these successfully mapped sectors were unique matches, while the rest were achieved after reaggregating the sectors in the Quantec dataset. In all, we obtained 41 unique sectors for which our analysis relies on.

While Ndubuisi et al. (2024) computed the index for the period 1993 to 2021, we restrict the observation to the period spanning 2008–21 for which we have corresponding firm-level information from the CIT-IRP5 dataset. As previously noted, our study explores the sector-specific energy vulnerability as an innate technological attribute. Therefore, to smooth the temporal fluctuations and reduce the effect of outliers, as is conventional in the related literature (see Rajan and Zingales 1998; Chen 2017; Turco et al. 2019), we aggregate each sector's energy vulnerability across the year using the median value.

Table 2 provides a summary statistic of the sector energy vulnerability considered in our analysis. The average energy vulnerability intensity is 0.19 with a standard deviation of 0.16. The median sector has an energy vulnerability intensity of 0.13. The three sectors with the least energy vulnerability intensity in our final sample include (in consecutive order) 'Household appliances (QSIC 358)' with an energy vulnerability intensity of 0.017, 'Other electrical equipment (QSIC 364_366)' with an energy vulnerability intensity of 0.018, and 'Motor vehicles (QSIC 381_382)' with an energy vulnerability intensity of 0.018. Conversely, the three sectors with the highest energy vulnerability intensity in our sample include (in consecutive order) 'Non-ferrous metal products (QSIC 352)' with an energy vulnerability intensity of 0.514, 'Knitted, crocheted articles (QSIC 313)' with an energy vulnerability intensity of 0.6, and 'Coke, petroleum products, and nuclear fuel (QSIC 331_333)' with an energy vulnerability intensity of 0.605. Comparing our sector energy vulnerability to those in Ndubuisi et al. (2024), we observe that the ranking of each sector's energy vulnerability is similar, albeit the intensity level differs. This difference stems from the sample coverage. Our sample covers the period spanning 2008–21, while Ndubuisi et al.'s (2024) sample covers the period spanning 1993–2021. Further, besides the sectors at the right and left tails of the index's distribution, we also observe slight differences in some of the rankings of the sectors in our sample when compared to those in Ndubuisi et al. (2024). This difference is largely driven by the sector reaggregation we did to ensure comparability between the sectors in the Quantec and CIT-IRP5 datasets, respectively.

3.3 Electricity crisis

Ndubuisi et al. (2024) provide a detailed discussion of South Africa's electricity sector landscape and crises. As noted by the authors, one of the hallmarks of South Africa's electricity crisis is the underperformance of its power plants, as about 80 per cent of them have reached or passed their mid-life cycle, leading to insufficient capacity to generate and reticulate electricity. Ultimately, the country has resulted to regular enforced power cuts since 2007 to keep the lights on in the country. Ultimately, an ideal measure of the crisis would be to exploit the introduction of loadshedding in 2007 as an exogenous electricity supply shock in the country and then examine how firms respond to it (see Ndubuisi et al. 2024). Unfortunately, the CIT-IRP5 dataset only starts in 2008. As an alternative approach, therefore, we exploit variations in the country's electricity capacity factor to capture the trends in the country's electricity crisis.

Figure 1 shows the evolution of South Africa's electricity capacity factor (ECF) from 1985 to 2021. We compute the variable as the ratio of the country's total electricity generated in a year to its total electricity-generating capacity in that year. The original data used to compute the variable are sourced from the EIA database. Higher values of ECF means better electricity-generating performance. Hence, Figure 1 shows that the country's ECF has consistently declined since 2007, the year that the country witnessed its first loadshedding. The trends in the country's electricity crisis are therefore reflected and captured in the ECF. Since our study focuses on the electricity crisis, rather than merely employing the level variation in the country's ECF, we compute and use the volatility of the log-transformed ECF as an empirical measure of the electricity crisis. In this case, higher values of the resulting index would imply higher cyclicality and, therefore, a bad state.[8]

To measure the ECF volatility, we compute the rolling standard deviation of ECF over a three-year window. Since one of the weaknesses of this approach is that the window is arbitrarily chosen, we test the robustness of our results to ECF volatility computed based on five-year and seven-year windows, respectively. We rely on the long ECF series—that is, 1985–2021—to compute the volatility measure, after which we extract the time span that corresponds to observation in the CIT-IRP5 dataset—i.e. 2008–21.[9] In the robustness check, we also directly use the ECF in a regression, multiplying the variable by a negative constant such that higher values of the resulting index would mean poor electricity performance. Further, we use the electricity generation per capita, multiplying the variable also by a negative constant to obtain the inverse wherein the higher values would suggest poor electricity performance. Data used to compute these alternative indicators are all sourced from the Energy Information Administration (EIA) database.

4 Results and discussion

4.1 Baseline regression: main results

4.1.1 The effect of the electricity crisis on jobs

Table 3 presents the key results on manufacturing jobs. Column 1 shows the result when we only include the sector energy vulnerability index (EV_j) and the interaction term comprising sector

[8] In an unreported result, we have directly used the ECF when estimating Equation 1. As expected in this case, the coefficient of the interaction term turns out positive and statistically significant, implying that the better ECF the better the performance of firms with energy-vulnerable firms being disproportionately better off. However, we opt to rely on estimation based on the volatility measure as it is better attuned with the concept and idea of a crisis.

[9] We use the 'rangestat' Stata routine to compute the standard deviation for the respective window periods.

electricity vulnerability as well as the electricity crisis indicator EC_tconditioning on year and firm fixed effects. The sector energy vulnerability index enters positively into the regression and is significant at 1 per cent. However, the coefficient of the interaction term enters negatively and is also significant at 1 per cent. The result thus indicates a negative effect of the electricity crisis on manufacturing jobs with the adverse effect being more severe for sectors with higher electricity vulnerability. In column 2, we include a battery of firm characteristics. We observe that introducing these controls does not change our main result. In particular, the coefficient of the variable of interest only marginally dropped from 1.89 in column 1 to 1.83 in column 2.

Column 3 shows the result when we further introduce the sector fixed effects, which is in line with our baseline specification. The findings from the previous results remain unchanged. Importantly, the coefficient of the interaction term is largely identical to that of the previous result, indicating that the result is not driven by omitted variables at the firm and sector level. In terms of economic significance, the results reported in column 3 (which is our preferred estimate as it is consistent with the baseline specification) thus indicate that, for a firm in a sector with an average energy vulnerability intensity of 0.19, a standard deviation increase in the crisis variable reduced the employment level by about 1 percentage point. For the same standard deviation increase in the crisis variable, the job-reduction effect is about 0.08 percentage points for a sector like the 'Household appliances sector (QSIC 358)', which has the least energy vulnerability intensity and 3.2 percentage points for a sector like the 'Coke, petroleum products, and nuclear fuel sector (QSIC 331_333)', which has the highest energy vulnerability intensity. Overall, the result is consistent with Ndubuisi et al. (2024), who document a negative association between the ongoing electricity crisis in the country and manufacturing jobs at the sector level, especially for energy-vulnerable sectors. More broadly, it corroborates findings from Mensah (2024) that empirically showed that negative electricity supply shocks destroy jobs. Our finding contributes to these studies by providing firm-level evidence for manufacturing firms in South Africa, further highlighting the causal pathway to be the extent of a firm's exposure to the energy sector.

Although our primary focus is on the overall sector energy vulnerability, columns 4 and 5 present the results for the two subcomponents of sector electricity vulnerability. Column 4 displays the outcomes without sector fixed effects, while column 5 includes them. In both scenarios, only the estimated coefficient of the interaction term, which combines the crisis variable and sector exposure through forward linkage, is statistically significant. This suggests that the negative employment impact of the electricity crisis is more pronounced for firms supplying to the electricity sector. Regarding the control variables, all coefficients, except for labour productivity, are positive and statistically significant. These results align with previous literature. For example, the negative coefficient for labour productivity supports the broader argument that higher productivity allows firms to increase production and employment but also reduces the number of workers needed to produce a given output, potentially lowering worker demand (see Autor and Salomons 2017). The positive coefficient for foreign ownership confirms earlier findings by Karlsson et al. (2009) and Lipsey et al. (2013), which indicate a positive relationship between foreign ownership and employment growth. Similarly, the positive impact of working capital on jobs is consistent with previous studies showing that financial constraints negatively affect a firm's job-creation potential (Demirhan and Aldan 2021).

4.1.2 The effect of the electricity crisis on investments

Table 4 presents our key findings on the capital investment of manufacturing firms. Column 1 shows results when we include only the sector energy vulnerability index and the interaction term, while controlling for year and firm fixed effects. The coefficient of the sector electricity vulnerability index is positive, whereas the interaction term's coefficient is negative and statistically significant at all conventional significance levels. Column 2 includes firm-level controls, and

Column 3 adds sector fixed effects. In both cases, the interaction term remains negative and highly statistically significant at the 1 per cent significance level. Comparing the sizes of the interaction term's estimated coefficients across the three columns, their consistency suggests the result is not driven by omitted variables at the firm or sector level. Economically, the interaction term's coefficient in column 3 implies that a standard deviation increase in the crisis reduced capital investment by 0.34 percentage points for a firm in a sector with an average energy vulnerability intensity of about 0.19. For firms in the sector with the least energy vulnerability intensity, a standard deviation increase in the crisis reduced their capital investment by 0.02 percentage points. However, for firms in a sector with the highest energy vulnerability intensity, it is about a 0.8 percentage point decline in capital investment for a standard deviation increase in the crisis.

Overall, the preceding results show that, in addition to jobs, the ongoing electricity crisis in South Africa has declined manufacturing firms' capital investments, with a more pronounced decline for firms in energy-vulnerable sectors. While our analysis focuses on electricity supply shocks, the results are in line with Sadath and Acharya (2015) who found that the energy price rise in India had a negative effect on the investment of manufacturing firms in the country. It is also consistent with Abeberese (2020) who, using data on Ghanaian manufacturing firms, found a decline in investments in plant and machinery during the electricity rationing period, with a more pronounced decline for firms in electricity-intensive sectors. Nonetheless, our study deviates from these in that we focus on a sector backward and forward linkage to the electricity sector to operationalize sector electricity vulnerability while they used a sector's average ratio of electricity expenditure to output.

Columns 4 and 5 present regression results for the two subcomponents. In both columns, the interaction term, involving the electricity crisis and either subcomponent, is negative and statistically significant at conventional levels. This indicates that the adverse effects of the electricity crisis extend to firms with backward and forward linkages to the electricity sector. Economically, for a firm in a sector with an average forward energy vulnerability intensity of 0.082, a standard deviation increase in the crisis would reduce employment by about 0.57 percentage points. Conversely, for a firm in a sector with an average backward energy vulnerability intensity of 0.182, the same increase in the crisis would reduce employment by about 0.70 percentage points. Thus, while the forward linkage is statistically robust, the inter-linkage has the greatest impact on how electricity shocks influence firms' investment decisions and employment levels.

