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Energy Prices, Energy Intensity, and Firm Performance

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Abstract

This paper estimates the effect of electricity prices on firm performance, focusing on firm productivity, sales, and employment. Using the World Bank Business Pulse Survey data for a sample of 24 emerging markets and developing economies during 2019–23, the paper estimates the average effect and the heterogeneous effects across industries of varying energy intensity and firms that implemented (or did not implement) energy efficiency measures (self-reported in the Business Pulse Survey). The findings show that increasing electricity prices by 1 percent reduces employment at firms in energy-intensive industries that did not adopt energy efficiency measures by about 1.5 percent, compared with similar firms in energy-non-intensive sectors. In parallel, energy-intensive firms may increase sales and productivity but this result is robust to all alternative specifications. Firms may increase sales while reducing employment after energy price hikes, by adopting energy-efficient technologies and by passing through costs to consumers in inelastic markets while reducing employment in energy-intensive sectors due to cost pressures. These results highlight the adoption of energy efficiency measures by firms as an important employment protection policy action to cope with future volatility in energy (electricity) prices.

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World Bank

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1. Introduction

The link between rising energy costs and firm performance has garnered increasing attention in academic and policy discussions due to the broader adoption of carbon pricing mechanisms and the gradual elimination of energy subsidies. As these policy changes elevate nonrenewable energy prices—a crucial input in the production processes of many industries—firms may experience notable performance implications. Higher energy costs generally affect profitability and operational efficiency by increasing production expenses, particularly in energy-intensive sectors. Firms with greater energy dependence often face heightened stock market volatility due to increased uncertainty and lower expected cash flows (Sadorsky 1999; Henriques & Sadorsky 2008). Moreover, rising energy costs may constrain corporate investment strategies, leading to reduced capital expenditures, especially in industries reliant on energy inputs (Kilian 2008; Bloom 2009).

The increased accessibility of firm-level data has opened new avenues for empirical studies of the complex link between energy price fluctuations and firm performance. Cali et al. (2022) show that, in Indonesia and Mexico, increases in electricity prices harm manufacturing plants' performance. However, fuel price hikes result in higher productivity and profits of manufacturing plants. Fuel prices incentivize plants to replace inefficient fuel-powered with more productive electricity-powered capital equipment. Their results help to re-evaluate the policy trade-off between reducing carbon emissions and improving economic performance, particularly in countries with large fuel subsidies, such as Indonesia and Mexico. Cali et al. (2023) studied firms from 12 sectors and 11 middle-income countries during 2002–2013, using World Bank Enterprise Survey data. The study did not consistently find that higher energy prices negatively affect economic performance; they may even enhance it in some cases. Firms might be able to offset increased energy costs through innovation or new market strategies. The impact of energy prices on firms is a multifaceted issue, depending on several characteristics, including energy intensity, firm size, ownership type, and previous experience with electricity outages—which made companies less sensitive to price increases, likely due to their familiarity with managing energy and input shortages.

The dynamic effects of energy price shocks on firm performance have also been explored. Andre et al. (2023) analyze firm-level data from 21 OECD countries (1995–2020) and show that energy price shocks impact firm productivity through immediate cost increases and longer-term adjustments. The study highlights sectoral and firm-level heterogeneity, finding that energy price hikes initially reduce productivity, particularly in energy-intensive sectors and firms under financial constraints. However, medium-term productivity improvements often follow as firms adapt, typically through increased investment. These findings align with the "pollution haven" hypothesis, which suggests that higher energy costs erode competitiveness and may drive firms to relocate (Copeland & Taylor 2004), and the Porter hypothesis, which posits that higher carbon prices can enhance productivity by incentivizing efficiency and innovation (Porter & van der Linde 1995). This dual perspective underscores the nuanced impact of energy price shocks on firm outcomes, blending short-term losses with potential long-term gains.