Regarding the controls, only firm age, size, and working capital are statistically significant at conventional levels. The negative coefficient for firm age suggests that older firms invest less, while the positive coefficient for firm size indicates that larger firms invest more. As expected, the negative coefficient for working capital highlights the competition between working capital and capital investment due to limited funding (see Fazzari and Petersen 1993; Ding et al. 2013).

4.1.3 The effect of the electricity crisis on exports

Negative electricity supply shocks could negatively impact firms' export decisions and capacity. For instance, electricity shortage can increase operational costs and quality debasement that drive down international competitiveness. It can also cause production delays, resulting in supply chain disruptions. Despite this, the literature on the firm-level effects of electricity shocks has proceeded without considering how the export activities of firms are affected. We fill this gap by providing novel evidence on how manufacturing firms' extensive export margin is affected by electricity shortages or disruptions.

Table 5 presents our key results on manufacturing firms' exports. The outcome variable across the column is a dummy variable that takes the value of one for exporting firms and zero for nonexporting firms. The structure of the table is similar to Tables 3 and 4. Column 1 therefore shows the results when we only include the sector electricity vulnerability index and the interaction term while conditioning on year and firm fixed effects. Again, the coefficient of the interaction variable turns out negative and statistically significant at all conventional significance levels. Column 2 shows the results when we further introduce firm-level controls, and sector fixed effects are included in column 3. In both cases, the estimated coefficient of the interaction term remains negative and statistically significant at the 10 per cent significance level. Comparing the sizes of the estimated coefficients of the interaction variable across the three columns, they remain largely the same, which further reiterates that the results are not driven by omitted variables at the firm and sector levels.

Columns 4 and 5 show the regression result for the subcomponent. In both columns, the estimated coefficient on the interaction term enters negatively, albeit only that of forward linkage turns out statistically significant at conventional significance levels. In Appendix Table A2, we report the results on the intensive export margin. Estimation of the regressions that yield the results are achieved using the PPML to account for zeroes, as has become conventional in trade literature. The coefficient of the interaction term is negative and statistically significant across the columns in the table. As per the result on the subcomponent, unlike for the extensive export margin, the coefficient of their respective interactions with the electricity crisis indicator are all negative and statistically significant at the 5 per cent level. Overall, the results indicate that the adverse effect of the electricity crisis materializes in both reducing the decision to export and the export intensity, with the effect being severe for firms in sectors with high energy vulnerability intensity.

Turning to the other firm characteristics, only the coefficient of firm age, size, and productivity turn out statistically significant in the regression reported in Table 5. In all the columns, the coefficient of these variables shows a positive relationship with exports. These coefficients remain positive and statistically significant for the intensive margin (as reported in Appendix Table A2). The coefficients of foreign connection and working capital further turn significant for the intensive margin and are positive. Overall, the coefficient of age enters the regression positively, implying that older firms are more likely to export, which is consistent with Wagner (2015). Likewise, the result that larger firms and more productive firms are more likely to export are consistent with past studies (see Hirsch and Adar 1974; Yasar et al. 2006; Hernández 2020; Konte and Ndubuisi 2021).

4.2 Baseline regressions: robustness checks

The result in the previous section indicates that the ongoing electricity crises in South Africa have adversely affected jobs, capital investments, and exports with the effects being most severe for firms in sectors with high energy vulnerability intensity. In this section, we subject our result to several sensitivity checks to ascertain the robustness of our results. First, the generalized DiD framework using panel data are likely to be subject to a serial correlation problem, which ultimately influences the standard errors. Existing studies have therefore modelled the standard error in different ways to ensure it is not severely underestimated. To address this concern, we show the results using alternative standard errors. Appendix Table A3 shows the result when we use the robust option. Appendix Table A4 shows the result when we cluster the standard error at the firm level, and Appendix Table A5 shows the result when we cluster the standard error at the sector level. Across the three tables, we obtain results that are consistent with the baseline results.

One of our identification assumptions in Section 3.1 is that factors affecting $\hat{A}_{ijt}$ are uncorrelated with $EC_t * EV_j$. To test the sensitivity of our result to this assumption, Appendix Table A6 shows the result when we introduce an interaction between the crisis variable and other sector characteristics including labour productivity, capital labour ratio, trade openness, and real output. Data for these sector characteristics are sourced from the Quantec statistical database (Quantec 2023).[10] If our baseline result is biased by either of these possible confounding factors, the coefficient of $EC_t * EV_j$ would turn statistically insignificant. Columns 1, 3, and 5 show the regression results without sector fixed effects. Columns 2, 4, and 6, on the other hand, show the result when we introduce sector fixed effects. Across all the columns in the table, the coefficient of $EC_t * EV_j$ remains negative and statistically significant at all conventional significant levels, suggesting that the baseline results are independent of other sector characteristics.

As noted, the baseline results rely on the ECF volatility computed as the rolling standard deviation of ECF over a three-year window. To ensure that our results are not sensitive to measurement of the crisis variable, Appendix Tables A7 and A8 show the result when we compute the ECF volatility as a rolling standard deviation of ECF over five-year and seven-year window periods. Using these alternative indicators, the results on the interaction variable remain the same in suggesting that the electricity crisis has destroyed jobs, lowered capital investments, and upended export activities in the country, with the effect being disproportionately higher for firms in sectors with higher energy-vulnerable intensity. Appendix Table A9 shows the result when we use the crisis variable constructed as the inverse of ECF, while Table A10 shows the result when we use another crisis variable constructed as the inverse of the ratio of annual electricity generation to total population. The results in both cases remain consistent with the baseline results.

4.3 Electricity crises, electricity vulnerability, and heterogenous firm response

Thus far, our analysis relied on the implicit assumption that firms within the same sector react uniformly to the electricity crisis. We relax this assumption in this section, exploring the role of firm characteristics in influencing how firms are affected by the ongoing electricity crisis in the country. We particularly examine how firm ownership structure, age, size, and financial status interact with a firm's electricity vulnerability to determine the effect of the ongoing electricity crisis on firm outcomes.

4.3.1 Firms' response to electricity crises: the role of foreign ownership status

In this section, we consider how a firm's foreign ownership status interacts with the firm's electricity vulnerability to determine the effect of the ongoing electricity crisis on firm outcome. Foreign-owned firms may be less affected by negative electricity supply shocks because they are able to leverage their international networks and resources (Dollar et al. 2005). Foreign-owned firms also often possess advanced technologies and infrastructure, including superior IT systems, automation, and energy management solutions, which can mitigate or moderate the impact of an electricity crisis. This perspective aligns with Bu et al. (2019), who found that foreign direct investment (FDI) firms are more energy efficient than non-FDI firms. Other things being equal, therefore, we expect foreign-owned firms to be less affected by the ongoing electricity crisis than domestic-owned firms.

Table 6 presents a split sample result when we consider firm ownership structure based on foreign ownership status. Panel A shows the result for domestic firms, while Panel B shows the result for foreign-owned firms. The coefficient of the interaction variable remains negative and consistently significant at the conventional significance level in panel A, while it turns statistically insignificant across all the columns in panel B. These results imply that whilst the economic activities and performance of electricity vulnerable firms are most adversely affected, the severity of this effect

[10] For each sector, we use the median value like in the case of the energy vulnerability intensity.

is higher for domestic firms. The results therefore align with the preceding argument that foreign-owned firms are less affected by the ongoing electricity crisis than domestic-owned firms. Other things being equal, this result also implies that the baseline result reported in Table 6 is largely driven by domestic-owned firms in our sample.

4.3.2 Firms' response to electricity crises: the role of financial status

Moving on, we consider the role of firm financial status, distinguishing between financially constrained and financially unconstrained firms. Conceptually, electricity crises often force firms to adopt costly mitigation or coping strategies. These typically involve financial resources to invest in backup power systems, maintain their daily operation, and invest in advanced technologies and automation to minimize the crisis's impact. Financially constrained firms, with their tighter cash flows, face difficulties funding these investments and covering costs associated with prolonged downtime or damages, such as repairing damaged equipment, replacing lost inventory, and compensating for delayed deliveries that are caused by the crisis. Further, unlike financially unconstrained firms that usually have robust risk management strategies and contingencies in place, financially constrained firms have less operational flexibility. They struggle to quickly shift production schedules, relocate operations, or make rapid adjustments in response to negative shocks due to their limited financial resources. Consequently, financially constrained firms are less capable of mitigating the negative impact of an electricity crisis on their economic activities and performance.

Table 7 shows the result when we consider the role of financial status. To identify a firm's financial status, we use the working capital following Hottenrott and Czarnitzki (2016). We particularly use the sample median value to split the sample wherein firms with values higher than the median value are considered financially unconstrained firms. The rest are then considered financially constrained firms. Panel A of Table 7 shows the results for financially constrained firms, and panel B shows the results for financially unconstrained firms. The estimated coefficient of the interaction term remains negative and statistically significant across the columns in panel A, implying a negative effect of the crisis on financially constrained firms with the effect being more pronounced for energy-vulnerable intensive firms. In panel B, however, the coefficient of the interaction variable is consistently statistically insignificant across all columns. The results thus confirm our argument that financially constrained firms are more vulnerable to any disruptions caused by the crisis.

4.3.3 Firms' response to electricity crises: the role of firm size

Next, we consider how firm size interacts with the firm's electricity vulnerability to determine the effect of the ongoing electricity crisis on firm outcome. Conceptually, we argue that the impact of firm size on the relationship between electricity crises and firm performance is complex and multifaceted. Large firms often possess more resilient infrastructures, allowing them to better cope with or adapt to crises. Among others, these typically include backup power systems and distributed operations across various locations, which enables them to shift operations to unaffected areas or redistribute workloads. Additionally, large firms are more likely to have insurance policies to cover losses and use financial instruments like hedging to manage risks induced by the electricity crises, thus mitigating financial impacts. SMEs, on the other hand, lack these robust soft infrastructures that could help them cope with the crisis. This is further accentuated by their liability of smallness that limits the extent to which they source external finance to meet the need.

Nonetheless, large firms can still be significantly affected by electricity crises compared to SMEs. SMEs generally have simpler operations, less reliance on automated systems, and lower output levels. In contrast, large firms depend on complex, energy-intensive automated systems and have higher fixed costs, including salaries for a large workforce, rent for substantial facilities, and maintenance for extensive equipment. In this case, while the electricity crisis disrupts the economic activities and performance of SMEs, the overall impact is generally less severe than for large firms due to the smaller scale and scope of their operations. This perspective is supported by Cole et al. (2018), who found that power outages significantly affect firm sales in sub-Saharan Africa for both small and large firms, but the impact is more pronounced for large firms.