The recent energy price surge, triggered by the strong economic recovery following COVID-19 and the Russian invasion of Ukraine, has sparked renewed interest in the subject. Battistini et al. (2022) focus on EU economies during 2020-2022 and highlight a few interesting aspects. Energy price shocks disproportionately affect firms based on their energy dependence and hedging strategies. Energy-intensive sectors are particularly hard-hit, facing greater financial stress and profitability challenges due to heightened costs and supply chain disruptions. Spiking energy prices have triggered a significant worsening of the energy terms of trade in the euro area. This has impacted companies by reducing their purchasing power and increasing operational costs, affecting their profitability and investment decisions. Ari et al. (2022) employed the IMF-World Bank CPAT model and found clear evidence of a regressive impact on European households' finances. However, the effects on European businesses are less clear-cut, with mixed results regarding the loss of competitiveness. The increase in energy costs for energy-dependent and trade-sensitive industries within the European Union may not be disproportionately higher than for non-EU countries due to variations in natural gas reliance or the use of other energy products across different nations.

When evaluating the effects of fluctuating energy prices, the role of fossil fuel subsidies must be carefully considered. Accurately pricing fossil fuels is essential for the efficient allocation of an economy's scarce resources and investment across sectors and activities. An efficient price incorporates both the supply costs and the environmental externalities of fuel consumption (Coady et al. 2019). However, substantial subsidies or underpricing distort market signals, leading to the overconsumption of fossil fuels, exacerbating global warming, and intensifying local environmental degradation. For instance, Black et al. (2023) report that global fossil fuel subsidies reached an unprecedented $7 trillion in 2023, as governments sought to shield consumers and businesses from energy price spikes triggered by the Russian Federation's invasion of Ukraine and the post-pandemic economic recovery. These subsidies, while aimed at providing short-term relief, may have inadvertently delayed firms' and households' consideration of environmental costs in consumption and investment decisions. As a result, the adoption of energy-efficient technologies and sustainable practices has likely been postponed, undermining long-term climate goals (Bovenberg & de Mooij 1994; Parry et al. 2021).

Against this backdrop, this paper contributes to the existing body of research by focusing on the impact of country-specific energy price fluctuations during 2019-2023 on firms in emerging economies using the World Bank Business Pulse Survey—a dataset not used yet for this type of analysis in the literature—together with the CPRS classification of Battiston et al. (2022) to gauge the risk exposure of sectors to (the intensity of treatment by) the energy price fluctuations. Furthermore, the paper contributes to the literature by shedding light on the specific context of emerging economies, employing rapid survey data to grasp the nuances of business cycles, using the quarterly country-specific electricity price tariffs for businesses, matching the latter with the month in which a firm was surveyed, and highlighting the differentiated effects of sectoral energy intensity in conjunction with firm-level energy efficiency measures as indicators of a firm's exposure to energy price fluctuations and preparedness to manage energy price shocks.

Using a different data set with larger country coverage, our baseline findings confirm prior evidence from Cali et al. (2022, 2023) that electricity price increases, on average, lead to higher productivity and sales for firms. However, the magnitude of this positive effect is significantly reduced for firms that have not implemented energy efficiency measures, suggesting that such initiatives are critical for firms to adapt to evolving energy market trends. In addition, when the baseline results are subjected to a battery of robustness tests the results do not survive in all alternative specifications. By contrast, we find that rising electricity prices exert a negative effect on employment, particularly in energy-intensive industries where energy efficiency measures are absent. This result highlights the vulnerability of labor markets in sectors heavily reliant on energy (electricity) inputs, especially in developing economies where the adoption of efficiency-enhancing technologies often lags.

These findings align with evidence from Aldy and Pizer (2015), who show that energy-intensive firms are disproportionately affected by energy price increases due to their limited flexibility in reducing energy consumption. Similarly, Sato et al. (2019) emphasize the employment risks in sectors with high energy dependency, particularly in regions with limited policy support for energy efficiency. Our study's integration of industry-level energy intensity with firm-level adaptations provides a novel contribution by offering deeper insights into how electricity price changes propagate through different economic layers. Compared to earlier studies, such as Martin et al. (2014), which primarily focused on advanced economies or treated energy price impacts in aggregate terms, this paper uniquely highlights the heterogeneity of these effects across firms in developing countries, where structural constraints and varying levels of technological adoption exacerbate disparities in energy price impacts.

Our findings underline the importance of energy efficiency measures not only as a tool for enhancing productivity and sales, but also as a critical buffer against adverse employment effects associated with rising electricity prices. This aligns with evidence from Bloom et al. (2010), who emphasize that firm-level innovations, including energy efficiency improvements, are key to maintaining competitiveness during economic transitions. Our findings also complement those by Newell et al. (2021), which highlight the role of energy efficiency in mitigating the labor market disruptions associated with volatile energy prices, particularly in energy-intensive sectors.