Table 8 shows the split sample result when we consider firm size. Categorization of the firms are revenue-based, wherein firms with an annual gross sale that is greater than ZAR250 million are considered larger firms, while firms with revenue below are considered smaller and medium firms. Panel A shows the regression result of how the employment, investment, and export behaviours of SMEs respond to the ongoing electricity crisis across varying degrees of electricity vulnerability. Panel B, on the other hand, shows similar regression results for larger-sized firms. The results presented in the table indicate a job destruction effect associated with the crisis for both large-sized and small- and medium-sized firms. However, the size of the coefficient is higher in the sample for large-sized firms, implying that the job destruction effect is higher for large-sized firms. When we consider the investment and export outcomes, however, the interaction term is statistically significant only in the sample consisting of SMEs. This latter result, therefore, aligns with our argument that the severity of the crisis, in terms of losses in investments and exports, is higher for SMEs compared with large-sized firms.

4.3.4 Firms' response to electricity crises: the role of firm age

Older firms often experience path dependency, where the costs of changing direction become prohibitively high, even during crises. This technological lock-in makes it difficult and expensive for them to adopt newer, more resilient technologies. They may also suffer from organizational inertia, where resistance to change prevents system and process upgrades needed to handle the cascading effects of an electricity crisis. This resistance can be due to cost concerns and the complexity of overhauling existing systems. As a result, older firms frequently rely on legacy systems and outdated infrastructure, which may not be as resilient to power interruptions or enable them to stay competitive during an electricity crisis.

Furthermore, older firms tend to have larger and more complex operations, making them more vulnerable to disruptions caused by an electricity crisis. In contrast, younger firms are typically more agile, adaptable, and flexible. They often use modern technology and resilient infrastructure designed to withstand power interruptions during crises. Additionally, their smaller size allows them to quickly implement alternative strategies to manage disruptions. Therefore, it is expected that the ongoing electricity crisis will have a more severe negative impact on older firms compared to younger ones.

In line with the preceding discussion, Table 9 presents a split sample result when we differentiate between younger versus older firms. We make this categorization using the sample median age. We report the regression result for younger firms in panel A, while the results for older firms are reported in panel B. Except for capital investment, the coefficient of the interaction term turns statistically insignificant for jobs and exporting for the sample containing younger firms. In the case of older firms, the coefficient is statistically negative and statistically significant for jobs and capital investment and insignificant for exporting. The result presented in the table thus partially supports our previous argument of older firms being more affected by the crisis. The emerging evidence indicates a more nuanced relation that is dependent on the considered performance measure.

5 Conclusion

Electricity is fundamental to modern society, serving several essential functions such as the operation of modern business. Its role in this regard spans across operational efficiency, cost management, technological advancement, and market competitiveness. Ultimately, access to stable and affordable electricity is quintessential to drive firm performance and competitiveness both locally and globally. Motivated by these, this paper examined how the ongoing electricity crisis in South Africa has affected jobs, capital investment, and export activities among manufacturing firms in the country. We addressed our research objective by employing a generalized DiD approach, wherein we examined the effect of the electricity crisis by comparing changes in the performance of firms across manufacturing subsectors expected to be affected differentially by an intensification of the crisis.

Consistent with our empirical approach, our analysis relies on merged panel data comprising country indicator of electricity crisis, sector electricity vulnerability, and firm-level indicators for the period between 2008 and 2021. Findings from our analysis indicate that the ongoing electricity crises have destroyed jobs, lowered capital investments, and upended export activities in South Africa. Importantly, this adverse effect of the electricity crises is worse for firms with higher energy vulnerability intensity—defined herewith as firms in sectors with stronger backward and forward linkages to the electricity sector. In further analysis, we examine how firm ownership structure, age, size, and financial status interacts with the firm's electricity vulnerability to determine the effect of the ongoing electricity crisis on firm outcome. We found that domestic and financially constrained firms with higher electricity vulnerability were severely affected relative to their foreign and financially unconstrained counterparts. The findings based on firm size and age are more nuanced. We found an adverse effect of the electricity crises on jobs irrespective of the firm size. For investments and exports, we only find a significant effect for small- and medium-sized firms. The results also suggest that the electricity crises adversely affected the investment and export activities of younger firms while leaving their jobs unharmed. Conversely, the crises resulted in larger firms shedding off workers and lowering capital investment. However, their export activities remain unharmed.

Overall, our study provides new insights into the real effects of electricity crises on the economy. Specifically, the findings underscore the role of sector and firm heterogeneity in determining how firms are affected by the ongoing electricity crisis in South Africa. The findings emphasize the need for policies to consider these heterogeneities when designing measures to help firms cope with the adverse effects of the crisis. For instance, our finding that the adverse effects of the electricity crisis intensifies with sector electricity vulnerability highlights the need for tailor-made government policies for firms in those sectors. At the same time, the findings that domestic and financially constrained firms even within sectors with similar electricity vulnerability intensity also highlight the need for more granularity in the design of such policies. This call for targeted, effective, and granular policies cannot be overemphasized given the limited fiscal space in the country.

Despite the policy relevance of this paper, it has some shortfalls. First, our analyses covered the period between 2008 and 2021, due to the fact that the CIT-IRP5 firm dataset only started in 2008. Future studies could examine the relationships explored in the paper by considering earlier and later periods whenever alternative firm-level panel data become available or the CIT-IRP5 is extended. Furthermore, manufacturing firms and sectors are interlinked through supply chains. As a result, sectors with lower electricity vulnerability could be severely affected if that sector sources intermediate inputs from a severely vulnerable sector and vice versa. Analyses of these spillover effects could add to the literature. Finally, examining how firms and manufacturing sectors are mitigating electricity shocks through the adoption of generators and solar plants when firm-level data become available in the CIT-IRP5 could contribute to the literature.

References

Abeberese, A. B. (2020). 'The Effect of Electricity Shortages on Firm Investment: Evidence from Ghana'. *Journal of African Economies*, 29(1): 46–62.

Abeberese, A. B., C. G. Ackah, and P. O. Asuming (2021). 'Productivity Losses and Firm Responses to Electricity Shortages: Evidence from Ghana'. *The World Bank Economic Review*, 35(1): 1–18. https://doi.org/10.1093/wber/lhz027

Alimov, A. (2019). 'Intellectual Property Rights Reform and the Cost of Corporate Debt'. *Journal of International Money and Finance*, 91: 195–211. https://doi.org/10.1016/j.jimonfin.2018.12.004

Autor, D., and A. Salomons (2017). 'Does Productivity Growth Threaten Employment'. In *ECB Forum on Central Banking, Sintra, Portugal* (pp. 26–8).

Bah, M. M., and M. Azam (2017). 'Investigating the Relationship Between Electricity Consumption and Economic Growth: Evidence from South Africa'. *Renewable and Sustainable Energy Reviews*, 80: 531–7. https://doi.org/10.1016/j.rser.2017.05.251

Bhorat, H., and T. Köhler (2024). 'Watts Happening to Work? The Labour Market Effects of South Africa's Electricity Crisis. WIDER Working Paper 2024/20. Helsinki: UNU-WIDER. https://doi.org/10.35188/UNU-WIDER/2024/478-6

Bu, M., S. Li, and L. Jiang (2019). 'Foreign Direct Investment and Energy Intensity in China: Firm-Level Evidence'. *Energy Economics*, 80: 366–76. https://doi.org/10.1016/j.eneco.2019.01.003

Chen, W. (2017). 'Do Stronger Intellectual Property Rights Lead to More R&D-Intensive Imports?' *The Journal of International Trade & Economic Development*, 26(7): 865–83. https://doi.org/10.1080/09638199.2017.1312493

Cissokho, L. (2019). 'The Productivity Cost of Power Outages for Manufacturing Small and Medium Enterprises in Senegal'. *Journal of Industrial and Business Economics*, 46(4): 499–521. https://doi.org/10.1007/s40812-019-00128-8

Cole, M. A., R. J. Elliott, G. Occhiali, and E. Strobl (2018). 'Power Outages and Firm Performance in Sub-Saharan Africa'. *Journal of Development Economics*, 134: 150–9. https://doi.org/10.1016/j.jdeveco.2018.05.003

Demirhan, A. A., and A. Aldan (2021). 'Financial Constraints and Firm Employment: Evidence from Turkey'. *Borsa Istanbul Review*, 21(1): 69–79. https://doi.org/10.1016/j.bir.2020.07.003

Ding, S., A. Guariglia, and J. Knight (2013). 'Investment and Financing Constraints in China: Does Working Capital Management Make a Difference?' *Journal of Banking & Finance*, 37(5): 1490–507. https://doi.org/10.1016/j.jbankfin.2012.03.025

Dollar, D., M. Hallward-Driemeier, and T. Mengistae (2005). 'Investment Climate and Firm Performance in Developing Economies'. *Economic Development & Cultural Change*, 54(1): 1–31. https://doi.org/10.1086/431262

Dutta, A., and S. Sharma (2008). 'Intellectual Property Rights and Innovation in Developing Countries: Evidence from India'. Washington, DC: International Finance Corporation, World Bank Group. Available at: http://documents.worldbank.org/curated/en/112091468267358188/Intellectual-property-rights-and-innovation-in-developing-countries-evidence-from-India (accessed 20 February 2024).

EIA (2024). 'Independent Statistics and Analysis: US Energy Information Administration'. Available at: https://www.eia.gov/international/data/world (accessed 31 May 2024).

Falentina, A. T., and B. P. Resosudarmo (2019). 'The Impact of Blackouts on the Performance of Micro and Small Enterprises: Evidence from Indonesia'. *World Development*, 124: 104635. https://doi.org/10.1016/j.worlddev.2019.104635

Fazzari, S. M., and B. C. Petersen (1993). 'Working Capital and Fixed Investment: New Evidence on Financing Constraints'. *The RAND Journal of Economics*, 328–42. https://doi.org/10.2307/2555961

Fisher-Vanden, K., E. T. Mansur, and Q. J. Wang (2015). 'Electricity Shortages and Firm Productivity: Evidence from China's Industrial Firms'. *Journal of Development Economics*, 114: 172–88. https://doi.org/10.1016/j.jdeveco.2015.01.002

Guo, D., Q. Li, P. Liu, X. Shi, and J. Yu (2023). 'Power Shortage and Firm Performance: Evidence from a Chinese City Power Shortage Index'. *Energy Economics*, 119: 106593. https://doi.org/10.1016/j.eneco.2023.106593

Hernández, P. J. (2020). 'Reassessing the Link Between Firm Size and Exports'. *Eurasian Business Review*, 10(2): 207–23. https://doi.org/10.1007/s40821-019-00126-9

Hirsch, S., and Z. Adar (1974). 'Firm Size and Export Performance'. *World Development*, 2(7): 41–6. https://doi.org/10.1016/0305-750X(74)90046-1

Hottenrott, H., B. H. Hall, and D. Czarnitzki (2016). 'Patents as Quality Signals? The Implications for Financing Constraints on R&D'. *Economics of Innovation and New Technology*, 25(3): 197–217. https://doi.org/10.1080/10438599.2015.1076200

Jorgenson, D. W. (1984). 'The Role of Energy in Productivity Growth'. *The Energy Journal*, 5(3): 11–26. https://doi.org/10.5547/ISSN0195-6574-EJ-Vol5-No3-2

Karlsson, S., N. Lundin, F. Sjöholm, and P. He (2009). 'Foreign Firms and Chinese Employment'. *World Economy*, 32(1): 178–201. https://doi.org/10.1111/j.1467-9701.2009.01162.x

Konte, M., and G. Ndubuisi (2021). 'Financial Constraint, Trust, and Export Performances: Firm-Level Evidence from Africa'. *Journal of Institutional Economics*, 17(4): 583–605. https://doi.org/10.1017/S1744137421000059

Lin, B., and P. K. Wesseh Jr (2014). 'Energy Consumption and Economic Growth in South Africa Reexamined: A Nonparametric Testing Approach'. *Renewable and Sustainable Energy Reviews*, 40: 840–50. https://doi.org/10.1016/j.rser.2014.08.005

Lipsey, R. E., F. Sjöholm, and J. Sun (2013). 'Foreign Ownership and Employment Growth in a Developing Country'. *The Journal of Development Studies*, 49(8): 1133–47. https://doi.org/10.1080/00220388.2013.794264

Ma, Y., B. Qu, and Y. Zhang (2010). 'Judicial Quality, Contract Intensity and Trade: Firm-Level Evidence from Developing and Transition Countries'. *Journal of Comparative Economics*, 38(2): 146–59. https://doi.org/10.1016/j.jce.2009.09.002

Mabugu, T., and R. Inglesi-Lotz (2022). 'The Effect of Mismatched Supply and Demand of Electricity on Economic Growth in South Africa'. *Energy Sources, Part B: Economics, Planning, and Policy*, 17(1): 2038731. https://doi.org/10.1080/15567249.2022.2038731

Maskus, K. E., S. Milani, and R. Neumann (2019). 'The Impact of Patent Protection and Financial Development on Industrial R&D'. *Research Policy*, 48(1): 355–70. https://doi.org/10.1016/j.respol.2018.09.005

Mensah, J. T. (2024). 'Jobs! Electricity Shortages and Unemployment in Africa'. *Journal of Development Economics*, 167: 103231. https://doi.org/10.1016/j.jdeveco.2023.103231

Moyo, B. (2013). 'Power Infrastructure Quality and Manufacturing Productivity in Africa: A Firm Level Analysis'. *Energy Policy*, 61: 1063–70. https://doi.org/10.1016/j.enpol.2013.05.111

National Treasury and UNU-WIDER (2023). 'CIT-IRP5 Firm-Level Panel 2008–2021 [dataset]. Extraction 5 Version 1'. Pretoria: South African Revenue Service [producer of the original data], 2018. Pretoria: National Treasury and UNU-WIDER [producer and distributor of the harmonized dataset], 2023.

Ndubuisi, G., and S. Owusu (2022). 'Trust, Efficient Contracting and Export Upgrading'. *The European Journal of Development Research*, 1–22. https://doi.org/10.1057/s41287-021-00486-x

Ndubuisi, G., E. K. Avenyo, and R. Asiama (2024). 'Dancing on the Grid: Electricity Crises, Manufacturing Energy Vulnerability, and Jobs in South Africa'. WIDER Working Paper 2024/41. Helsinki: UNU-WIDER. https://doi.org/10.35188/UNU-WIDER/2024/503-5

Odhiambo, N. M. (2009). 'Electricity Consumption and Economic Growth in South Africa: A Trivariate Causality Test'. *Energy Economics*, 31(5): 635–40. https://doi.org/10.1016/j.eneco.2009.01.005

Pretorius, I., S. J. Piketh, and R. P. Burger (2015). 'The Impact of the South African Energy Crisis on Emissions'. *WIT Transactions on Ecology and the Environment*, 198: 255–64. https://doi.org/10.2495/AIR150211

Quantec Statistical Database (2023). 'Industry Trends'. Available at: https://www.easydata.co.za/ (accessed 2 September 2023).

Rajan, R., and L. Zingales (1998). 'Financial Development and Growth'. *American Economic Review*, 88(3): 559–86.

Sadath, A. C., and R. H. Acharya (2015). 'Effects of Energy Price Rise on Investment: Firm Level Evidence from Indian Manufacturing Sector'. *Energy Economics*, 49: 516–22. https://doi.org/10.1016/j.eneco.2015.03.011

Stern, D. I., and A. Kander (2012). 'The Role of Energy in the Industrial Revolution and Modern Economic Growth'. *Energy Journal*, 33(3). https://doi.org/10.5547/01956574.33.3.5

Turco, A. L., D. Maggioni, and A. Zazzaro (2019). 'Financial Dependence and Growth: The Role of Input-Output Linkages'. *Journal of Economic Behavior & Organization*, 162, 308–28. https://doi.org/10.1016/j.jebo.2018.11.024

Wagner, J. (2015). 'A Note on Firm Age and the Margins of Exports: First Evidence from Germany'. *The International Trade Journal*, 29(2): 93–102. https://doi.org/10.1080/08853908.2014.984796

Wiese, M., and L. M. van der Westhuizen (2024). 'Impact of Planned Power Outages (Load Shedding) on Consumers in Developing Countries: Evidence from South Africa'. *Energy Policy*, 187: 114033. https://doi.org/10.1016/j.enpol.2024.114033

Yasar, M., C. H. Nelson, and R. Rejesus (2006). 'Productivity and Exporting Status of Manufacturing Firms: Evidence from Quantile Regressions'. *Review of World Economics*, 142, 675–94. https://doi.org/10.1007/s10290-006-0088-2

Tables and figures

Table 1: Variable definition and descriptive statistics

Variable	Descriptions	Observation	Mean	Std. dev.	Min	Max
Jobs	Log (total number of employees)	123,215	3.7	1.5	0	10.7
Investment	Ratio of total capital expenditure to total asset	123,215	0.23	0.24	0	9.9
Export dummy	=1 if a firm exports and =0 otherwise	123,215	0.39	0.49	0	1
Export value	Log (export value)	47,656	13.38	2.61	0	23.7
Age	Log (age)	123,215	3.37	0.69	0	8.29
Foreign ownership	=1 if a firm states that its ultimate holding company is resident outside South Africa; and =0 otherwise	123,215	0.04	0.19	0	1
Firm size	=1 if firm gross sales > ZAR250,000,000; and =0 otherwise	123,215	0.05	0.22	0	1
Labor productivity	Log (ratio of sales to total employment)	122,332	13.97	1.59	0	22.3
Foreign connection	=1 if South African firm but has a foreign connection; and =0 otherwise	123,215	0.03	0.18	0	1
Working capital	Log (total current asset less total current liability)	122,392	8.9	12.09	-20.1	24.9
Electricity crisis	Rolling standard deviation of electricity capacity factor (ECF) over a three-year window	123,215	0.04	0.03	0.006	0.09

Note: the logged variables are computed using the inverse hyperbolic function. The age variable is computed based on the firm's incorporation year.

Source: authors' calculations using data from the EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

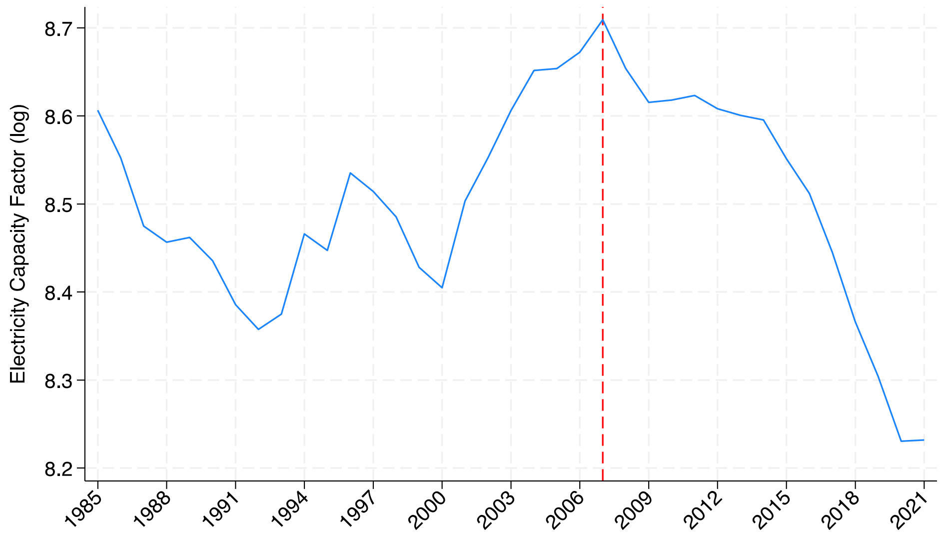
Table 2: Energy vulnerability intensity

SIC	SIC description	Energy vulnerability
358	Household appliance	0.017
364_366	Other electrical equipment	0.018
381_382	Motor vehicle	0.018
305	Beverages	0.023
383	Parts & accessories	0.033
371_373	Radio, television, & communication apparatus	0.047
374_376	Professional equipment	0.052
361_362	Electric motors, generators, transformers; electricity distribution & control apparatus	0.060
314	Wearing apparel	0.062
306	Tobacco	0.067
311	Textiles	0.082
363	Insulated wire & cables	0.092
317	Footwear	0.096
323	Paper & paper products	0.097
359	Office, accounting, computing machinery	0.101
342	Non-metallic mineral products	0.104
356	General purpose machinery	0.110
335_336	Other chemical products	0.112
301	Meat, fish, fruit, etc.	0.114
303	Grain mill products	0.123
321	Sawmilling & planning of wood	0.131
357	Special purpose machinery	0.132
302	Dairy products	0.137
304	Other food products	0.143
391	Furniture	0.154
315_316	Leather and leather and fur products	0.167
312	Other textile products	0.183
337	Rubber products	0.208
392_395	Other manufacturing groups	0.264
354	Structural metal products	0.264
338	Plastic products	0.279
384_387	Other transport equipment	0.288
322	Products of wood	0.310
334	Basic chemicals	0.316
355	Other fabricated metal products	0.349
324_326	Printing, recorded media	0.410
341	Glass & glass products	0.449
351	Basic iron and steel products	0.467
352	Non-ferrous metal products	0.514
313	Knitted, crocheted articles	0.601
331_333	Coke, petroleum products, & nuclear fuel	0.606

Note: original series were computed using the input-output table on the universe of sectors in the South African economy. The table therefore shows only a subsample energy vulnerability intensity of manufacturing sectors covered in our sample.