By focusing on developing economies, this study expands the literature on energy price shocks—which has predominantly centered on advanced economies—and addresses critical gaps in understanding the shocks' differentiated effects. Consistent with Popp (2019), our results suggest that fostering widespread adoption of energy efficiency practices is essential for mitigating the employment risks of transitioning to greener energy systems. Particularly for energy-intensive industries in developing countries, these measures are crucial for safeguarding jobs and ensuring firms remain competitive amid fluctuating electricity prices and shifting global energy markets.

The rest of the paper is organized as follows. Section 2 describes the employed data. Section 3 explains the estimation methodology and identification. Section 4 discusses the estimation results and their robustness checks. Section 5 concludes.

2. Data

Our analysis uses data from the Business Pulse Surveys (BPS) developed by the World Bank to monitor the impact of the COVID-19 pandemic on the private sector. The questionnaire collects information on several dimensions of firm performance, spanning from basic economic indicators—such as the operating status of the business, year of establishment, sales, and employment—as well as firm-specific practices such as managerial practices, technology adoption, and implementation of energy-efficient measures. Firms were surveyed from April 2020 (about end-2019 performance) to June 2023 in several waves, providing a unique perspective on the private sector's response to the pandemic and the subsequent economic disturbances caused by the fast post-COVID-19 recovery, Russia's invasion of Ukraine, and the associated energy price surges and fluctuations.

Our sample comprises an unbalanced panel of 63,716 observations drawn from 24 countries across four regions (Eastern and Central Europe, Latin America and the Caribbean, South Asia and the Pacific, and Sub-

Saharan Africa).[1] Due to data availability issues, the analysis is limited to 16 countries. This reduction stems primarily from misreporting in the sales variable but is also due to incomplete data for control variables, and electricity prices; the latter is, for example, not available for Tajikistan. Furthermore, self-reported energy efficiency measures are not available in all countries. Consequently, regressions that include energy efficiency measures are based on data from 13 countries. The sample covers micro, small, medium, and large businesses across all main sectors (agriculture, manufacturing, retail, and other services, including construction).[2]

Table A1 (a-c) in the Annex describes the sample distribution across years, sectors, and firm sizes at the country level. This breakdown is instrumental for categorizing sectors by their energy usage intensity. The sectors are meticulously disaggregated to the most granular level the sampling methodology allows. Within the sample, agriculture accounts for 6 percent of the firms, manufacturing for 25 percent, wholesale and retail for 24 percent, and a diverse array of other services for 45 percent. Within the service sector, food services and accommodation represent 23 percent, transportation and information and communication technology (ICT) account for 13 percent, and construction for 12 percent. The remaining firms are engaged in financial activities, real estate, education, health, and other sectors.

Table A2 in the Annex shows the summary statistics of the main variables used in the analysis. The dependent variables used in the estimations are employment, sales, and sales per worker as a measure of labor productivity.[3,4] The median firm has sales of $12,312, 6 workers,[5] with a labor productivity of $1,950 per worker, and has been operating for 15 years. Figure 1 depicts the trends of our outcome variables, labor productivity, sales, and employment.

To address the effects of energy price shocks on firm performance, our paper carefully manages four critical aspects of the data. The first aspect involves classifying sectors based on their energy intensity following the Climate Policy Relevant Sectors (CPRS) framework introduced by Battiston et al. (2017). The CPRS taxonomy identifies energy-intensive sectors through a multifaceted lens, considering (i) the emissions produced by each sector's economic activities, (ii) the sector's contribution to the Greenhouse Gas (GHG) emissions chain, (iii) the sector's engagement in specific policy processes, including its lobbying capacity; and (iv) the transition risk associated with the sector, which inversely relates to the level of fuel substitutability. A sector is deemed energy-intensive if its activities result in emissions, utilizes fuel (or a mix of fuels) as a primary input, and has a low potential for substituting these fuels. The sector classification by energy usage is systematically outlined in Table A3 in the Annex.

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[1] For each country, the sample frame was based on the statistical data from the National Statistical Committees of each country at the time of the survey's first implementation. For the later survey waves, the list of companies was updated using lists of business associations and internal lists of entrepreneurs from the survey firm.

[2] It is also worth acknowledging that firm weights are unavailable, so the sample is not representative. However, the estimations control for firm characteristics, muting to some extent the composition effects.