Source: authors' calculations using data from Ndubuisi et al. (2024).

Figure 1: Evolution of South Africa's electricity capacity factor (ECF)



Note: ECF is computed as the ratio of South Africa's total electricity generated in a year to its total electricity generating capacity in that year. The red reference line shows the beginning of the electricity in 2007.

Source: authors' calculations using data from the EIA (2024) database.

Table 3: Baseline: electricity crisis, energy vulnerability, and jobs

	(1)	(2)	(3)	(4)	(5)
Electricity crisis×energy vulnerability	-1.8932***	-1.8254***	-1.8212***		
	(0.701)	(0.645)	(0.646)		
Energy vulnerability	0.1352**	0.0986**			
	(0.054)	(0.049)			
Electricity crisis×energy vulnerability (backward)				-0.7502	-0.7239
				(0.568)	(0.569)
Energy vulnerability (backward)				0.0817**	
				(0.041)	
Electricity crisis×energy vulnerability (forward)				-2.1025***	-2.1217***
				(0.596)	(0.597)
Energy vulnerability (forward)				0.0529	
				(0.047)	
Age (log)		0.4032***	0.4031***	0.4031***	0.4030***
		(0.021)	(0.021)	(0.021)	(0.021)
Foreign ownership		0.0869***	0.0871***	0.0867***	0.0868***
		(0.028)	(0.028)	(0.028)	(0.028)
Firm size		0.5554***	0.5558***	0.5547***	0.5553***
		(0.034)	(0.034)	(0.034)	(0.034)
Labor productivity (log)		-0.1190***	-0.1189***	-0.1190***	-0.1189***
		(0.009)	(0.009)	(0.009)	(0.009)
Foreign connection		0.1373***	0.1374***	0.1379***	0.1381***
		(0.026)	(0.026)	(0.026)	(0.026)
Working capital (log)		0.0016***	0.0016***	0.0016***	0.0016***
		(0.000)	(0.000)	(0.000)	(0.000)
Constant	3.7110***	3.9799***	4.0012***	3.9807***	4.0016***
	(0.010)	(0.142)	(0.141)	(0.142)	(0.141)
# Observations	119,549	117,830	117,830	117,830	117,830

R-squared	0.922	0.931	0.931	0.931	0.931
Controls	NO	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES
Sector FE	NO	NO	YES	NO	YES

Note: standard errors in parentheses are clustered at the sector-firm level. The dependent variable is the log of total number of employees. The logged variables are computed using the inverse hyperbolic function. The electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a three-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector. *** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculations using data from the EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table 4: Baseline: electricity crisis, energy vulnerability, and investment

	(1)	(2)	(3)	(4)	(5)
Electricity crisis×energy vulnerability	-0.4405**	-0.4588***	-0.4504***		
	(0.173)	(0.171)	(0.171)		
Energy vulnerability	0.0293**	0.0310**			
	(0.013)	(0.013)			
Electricity crisis×energy vulnerability (backward)				-0.2586*	-0.2510*
				(0.150)	(0.150)
Energy vulnerability (backward)				0.0235**	
				(0.011)	
Electricity crisis×energy vulnerability (forward)				-0.4599***	-0.4549***
				(0.167)	(0.167)
Energy vulnerability (forward)				0.0230*	
				(0.012)	
Age (log)		-0.0410***	-0.0408***	-0.0410***	-0.0408***
		(0.005)	(0.005)	(0.005)	(0.005)
Foreign ownership		0.0054	0.0054	0.0054	0.0054
		(0.005)	(0.005)	(0.005)	(0.005)
Firm size		0.0135***	0.0138***	0.0134***	0.0137***
		(0.005)	(0.005)	(0.005)	(0.005)
Labor productivity (log)		-0.0012	-0.0012	-0.0012	-0.0012
		(0.001)	(0.001)	(0.001)	(0.001)
Foreign connection		-0.0009	-0.0011	-0.0008	-0.0010
		(0.004)	(0.004)	(0.004)	(0.004)
Work capital (log)		-0.0024***	-0.0024***	-0.0024***	-0.0024***
		(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.2230***	0.3980***	0.4044***	0.3979***	0.4046***
	(0.002)	(0.021)	(0.021)	(0.021)	(0.021)
# Observations	119,549	117,830	117,830	117,830	117,830
R-squared	0.770	0.777	0.777	0.777	0.777
Controls	NO	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES
Sector FE	NO	NO	YES	NO	YES

Note: standard errors in parentheses are clustered at the sector-firm level. The dependent variable is the capital investment measured as the ratio of total capital expenditures to total assets. The logged variables are computed using the inverse hyperbolic function. The electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a three-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector. *** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculations using data from the EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table 5: Electricity crisis, energy vulnerability, and exporting

	(1)	(2)	(3)	(4)	(5)
Electricity crisis×energy vulnerability	-0.4838*	-0.5091*	-0.5275*		
	(0.283)	(0.285)	(0.286)		
Energy vulnerability	0.0414**	0.0458**			
	(0.021)	(0.021)			
Electricity crisis×energy vulnerability (backward)				-0.2848	-0.2922
				(0.255)	(0.255)
Energy vulnerability (backward)				0.0336*	
				(0.018)	
Electricity crisis×energy vulnerability (forward)				-0.4765*	-0.4961*
				(0.262)	(0.263)
Energy vulnerability (forward)				0.0273	
				(0.020)	
Age (log)		0.1145***	0.1148***	0.1145***	0.1147***
		(0.009)	(0.009)	(0.009)	(0.009)
Foreign ownership		0.0013	0.0018	0.0013	0.0018
		(0.010)	(0.010)	(0.010)	(0.010)
Firm size		0.0556***	0.0552***	0.0555***	0.0552***
		(0.010)	(0.010)	(0.010)	(0.010)
Labor productivity (log)		0.0099***	0.0099***	0.0099***	0.0099***
		(0.001)	(0.001)	(0.001)	(0.001)
Foreign connection		0.0024	0.0024	0.0025	0.0025
		(0.008)	(0.008)	(0.008)	(0.008)
Work capital (log)		0.0001	0.0001	0.0001	0.0001
		(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.3871***	-0.1435***	-0.1344***	-0.1428***	-0.1344***
	(0.004)	(0.036)	(0.036)	(0.036)	(0.036)
# Observations	119,549	117,830	117,830	117,830	117,830
R-squared	0.823	0.824	0.824	0.824	0.824
Controls	NO	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES
Sector FE	NO	NO	YES	NO	YES

Note: standard errors in parentheses are clustered at the sector-firm level. The dependent variable is a dummy variable that takes the value of one if a firm exports and zero otherwise. The electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a three-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector. *** $p<0.01$, ** $p<0.05$, * $p<0.10$

Source: authors' calculations using data from the EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table 6: Ownership structure and the real effects of the electricity crisis

	Jobs		Investment		Export	
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Domestic firms					
Electricity crisis×energy vulnerability	-1.9872***	-1.9861***	-0.4933***	-0.4849***	-0.5204*	-0.5399*
	(0.654)	(0.655)	(0.178)	(0.179)	(0.298)	(0.299)
Energy vulnerability	0.0862*		0.0313**		0.0504**	
	(0.048)		(0.013)		(0.022)	
Constant	4.3842***	4.4029***	0.4100***	0.4164***	-0.1120***	-0.1017***
	(0.158)	(0.158)	(0.023)	(0.023)	(0.037)	(0.036)
Controls	YES	YES	YES	YES	YES	YES
# Observations	113,565	113,565	113,565	113,565	113,565	113,565
R-squared	0.928	0.928	0.776	0.776	0.819	0.819
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	YES	NO	YES
	Panel B: Foreign firms					
Electricity crisis×energy vulnerability	-3.9362	-4.0069	0.4493	0.4917	-0.1748	-0.1517
	(2.785)	(2.837)	(0.640)	(0.654)	(1.022)	(1.058)
Energy vulnerability	1.0176**		0.0168		-0.1002	
	(0.475)		(0.046)		(0.069)	
Constant	3.6148***	3.8347***	0.3240***	0.3309***	0.2205	0.2116
	(0.429)	(0.415)	(0.069)	(0.070)	(0.174)	(0.176)
Controls	YES	YES	YES	YES	YES	YES
# Observations	3,990	3,990	3,990	3,990	3,990	3,990
R-squared	0.952	0.953	0.858	0.860	0.839	0.840
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	YES	NO	YES

Note: standard errors clustered at the sector-firm level in parentheses. All columns contain unreported firm characteristics as contained in Tables 1–3. The dependent variable in columns 1 and 2 is the log of total number of employees. The dependent variable in columns 3 and 4 is capital investment measured as the ratio of total capital expenditure to total asset. The dependent variable in columns 5 and 6 is a dummy variable that takes the value of one if a firm exports and zero otherwise. The electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a three-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector.
*** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculations using data from the EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table 7: Financial status and the real effects of the electricity crisis

	Jobs		Investment		Export	
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Financially constrained					
Electricity crisis×energy vulnerability	-2.0503***	-2.0497***	-0.4888**	-0.4777**	-0.5764*	-0.6054*
	(0.711)	(0.713)	(0.209)	(0.209)	(0.329)	(0.330)
Energy vulnerability	0.1099**		0.0331**		0.0516**	
	(0.051)		(0.015)		(0.023)	
Constant	4.1896***	4.2115***	0.4056***	0.4131***	-0.1797***	-0.1698***
	(0.163)	(0.163)	(0.025)	(0.024)	(0.038)	(0.038)
Controls	YES	YES	YES	YES	YES	YES
# Observations	102,016	102,016	102,016	102,016	102,016	102,016
R-squared	0.916	0.916	0.766	0.766	0.805	0.805
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	YES	NO	YES
	Panel B: Financially unconstrained					
Electricity crisis×energy vulnerability	-0.6540	-0.6443	-0.3904	-0.3973	0.3858	0.3550
	(1.414)	(1.438)	(0.263)	(0.265)	(0.553)	(0.558)
Energy vulnerability	0.1533		0.0244		-0.0080	
	(0.180)		(0.021)		(0.047)	
Constant	4.6742***	4.7266***	0.1815***	0.1823***	0.2387**	0.2390**
	(0.397)	(0.388)	(0.041)	(0.041)	(0.111)	(0.110)
Controls	YES	YES	YES	YES	YES	YES
# Observations	15,607	15,607	15,607	15,607	15,607	15,607
R-squared	0.943	0.943	0.856	0.856	0.844	0.845
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	YES	NO	YES