[3] Sales per worker is a widely used proxy for labor productivity, offering a practical measure of output per unit of labor input, especially when value-added data are unavailable. Bloom et al. (2010) emphasize its effectiveness in capturing labor efficiency and management practices, while Syverson (2011) notes that it may reflect other factors, such as market power or capital intensity, which could distort comparisons. Despite these limitations, Bartelsman et al. (2004) highlight its importance in developing economies, where sales data often provide the most accessible alternative for productivity analysis.

[4] Sales and sales per worker are winsorized at the 5 and 95 percentiles.

[5] Few firms in the Philippines have more than 100,000 workers.

The second element is measuring energy price shocks. We use the commercial electricity rate shown in Figure 1, compiled quarterly by Global Petrol Prices for each country. For the countries included in the sample, electricity rates, on average, fell during 2020 and 2021, reaching their nadir in the last quarter of 2021. Subsequently, there was a recovery in the rates during 2022. The price fluctuation ranged from $0.03 to $0.38 per kWh. In the case of oil prices, the range was between $33.7 and $113.

The third aspect refers to fossil fuel subsidies. We measure this aspect using the IMF data (Black et al., 2023), which provide, for 170 countries, the estimates of explicit subsidies for fossil fuels, i.e., undercharging for the supply cost of fossil fuels. All but five countries in the dataset, among them Tajikistan, have no (zero) petroleum subsidies. In the case of explicit subsidies for electricity, only three countries in the dataset do not have subsidies. Considering countries with explicit subsidies, the petroleum subsidies range from 0.00004 to 3.58 percent of GDP, while electricity subsidies range from 0.04 to 9.76 percent of GDP. The distributions of such subsidies overtime are depicted in Figures 3 (panels a and b).

The fourth data aspect concerns firms' adoption of energy efficiency practices. This is a crucial factor because it can significantly influence a firm's resilience to energy price fluctuations. To account for these practices, we draw on data from the BPS, which features a module focused on firms' energy efficiency measures. The survey queries firms on implementing technologies or methods to improve energy usage efficiency. Those who have adopted energy efficiency solutions are prompted to detail the specific technologies or practices in use. These practices encompass questions about LEED certification for buildings, adopting efficient lighting systems, adherence to ISO 14001 or 50001 standards, or engagement in carbon trading schemes. About 38 percent of the surveyed firms acknowledge that they do not employ energy efficiency technologies or practices. Yet, this figure masks considerable cross-country heterogeneity. For example, in Armenia, 99 percent of the surveyed firms reported using at least one energy-saving approach. By contrast, in Paraguay, a striking 86 percent of firms indicated they do not engage in any such practices. For a more detailed breakdown, see Table A2 in the Annex.

3. Estimation methodology

To assess the impact of energy shocks on firm performance, we utilize the BPS sample for 24 developing countries over the 2019-2023 period, covering large fluctuations in country-level electricity prices. We hypothesize that a firm's susceptibility to the energy price shock is contingent on the shock's magnitude at a specific time, the firm's energy requirements for its operations that we assume are sector-specific, and any energy efficiency measures or lack thereof that can make the firm-level energy efficiency deviate from its sector’s average.

As explained in the data section, the variations in the shock intensity are quantified through the monthly electricity data for each country matched to firm surveys by the month of the firms’ interviews. The BPS data's unique advantage lies in recording the precise survey date for each firm, introducing firm-level variation in shock exposure across countries. This aspect is critical as the shock's magnitude is shown to vary from month to month (Figure 2). The energy usage intensity is determined based on CPRS classification; sectors such as manufacturing, construction, and transportation are categorized as energy-intensive, in contrast to agriculture, retail, and other services, which are classified as less energy-intensive using the Battiston et al. (2022) methodology which is predetermined at the global level and not influenced by firm or sector energy technology adoption at the country level.

We evaluate firm performance using three metrics: labor productivity (sales per worker) and, separately, sales and employment. Labor productivity is used due to the unavailability of value-added data (Bartelsman et al., 2004).[6] We hypothesize that firms with a higher degree of exposure to energy price increases may experience a reduction in sales, are likely to downsize and cut jobs, and could experience a drop in productivity because firm costs may rise faster than revenues, and some supply chain disruptions may reduce firms' ability to make profit-maximizing decisions. Additionally, we hypothesize that firms operating in energy-intensive (CPRS) sectors will be disproportionately affected, with the effect of energy prices on their performance further amplified.

The baseline regression to assess the effect of energy prices on firm performance is described in equation (1) where we focus on the energy price effect associated with fluctuations in electricity prices that we observe at the country level and can better identify and use the global prices of oil only as a control variable:

$$prf_{i,j,k,t} = \alpha \cdot pel_{k,t} + \beta \cdot cprs_j + \gamma \cdot pel_{k,t} \cdot cprs_j + \rho \cdot X_{i,t} + \pi_j + \theta_k + \mu_{k,t} + \omega_t + \varepsilon_{i,j,k,t} \quad (1)$$

where $prf_{i,j,k,t}$ is the performance of firm *i* in sector *j* in country *k* at time *t*, pel is the price of electricity that varies over time at the country level, $cprs$ is the sector-specific classification according to energy usage intensity, $X_{i,t}$ is a vector of firm control characteristics, including age and size clusters (micro, small, medium, large)[7] as well as the monthly global price of oil, μ_j are sector-specific dummies to account for sector-specific characteristics other than energy usage intensity, θ_k are country-level fixed effects to control for country characteristics that are invariant in the short term, such as institutions or market structures, $\mu_{k,t}$ are country-time fixed effects to control for time-varying macroeconomic conditions common for all firms in a given country that vary over time, ω_t are the time-fixed effects to control for time-varying global factors that affect all countries, sectors, and firms. The equation is estimated by OLS using robust standard errors. Weights are employed in the analysis to equalize the emphasis on smaller versus larger countries.

Note that relevant firm characteristics are carefully considered for each regression: to reduce omitted variable concerns, size dummies are incorporated when assessing labor productivity or sales as the dependent variables, while sales quartiles are used when employment is the dependent variable. The age of firms is controlled for because older firms may utilize energy efficiency practices and generate outcomes different from younger firms.[8] The overall effect of electricity price fluctuations on a firm in the energy-intensive (CPRS) sector is then given by: $\alpha + \gamma$.

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[6] Bartelsman et al. (2004) highlight its importance in developing economies, where sales data often provide the most accessible alternative for productivity analysis.

[7] Micro (1 to 5 employees), small (6 to 19), medium (20 to 99), large (100 or more employees); the omitted category in the regressions is "small". When the dependent variable is employment, size is determined based on the quartiles of sales, with the lowest quartile serving as the omitted category.

[8] The age of a firm significantly influences its performance, reflecting variations in experience, resource accumulation, and adaptability. Young firms often exhibit higher growth rates but face greater financial constraints and survival risks, as noted by Haltiwanger et al. (2013). In contrast, older firms benefit from established customer bases and operational efficiencies but may encounter innovation inertia (Huergo & Jaumandreu, 2004). Coad et al. (2016) find that firm age interacts with industry dynamics, where mature firms in competitive sectors must innovate to sustain performance.

Equation (2) introduces the energy inefficiency variable, efm_i, which identifies firms that do not implement any action to manage or reduce energy usage. Notice that the variable does not vary over time because it is only asked in the last wave of the follow-up surveys. There are three additional terms pertaining to efm_i: interacted with the electricity price, $pel_{k,t}$, interacted with the energy intensity dummy, $cprs_j$, and in a triple interaction with both the energy price and energy intensity vector. Because firms applying techniques to manage or reduce energy use will become less dependent on energy, we expect these firms to suffer less from the energy price increase. The interactions with electricity price, with the energy intense dummy, and the triple interaction will indicate whether firms that are more exposed to energy price shocks but have not introduced energy savings suffered more from the shock. We therefore expand equation (1) as follows:

$$prf_{i,j,k,t} = \alpha \cdot pel_{k,t} + \gamma \cdot pel_{k,t} \cdot cprs_j + \sigma \cdot pel_{k,t} \cdot efm_i + \varphi \cdot pel_{k,t} \cdot cprs_j \cdot efm_i + \beta \cdot cprs_j + \delta \cdot efm_i + \tau \cdot cprs_j \cdot efm_i + \rho \cdot X_{i,t} + \pi_j + \theta_k + \mu_{k,t} + \omega_t + \varepsilon_{i,j,k,t} \qquad (2)$$

Note that we do not use firm-level fixed effects in this specification because they are perfectly correlated with the efm_i variable that varies only across firms. The overall effect of electricity price fluctuations on a firm in an energy-intensive sector that did not implement any energy efficiency measures will be thus given by: $\alpha + \gamma + \sigma + \varphi$.