Note: standard errors clustered at the sector-firm level in parentheses. All columns contain unreported firm characteristics as contained in Tables 1–3. The dependent variable in columns 1 and 2 is the log of total number of employees. The dependent variable in columns 3 and 4 is capital investment measured as the ratio of total capital expenditures to total assets. The dependent variable in columns 5 and 6 is a dummy variable that takes the value of one if a firm exports and zero otherwise. The electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a three-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector. *** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculations using data from the EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table 8: Firm size and the real effects of the electricity crisis

	Jobs		Investment		Export	
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Small and medium firms					
Electricity crisis×energy vulnerability	-2.1476***	-2.1409***	-0.4668**	-0.4612**	-0.6400**	-0.6578**
	(0.664)	(0.665)	(0.182)	(0.182)	(0.302)	(0.302)
Energy vulnerability	0.0998**		0.0306**		0.0506**	
	(0.048)		(0.013)		(0.022)	
Constant	4.0480***	4.0695***	0.4073***	0.4136***	-0.1688***	-0.1586***
	(0.149)	(0.148)	(0.022)	(0.022)	(0.037)	(0.037)
Controls	YES	YES	YES	YES	YES	YES
# Observations	112,001	112,001	112,001	112,001	112,001	112,001
R-squared	0.916	0.916	0.776	0.776	0.815	0.815
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	YES	NO	YES
	Panel B: Large firms					
Electricity crisis×energy vulnerability	-3.6770**	-4.1566***	-0.1831	-0.1081	0.1474	0.1904
	(1.533)	(1.563)	(0.465)	(0.472)	(0.778)	(0.798)
Energy vulnerability	0.3039		-0.0009		0.0655	
	(0.189)		(0.039)		(0.055)	
Constant	16.6565***	16.6769***	0.5546***	0.5315***	0.6193***	0.6280***
	(0.698)	(0.720)	(0.102)	(0.102)	(0.186)	(0.190)
Controls	YES	YES	YES	YES	YES	YES
# Observations	5,539	5,539	5,539	5,539	5,539	5,539
R-squared	0.977	0.978	0.844	0.846	0.865	0.865
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	YES	NO	YES

Note: standard errors clustered at the sector-firm level in parentheses. All columns contain unreported firm characteristics as contained in Tables 1–3. The dependent variable in columns 1 and 2 is the log of total number of employees. The dependent variable in columns 3 and 4 is capital investment measured as the ratio of total capital expenditures to total assets. The dependent variable in columns 5 and 6 is a dummy variable that takes the value of one if a firm exports and zero otherwise. The electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a three-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector. *** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculations using data from the EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table 9: Firm age and the real effects of the electricity crisis

	Jobs		Investment		Export	
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Younger firms					
Electricity crisis×energy vulnerability	-1.5216	-1.5226	-0.5572*	-0.5772*	-0.5886	-0.6013
	(1.193)	(1.197)	(0.302)	(0.303)	(0.476)	(0.477)
Energy vulnerability	0.1003		0.0237		0.0515	
	(0.086)		(0.020)		(0.032)	
Constant	5.1366***	5.1577***	0.3035***	0.3085***	0.1358***	0.1490***
	(0.161)	(0.161)	(0.018)	(0.017)	(0.030)	(0.029)
Controls	YES	YES	YES	YES	YES	YES
# Observations	58,142	58,142	58,142	58,142	58,142	58,142
R-squared	0.920	0.920	0.775	0.775	0.820	0.821
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	YES	NO	YES
	Panel B: Older firms					
Electricity crisis×energy vulnerability	-2.4465***	-2.4869***	-0.5203**	-0.5148**	-0.4046	-0.4196
	(0.810)	(0.812)	(0.225)	(0.225)	(0.405)	(0.406)
Energy vulnerability	0.0815		0.0392**		0.0470	
	(0.059)		(0.017)		(0.031)	
Constant	5.4876***	5.5036***	0.2214***	0.2302***	0.3483***	0.3574***
	(0.204)	(0.204)	(0.017)	(0.017)	(0.030)	(0.029)
Controls	YES	YES	YES	YES	YES	YES
# Observations	57,892	57,892	57,892	57,892	57,892	57,892
R-squared	0.948	0.948	0.814	0.814	0.837	0.838
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	YES	NO	YES

Note: standard errors clustered at the sector-firm level in parentheses. All columns contain unreported firm characteristics as contained in Tables 1–3. The dependent variable in columns 1 and 2 is the log of total number of employees. The dependent variable in columns 3 and 4 is capital investment measured as the ratio of total capital expenditures to total assets. The dependent variable in columns 5 and 6 is a dummy variable that takes the value of one if a firm exports and zero otherwise. The electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a three-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector. *** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculations using data from the EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

A Appendix

Table A1: Concordance table between CIT-IRP5 and Quantec

SIC Sectors in the CIT-IRP5 dataset	SIC sectors in the Quantec dataset	QSIC	merge_
Processing and preserving of fruit and vegetables Processing and preserving of fish, crustaceans and molluscs Processing and preserving of meat	Intermediate Input: Meat, fish, fruit etc. [QSIC 301]	301	m:1
Manufacture of dairy products	Intermediate Input: Dairy products [QSIC 302]	302	1:1
Manufacture of grain mill products, starches and starch products	Intermediate Input: Grain mill products [QSIC 303]	303	1:1
Manufacture of vegetable and animal oils and fats Manufacture of prepared animal feeds	Intermediate Input: Other food products [QSIC 304]	304	m:1
Manufacturing of beverages	Intermediate Input: Beverages [QSIC 305]	305	1:1
Manufacture of tobacco products	Intermediate Input: Tobacco [QSIC 306]	306	1:1
Spinning, weaving and finishing of textiles	Intermediate Input: Textiles [QSIC 311]	311	1:1
Manufacture of other textiles	Intermediate Input: Other textile products [QSIC 312]	312	1:1
Manufacture of knitted and crocheted apparel	Intermediate Input: Knitted, crocheted articles [QSIC 313]	313	1:1
Manufacturing of wearing apparel, except fur apparel	Intermediate Input: Wearing apparel [QSIC 314]	314	1:1
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery and harness; dressing and dyeing of fur Manufacture of articles of fur	Intermediate Input: Leather and leather and fur products [QSIC 315-316]	315_316	m:1
Manufacture of footwear	Intermediate Input: Footwear [QSIC 317]	317	1:1
Sawmilling and planing of wood	Intermediate Input: Sawmilling and planing of wood [QSIC 321]	321	1:1
Manufacture of products of wood, cork, straw and plaiting materials	Intermediate Input: Products of wood [QSIC 322]	322	1:1
Manufacture of paper and paper products	Intermediate Input: Paper and paper products [QSIC 323]	323	1:1
Reproduction of recorded media Printing and service activities related to printing	Intermediate Input: Printing, recorded media [QSIC 324-326]	324_326	m:1
Manufacture of coke oven products Manufacture of refined petroleum products	Intermediate Input: Coke, petroleum products and nuclear fuel [QSIC 331-333]	331_333	m:1
Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms Manufacture of pharmaceuticals, medicinal chemical and botanical products	Intermediate Input: Basic chemicals [QSIC 334]	334	m:1
Manufacture of other chemicals products	Intermediate Input: Other chemical products [QSIC 335-336]	335_336	1:1
Manufacture of rubber products	Intermediate Input: Rubber products [QSIC 337]	337	1:1
Manufacture of plastic products	Intermediate Input: Plastic products [QSIC 338]	338	1:1
Manufacture of glass and glass products	Intermediate Input: Glass and glass products [QSIC 341]	341	1:1
Manufacture of non-metallic mineral products n.e.c	Intermediate Input: Non-metallic mineral products [QSIC 342]	342	1:1
Manufacture of basic iron and steel	Intermediate Input: Basic iron and steel products [QSIC 351]	351	1:1
Manufacture of basic precious and other non-ferrous metals	Intermediate Input: Non-ferrous metal products [QSIC 352]	352	1:1
Manufacture of structural metal products, tanks, reservoirs and steam generators	Intermediate Input: Structural metal products [QSIC 354]	354	1:1
Manufacture of other fabricated metal products; metalworking service activities	Intermediate Input: Other fabricated metal products [QSIC 355]	355	1:1

Manufacture of general-purpose machinery	Intermediate Input: General purpose machinery [QSIC 356]	356	1:1
Manufacture of special-purpose machinery	Intermediate Input: Special purpose machinery [QSIC 357]	357	1:1
Manufacture of domestic appliances (electric, gas or other fuel) (for manufacture of commercial and industrial appliances, see division 28)	Intermediate Input: Household appliances [QSIC 358]	358	1:1
Manufacture of computers and peripheral equipment	Intermediate Input: Office, accounting, computing machinery [QSIC 359]	359	1:1
Manufacture of electronic components and boards	Intermediate Input: Electric motors, generators, transformers [QSIC 361] + Intermediate Input: Electricity distribution and control apparatus [QSIC 362]	361_362	m:m
Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus			
Manufacture of wiring and wiring devices	Intermediate Input: Insulated wire and cables [QSIC 363]	363	1:1
Manufacture of electric lighting equipment	Intermediate Input: Other electrical equipment [QSIC 364-366]	364_366	m:1
Manufacture of other electrical equipment			
Manufacture of consumer electronics	Intermediate Input: Radio, television and communication apparatus [QSIC 371-373]	371_373	m:1
Manufacture of communication equipment			
Manufacture of medical and dental instruments and supplies	Intermediate Input: Professional equipment [QSIC 374-376]	374_376	m:1
Manufacture of irradiation, electromedical and electrotherapeutic equipment			
Manufacture of optical instruments and photographic equipment			
Manufacture of measuring, testing, navigating and control equipment; watches and clocks (for manufacture of optical measuring and checking devices and instruments (e.g. fire control equipment, photographic light meters, range finders), see 2670)			
Manufacture of magnetic and optical media (for reproduction of recorded media (computer media, sound, video, etc.), see 1820)			
Manufacture of motor vehicles (for manufacture of bodies for motor vehicles, see 2920)	Intermediate Input: Motor vehicles [QSIC 381-382]	381_382	m:1
Manufacture of military fighting vehicles			
Manufacture of parts and accessories for motor vehicles	Intermediate Input: Parts and accessories [QSIC 383]	383	m:1
Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers			
Manufacture of other transport equipment n.e.c	Intermediate Input: Other transport equipment [QSIC 384-387]	384_387	1:1
Manufacture of furniture (for manufacture of furniture of ceramics, concrete and stone, see 2393, 2395, 2396)	Intermediate Input: Furniture [QSIC 391]	391	1:1
Other manufacturing n.e.c.	Intermediate Input: Other manufacturing groups [QSIC 392-395]	392_395	1:1

Note: 1:1 is the unique merge i.e. one to one merge. m:1 means many to one merge, while m:m means many to many merge. In the case of m:1 and m:m, we use the median energy vulnerability intensity.