4. Estimation results

Table 1 reports the estimation results using labor productivity (sales per worker) and separately sales and employment as the dependent variables. The baseline estimation suggests that firms in energy-intensive sectors tend to be more productive and have higher sales (columns 1 and 2). Sales and productivity in energy-intensive industries can be higher due to economies of scale, technological advancements, and market dynamics. High capital intensity reduces per-unit costs as production scales (Hall & Weiss, 1967), while innovations enhance efficiency (Caves et al., 1982). Inelastic demand and energy-saving technologies further boost competitiveness (Pindyck, 1981; Aldy & Pizer, 2015).

Similarly, firms in energy-intensive sectors tend to employ more full-time workers than firms of similar age, size, and sectoral characteristics in non-energy-intensive industries. This result could also be associated with the anecdotal evidence that more firms in energy-intensive industries are state-owned, with state-owned firms being known for over-employment. Evidence suggests that energy-intensive industries often have a higher proportion of state-owned enterprises (SOEs), which are commonly associated with overemployment. For instance, Lin, Cai, and Li (1998) highlight the prevalence of SOEs in sectors like steel production and coal mining, driven by social objectives such as employment stabilization rather than efficiency. Jefferson and Rawski (1994) and Dong and Putterman (2000) find that SOEs frequently maintain larger-than-necessary workforces, resulting in inefficiencies compared with privately-owned firms. This phenomenon is particularly evident in countries like China, where SOEs dominate energy-intensive sectors (Yusuf, Nabeshima, & Perkins, 2006), often prioritizing social stability over economic optimization.

Increases in global oil prices are associated with a rise in firm labor productivity as firms increase sales and reduce employment. Firms may increase sales and reduce employment after oil price hikes in various ways, for instance, by adopting energy-efficient technologies that trigger productivity gains and passing-through costs to consumers in inelastic markets (Aldy & Pizer, 2015; Pindyck, 1981). Simultaneously, cost increases might also lead to labor reductions, especially in energy-intensive sectors (Caves et al., 1982).

For increases in electricity prices, we observe a negative effect on labor productivity in contrast to the positive effect observed for oil prices. Unlike global oil prices, electricity prices are country-specific and reflect the average commercial electricity rates by country, allowing for better identification. The negative association between electricity prices and labor productivity may be due to rising electricity prices increasing operating costs and reducing competitiveness, leading to a drop in sales, especially in energy-intensive sectors (Aldy & Pizer, 2015). Similarly, firms may cut production to manage costs in competitive markets, hindering output and profitability (Pindyck, 1981; Caves et al., 1982).

Both petroleum and electricity subsidies are associated with lower firm employment through a strong negative effect. Petroleum and electricity subsidies can lower firm employment by encouraging capital-intensive production methods over labor-intensive ones. By reducing energy costs, subsidies incentivize firms to adopt automation and energy-efficient technologies, which reduces the need for workers. This shift towards automation is particularly evident in energy-intensive industries, where subsidies encourage investment in machinery instead of hiring labor (IMF, 2013). Additionally, subsidies can distort market signals, hindering the reallocation of resources to more labor-intensive sectors. As noted by the World Bank, these subsidies can lead to inefficiencies, promoting industries that rely more on capital than on labor, thus reducing overall employment opportunities (World Bank Group, 2024).

By contrast, electricity subsidies—but not petroleum subsidies—are associated with increasing firm sales and productivity. Electricity subsidies can enhance firm sales and productivity by lowering operational costs, allowing firms to invest in energy-efficient technologies and increase production. This reduction in energy costs enables firms to allocate resources more effectively, boosting output (Stern, 2013). In contrast, petroleum subsidies often support capital-intensive industries, distorting market signals and hindering resource reallocation (IMF, 2013). As a result, while electricity subsidies promote efficiency, petroleum subsidies may not have the same effect on firm performance (Aldy & Pizer, 2015).

Introducing interactions of energy prices and energy dependence

Next, we introduce the double interaction of country-level electricity prices with industry-specific energy dependence (intensity) which helps us identify a more causal relationship than the estimated associations presented in Table 1. This is because we assume that country-level electricity prices are exogenous relative to firm-level performance and so is the industry-level energy-intensity measure (CPRS classification) based on global experience.