Source: authors' calculation using data from National Treasury and UNU-WIDER (2023), Ndubuisi et al. (2024), and Quantec Statistical Database (2023).

Table A2: Electricity crisis, energy vulnerability, and export intensity

	(1)	(2)	(3)	(4)	(5)
Electricity crisis×Energy vulnerability	-5.7967**	-5.6918**	-5.7096**		
	(2.465)	(2.452)	(2.466)		
Energy vulnerability	0.4423**	0.4565***			
	(0.177)	(0.175)			
Electricity crisis×Energy vulnerability (Backward)				-4.0043*	-3.9856*
				(2.146)	(2.158)
Energy vulnerability (Backward)				0.2920*	
				(0.152)	
Electricity crisis×Energy vulnerability (Forward)				-4.4044*	-4.4635*
				(2.442)	(2.451)
Energy vulnerability (Forward)				0.3862**	
				(0.163)	
Age (log)		0.7137***	0.7119***	0.7136***	0.7120***
		(0.091)	(0.091)	(0.091)	(0.091)
Foreign Ownership		0.0616	0.0616	0.0616	0.0616
		(0.062)	(0.062)	(0.062)	(0.062)
Firm size		0.4550***	0.4546***	0.4549***	0.4544***
		(0.067)	(0.067)	(0.067)	(0.067)
Labor productivity (log)		0.1102***	0.1100***	0.1102***	0.1100***
		(0.015)	(0.015)	(0.015)	(0.015)
Foreign connection		0.1540***	0.1535***	0.1542***	0.1538***
		(0.056)	(0.056)	(0.056)	(0.057)
Work capital (log)		0.0037***	0.0037***	0.0037***	0.0037***
		(0.001)	(0.001)	(0.001)	(0.001)
Constant	13.4201***	9.1649***	9.2700***	9.1658***	9.2712***
	(0.030)	(0.399)	(0.397)	(0.399)	(0.397)
Observations	45,761	44,984	44,984	44,984	44,984
R-squared	0.812	0.814	0.814	0.814	0.814
Controls	NO	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES
Sector FE	NO	NO	YES	NO	YES

Note: standard errors in parentheses are clustered at the sector-firm level. The dependent variable is the log of positive export values. Age, labor productivity and working capital is log transformed using the inverse hyperbolic function. Electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a three-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector.

*** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculation using data from EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table A3: The real effect of electricity crisis: Robust standard error

	Jobs			Investment			Export		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Electricity crisis×Energy vulnerability	-1.8254***	-1.8212***		-0.4588***	-0.4504***		-0.5091**	-0.5275***	
	(0.391)	(0.392)		(0.107)	(0.107)		(0.203)	(0.204)	
Energy vulnerability	0.0986***			0.0310***			0.0458**		
	(0.038)			(0.010)			(0.019)		
Electricity crisis×Energy vulnerability (Backward)			-0.7502**			-0.2586***			-0.2848
			(0.342)			(0.094)			(0.181)
Energy vulnerability (Backward)			0.0817***			0.0235***			0.0336**
			(0.031)			(0.009)			(0.016)
Electricity crisis×Energy vulnerability (Forward)			-2.1025***			-0.4599***			-0.4765**
			(0.361)			(0.103)			(0.186)
Energy vulnerability (Forward)			0.0529			0.0230**			0.0273
			(0.037)			(0.010)			(0.018)
Constant	3.9799***	4.0012***	3.9807***	0.3980***	0.4044***	0.3979***	-0.1435***	-0.1344***	-0.1428***
	(0.102)	(0.101)	(0.102)	(0.015)	(0.015)	(0.015)	(0.028)	(0.027)	(0.028)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
# Observations	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830
R-squared	0.931	0.931	0.931	0.777	0.777	0.777	0.824	0.824	0.824
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Note: robust standard errors in parathesis. All columns contain unreported firm characteristics as contained in Tables 1-3. The dependent variable in columns 1-3 is the log of total number of employees. The dependent variable in columns 4-6 is capital investment measured as the ratio of total capital expenditure to total asset. The dependent variable in columns 7-9 is a dummy variable that takes the value of one if a firm exports, and zero if otherwise. Electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a three-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector.
*** p<0.01, ** p<0.05, * p<0.10
Source: authors' calculation using data from EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table A4: The real effect of electricity crisis: Standard error clustered at the firm level

	Jobs			Investment			Export		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Electricity crisis×Energy vulnerability	-1.8254***	-1.8212***		-0.4588***	-0.4504***		-0.5091*	-0.5275**	
	(0.604)	(0.605)		(0.160)	(0.161)		(0.268)	(0.268)	
Energy vulnerability	0.0986*			0.0310**			0.0458**		
	(0.054)			(0.014)			(0.022)		
Electricity crisis×Energy vulnerability (Backward)			-0.7502			-0.2586*			-0.2848
			(0.533)			(0.140)			(0.238)
Energy vulnerability (Backward)			0.0817*			0.0235**			0.0336*
			(0.045)			(0.012)			(0.019)
Electricity crisis×Energy vulnerability (Forward)			-2.1025***			-0.4599***			-0.4765*
			(0.554)			(0.155)			(0.245)
Energy vulnerability (Forward)			0.0529			0.0230*			0.0273
			(0.051)			(0.013)			(0.021)
Constant	3.9799***	4.0012***	3.9807***	0.3980***	0.4044***	0.3979***	-0.1435***	-0.1344***	-0.1428***
	(0.134)	(0.134)	(0.134)	(0.020)	(0.020)	(0.020)	(0.034)	(0.034)	(0.034)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830
R-squared	0.931	0.931	0.931	0.777	0.777	0.777	0.824	0.824	0.824
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	NO	YES	NO	NO	YES	NO

Note: clustered standard errors in parathesis. All columns contain unreported firm characteristics as contained in Tables 1-3. The dependent variable in columns 1-3 is the log of total number of employees. The dependent variable in columns 4-6 is capital investment measured as the ratio of total capital expenditure to total asset. The dependent variable in columns 7-9 is a dummy variable that takes the value of one if a firm exports, and zero if otherwise. Electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a three-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector. *** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculation using data from EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table A5: The real effect of electricity crisis: Standard error clustered at the sector level

	Jobs			Investment			Export		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Electricity crisis×Energy vulnerability	-1.8254*	-1.8212*		-0.4588*	-0.4504*		-0.5091*	-0.5275**	
	(0.914)	(0.914)		(0.263)	(0.264)		(0.261)	(0.259)	
Energy vulnerability	0.0986*			0.0310*			0.0458**		
	(0.057)			(0.017)			(0.021)		
Electricity crisis×Energy vulnerability (Backward)			-0.7502			-0.2586			-0.2848
			(0.970)			(0.191)			(0.334)
Energy vulnerability (Backward)			0.0817			0.0235*			0.0336*
			(0.052)			(0.013)			(0.018)
Electricity crisis×Energy vulnerability (Forward)			-2.1025***			-0.4599			-0.4765**
			(0.669)			(0.281)			(0.205)
Energy vulnerability (Forward)			0.0529			0.0230			0.0273
			(0.051)			(0.016)			(0.021)
Constant	3.9799***	4.0012***	3.9807***	0.3980***	0.4044***	0.3979***	-0.1435***	-0.1344**	-0.1428***
	(0.208)	(0.205)	(0.208)	(0.021)	(0.021)	(0.021)	(0.049)	(0.051)	(0.049)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
# Observations	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830
R-squared	0.931	0.931	0.931	0.777	0.777	0.777	0.824	0.824	0.824
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	NO	YES	NO	NO	YES	NO

Note: clustered standard errors in parathesis. All columns contain unreported firm characteristics as contained in Tables 1-3. The dependent variable in columns 1-3 is the log of total number of employees. The dependent variable in columns 4-6 is capital investment measured as the ratio of total capital expenditure to total asset. The dependent variable in columns 7-9 is a dummy variable that takes the value of one if a firm exports, and zero if otherwise. Electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a three-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector.

*** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculation using data from EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table A6: The real effect of electricity crisis: the role of confounding factors

	Jobs		Investment		Export	
	(1)	(2)	(3)	(4)	(5)	(6)
Electricity crisis×Energy vulnerability	-3.0037***	-2.8013***	-0.5203**	-0.5180**	-0.6319*	-0.6547**
	(0.802)	(0.771)	(0.205)	(0.202)	(0.339)	(0.328)
Energy vulnerability	0.1732***		0.0285*		0.0447*	
	(0.062)		(0.015)		(0.025)	
Electricity crisis×Labourproductivity	0.0080	0.0074	0.0020	0.0021	0.0079	0.0077
	(0.011)	(0.011)	(0.003)	(0.003)	(0.005)	(0.005)
Labor productivity	0.0001		0.0001		-0.0000	
	(0.001)		(0.000)		(0.000)	
Electricity crisis×Capitallabourratio	4.5859***	3.3856***	0.2066	0.2284	0.4503	0.4599
	(1.557)	(1.216)	(0.401)	(0.306)	(0.722)	(0.566)
Capital labor ratio	-0.1492		0.0148		0.0318	
	(0.117)		(0.030)		(0.054)	
Electricity crisis×tradeopen	0.0180	-0.0311	-0.0670**	-0.0685**	0.0360	0.0333
	(0.135)	(0.134)	(0.033)	(0.032)	(0.068)	(0.066)
Trade openness	0.0040		0.0060**		-0.0014	
	(0.009)		(0.003)		(0.005)	
Electricity crisis×Realoutput	-0.0499	0.1117	-0.0561	-0.0563**	0.0291	0.0320
	(0.165)	(0.097)	(0.046)	(0.027)	(0.074)	(0.044)
Real output	-0.0192*		0.0034		-0.0065	
	(0.011)		(0.003)		(0.005)	
Constant	3.9296***	3.9143***	0.3627***	0.4260***	-0.1613**	-0.1868***
	(0.194)	(0.158)	(0.042)	(0.029)	(0.073)	(0.050)
Controls	YES	YES	YES	YES	YES	YES
Observations	117,830	117,830	117,830	117,830	117,830	117,830
R-squared	0.931	0.931	0.777	0.777	0.824	0.824
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	YES	NO	YES

Note: standard errors clustered at the sector-firm level in parentheses. All columns contain unreported firm characteristics as contained in Tables 1-3. The dependent variable in columns 1 and 2 is the log of total number of employees. The dependent variable in columns 3 and 4 is capital investment measured as the ratio of total capital expenditure to total asset. The dependent variable in columns 5 and 6 is a dummy variable that takes the value of one if a firm exports, and zero if otherwise. Electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a three-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector. Note that labor productivity, capital labor ratio, trade openness, and real output displayed in the sector are at the sector level and the original series used to construct them are from the Quantec statistical database. *** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculation using data from EIA (2024) database, National Treasury and UNU-WIDER (2023), Quantec Statistical Database (2023), and Ndubuisi et al. (2024).

Table A7: The real effect of electricity crisis: Alternative electricity crisis indicator (1)

	Jobs			Investment			Export		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Electricity crisis×Energy vulnerability	-1.5061***	-1.4986***		-0.3019**	-0.2952**		-0.4517**	-0.4647**	
	(0.511)	(0.512)		(0.136)	(0.137)		(0.229)	(0.229)	
Energy vulnerability	0.1003**			0.0272**			0.0480**		
	(0.049)			(0.012)			(0.021)		
Electricity crisis×Energy vulnerability (Backward)			-0.5937			-0.1651			-0.2817
			(0.448)			(0.120)			(0.204)
Energy vulnerability (Backward)			0.0812**			0.0211**			0.0365**
			(0.040)			(0.011)			(0.017)
Electricity crisis×Energy vulnerability (Forward)			-1.7648***			-0.3175**			-0.3925*
			(0.476)			(0.132)			(0.211)
Energy vulnerability (Forward)			0.0557			0.0200*			0.0276
			(0.046)			(0.012)			(0.020)
Constant	3.9793***	4.0010***	3.9802***	0.3979***	0.4035***	0.3978***	-0.1436***	-0.1341***	-0.1430***
	(0.142)	(0.141)	(0.142)	(0.021)	(0.021)	(0.021)	(0.036)	(0.036)	(0.036)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
# Observations	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830
R-squared	0.931	0.931	0.931	0.777	0.777	0.777	0.824	0.824	0.824
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	NO	YES	NO	NO	YES	NO

Note: standard errors in parentheses are clustered at the sector-firm level. All columns contain unreported firm characteristics as contained in Tables 1-3. The dependent variable in columns 1-3 is the log of total number of employees. The dependent variable in columns 4-6 is capital investment measured as the ratio of total capital expenditure to total asset. The dependent variable in columns 7-9 is a dummy variable that takes the value of one if a firm exports, and zero if otherwise. Electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a five-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector. *** p<0.01, ** p<0.05, * p<0.10.

Source: authors' calculation using data from EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table A8: The real effect of electricity crisis: Alternative electricity crisis indicator (2)

	Jobs			Investment			Export		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Electricity crisis×Energy vulnerability	-1.4908***	-1.4876***		-0.2966**	-0.2903**		-0.4713**	-0.4847**	
	(0.523)	(0.524)		(0.139)	(0.140)		(0.237)	(0.238)	
Energy vulnerability	0.1123**			0.0294**			0.0531**		
	(0.052)			(0.013)			(0.022)		
Electricity crisis×Energy vulnerability (Backward)			-0.5499			-0.1543			-0.3060
			(0.458)			(0.122)			(0.213)
Energy vulnerability (Backward)			0.0836*			0.0218*			0.0405**
			(0.043)			(0.011)			(0.019)
Electricity crisis×Energy vulnerability (Forward)			-1.7932***			-0.3256**			-0.4012*
			(0.486)			(0.135)			(0.217)
Energy vulnerability (Forward)			0.0724			0.0232*			0.0316
			(0.049)			(0.013)			(0.021)
Constant	3.9791***	4.0034***	3.9799***	0.3979***	0.4039***	0.3978***	-0.1437***	-0.1330***	-0.1431***
	(0.142)	(0.141)	(0.142)	(0.021)	(0.021)	(0.021)	(0.036)	(0.036)	(0.036)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
# Observations	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830
R-squared	0.931	0.931	0.931	0.777	0.777	0.777	0.824	0.824	0.824
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	NO	YES	NO	NO	YES	NO

Note: standard errors in parentheses are clustered at the sector-firm level. All columns contain unreported firm characteristics as contained in Tables 1-3. The dependent variable in columns 1-3 is the log of total number of employees. The dependent variable in columns 4-6 is capital investment measured as the ratio of total capital expenditure to total asset. The dependent variable in columns 7-9 is a dummy variable that takes the value of one if a firm exports, and zero if otherwise. Electricity crisis is computed as the rolling standard deviation of electricity capacity factor (ECF) over a seven-year window. Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector. *** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculation using data from EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table A9: The real effect of electricity crisis: Alternative electricity crisis indicator (3)

	Jobs			Investment			Export		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Electricity crisis×Energy vulnerability	-0.4576***	-0.4572***		-0.1040**	-0.1019**		-0.1584**	-0.1629**	
	(0.161)	(0.162)		(0.043)	(0.043)		(0.072)	(0.072)	
Energy vulnerability	-4.1790***			-0.9430**			-1.4294**		
	(1.480)			(0.392)			(0.660)		
Electricity crisis×Energy vulnerability (Backward)			-0.1763			-0.0556			-0.1008
			(0.142)			(0.037)			(0.064)
Energy vulnerability (Backward)			-1.5685			-0.4979			-0.9032
			(1.299)			(0.344)			(0.591)
Electricity crisis×Energy vulnerability (Forward)			-0.5431***			-0.1102***			-0.1357**
			(0.150)			(0.042)			(0.066)
Energy vulnerability (Forward)			-5.0212***			-1.0076***			-1.2382**
			(1.376)			(0.382)			(0.607)
Constant	3.9796***	3.0418***	3.9805***	0.3980***	0.1901**	0.3979***	-0.1436***	-0.4751***	-0.1429***
	(0.142)	(0.362)	(0.142)	(0.021)	(0.091)	(0.021)	(0.036)	(0.155)	(0.036)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
# Observations	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830
R-squared	0.931	0.931	0.931	0.777	0.777	0.777	0.824	0.824	0.824
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	NO	YES	NO	NO	YES	NO

Note: standard errors in parentheses are clustered at the sector-firm level. All columns contain unreported firm characteristics as contained in Tables 1-3. The dependent variable in columns 1-3 is the log of total number of employees. The dependent variable in columns 4-6 is capital investment measured as the ratio of total capital expenditure to total asset. The dependent variable in columns 7-9 is a dummy variable that takes the value of one if a firm exports, and zero if otherwise. Electricity crisis is computed as electricity capacity factor (ECF) multiplied by a negative constant (-1). Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector. *** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculation using data from EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

Table A10: The real effect of electricity crisis: Alternative electricity crisis indicator (4)

	Jobs			Investment			Export		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Electricity crisis×Energy vulnerability	-0.9899**	-0.9960**		-0.2987***	-0.2933***		-0.4557**	-0.4679**	
	(0.425)	(0.426)		(0.112)	(0.113)		(0.191)	(0.192)	
Energy vulnerability	-2.1537**			-0.6446***			-0.9763**		
	(0.933)			(0.247)			(0.421)		
Electricity crisis×Energy vulnerability (Backward)			-0.3435			-0.1647*			-0.3102*
			(0.376)			(0.099)			(0.173)
Energy vulnerability (Backward)			-0.7052			-0.3493			-0.6591*
			(0.825)			(0.216)			(0.379)
Electricity crisis×Energy vulnerability (Forward)			-1.2326***			-0.3067***			-0.3666**
			(0.393)			(0.110)			(0.176)
Energy vulnerability (Forward)			-2.7447***			-0.6702***			-0.7981**
			(0.862)			(0.241)			(0.387)
Constant	3.9803***	3.4932***	3.9815***	0.3982***	0.2556***	0.3981***	-0.1433***	-0.3698***	-0.1427***
	(0.142)	(0.252)	(0.142)	(0.021)	(0.060)	(0.021)	(0.036)	(0.103)	(0.036)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830	117,830
R-squared	0.931	0.931	0.931	0.777	0.777	0.777	0.824	0.824	0.824
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Sector FE	NO	YES	NO	NO	YES	NO	NO	YES	NO

Note: standard errors in parentheses are clustered at the sector-firm level. All columns contain unreported firm characteristics as contained in Tables 1-3. The dependent variable in columns 1-3 is the log of total number of employees. The dependent variable in columns 4-6 is capital investment measured as the ratio of total capital expenditure to total asset. The dependent variable in columns 7-9 is a dummy variable that takes the value of one if a firm exports, and zero if otherwise. Electricity crisis is computed as the ratio between annual electricity generation to total population multiplied by a negative constant (-1). Energy vulnerability is computed as each sector's forward and backward dependence on the energy sector. *** p<0.01, ** p<0.05, * p<0.10

Source: authors' calculation using data from EIA (2024) database, National Treasury and UNU-WIDER (2023), and Ndubuisi et al. (2024).

B Data appendix

This data appendix is created in accordance with the requirements for users of the National Treasury Secure Data Facility (NT-SDF).

Data access

The data used for this research were accessed from the NT-SDF. Access was provided under a non-disclosure agreement, and our output was checked so that the anonymity of no firm or individual would be compromised. Our results do not represent any official statistics (NT or SARS). Similarly, the views expressed in our research are not the views of the NT or SARS.

Data structuring and cleaning

Our analysis relies on three primary sources: self-computed indicator of electricity crisis using information from the EIA database, energy vulnerability index from Ndubuisi et al. (2024) using the Quantec I-O Table for South Africa, and the custom transaction level dataset (citirp5_v5_0) (National Treasury and UNU-WIDER 2023). All our firm-level variables are drawn from the custom transaction dataset. To use the dataset, we first merge it with the incorporation year of each firm extracted from the IRP5, which is assessable from the NT-SDF. From the merged sample, we drop observations in the custom transaction data with negative or missing values for the following variables: sales, capital, employment, total asset, total current liabilities, and assets.

Table 1 provides a description of the firm-level characteristics drawn from the cleaned sample that we included in our analysis. Particularly, the variables on foreign connection and ownership structure are directly sourced from the database. The rest of the variables (jobs, export, size, labour productivity, financial status, working capital, ownership structure, and foreign connection) were computed using data series that were retrieved from the database, as described in Section 3.1 and Table 1. To identify the age of the firm, we use the incorporation year as a proxy.

To merge the citirp5_v5_0 data to the sector energy vulnerability index, we manually map the sector energy vulnerability index to the three-digit sectors with comparable names in the CIT-IRP5 datasets using the three-digit sector description in the Quantec I-O Table for South Africa. To maximize the mapping, we aggregated some of the sectors in the Quantec database to match to the three-digit SIC classification in the CIT-IRP5 datasets (see Table A1 in the Appendix). We successfully mapped the energy vulnerability index to 80 per cent of the three-digit manufacturing SIC sectors in the CIT-IRP5 datasets. About 51 per cent of these successfully mapped sectors were unique matches, while the rest were achieved after reaggregating the sectors in the Quantec dataset.