The results of double interactions reported in Table 2 clarify the final effect of energy prices on firm performance. They reveal that increases in electricity and oil prices are associated with increased sales and productivity of firms in energy-intensive sectors. This finding is consistent with the earlier hypothesis, based on the results in Table 1, that increasing oil prices can raise labor productivity. Firms may increase sales while reducing employment after oil price hikes by adopting energy-efficient technologies that lead to productivity gains and by passing-through costs to consumers in inelastic markets while reducing employment in energy-intensive sectors due to cost pressures (Aldy & Pizer, 2015; Caves et al., 1982; Pindyck, 1981). In sum, our estimation results reveal a notable decline in employment across firms due to increasing electricity prices. This negative employment response is particularly accentuated in firms categorized as energy-intensive according to the CPRS classification and could be even more pronounced if the policy response includes an increase in electricity subsidies. By contrast, rising electricity prices boost firm sales and productivity. These gains could be even more significant if a concurrent policy response introduces subsidies, which are fiscally costly and may transfer taxpayers' resources to firm owners and investors.

Accounting for energy efficiency measures

This section introduces the triple interaction among energy prices, industry-level energy intensity, and firm-level energy efficiency measures. It uses the instrumental variable (IV) approach to address a possible endogeneity of the firm-level energy-efficiency measures vis-à-vis the firm-level outcomes. This endogeneity may rise because well-performing firms may be more likely to implement energy-efficiency measures rather than only energy-efficiency measures affecting firm performance—raising reverse causality concerns. We use three candidate IV variables for the firm-level energy-efficiency measures. The validity of all three IV variables relies on the assumption that one firm taking an energy-efficiency measure cannot significantly influence all other firms of the same size across countries, firms in the same industry across countries, and firms in the same location (country).

Namely, for each firm, we calculate the average likelihood of energy efficiency measure adoption across firms of similar size, excluding the given firms from the calculation, and the analogous averages for firms in the same subsector and in the same location, always excluding the given firm from the sample. Then, we generate three candidate IVs interacting for a given firm: (i) the size and sector averages, (ii) the size and subsector averages, and (iii) the size, subsector, and location averages. From (i)-(iii), the instruments are assumed to show greater relevance because the richer interaction of averages creates a synthetic firm that is more similar to the given firm. Table A4 in the Annex reports the results of the first-stage regression of firm-level efficiency measures on the thus constructed instrument for each firm. All three computed instruments are relevant and significant at the 1 percent level. The size-subsector-location instrument is the most significant, statistically and economically; therefore, we use it as our baseline IV in this section. We use the other two instruments in robustness checks.

Table 3 reports the estimation results for equation (2) where we introduce the triple interaction of electricity prices, energy intensity of industries, and energy efficiency measures or lack thereof. The latter firm-level variable is instrumented by the size-sector-local average computed for each (excluding it from the computation sample). By controlling for double and triple interaction between global oil prices and country-level energy (commercial) electricity prices (oil and electricity), subsectoral energy intensity, and location (country) intensity, the estimation results reveal additional significant heterogeneities. We focus again on the interactions that include electricity prices because the data is more granular (i.e. country-level commercial electricity rates), and the energy efficiency measures reported at the firm level, which are mostly related to electricity consumption such as the LEED certification for buildings, adopting efficient lighting systems, adherence to ISO 14001 or 50001 standards.

The interactions of energy prices and energy intensity remain significantly positive for sales and productivity—as was the case in the estimation results using double interactions only (and no triple interaction). When controlling for additional heterogeneity in the specification of equation (2), the double interaction of energy intensity and oil prices becomes significantly negative in the employment regression. The double interaction of energy intensity and electricity prices remains negative but loses significance at common levels. However, this loss of significance would be due to the significant heterogeneity identified by the double interaction of electricity prices and energy-efficiency measures and the triple interaction of electricity prices, energy intensity, and energy-efficiency measures. The estimated coefficient on the double interaction between electricity prices and energy efficiency measures suggests that, after electricity price increases, firms that did not adopt energy efficiency measures reduce employment significantly more than other firms. The triple interaction is also estimated as significantly negative. Together with the double interaction, it delivers an effect that is economically almost three times as large as the respective double interaction effect in Table 2—suggesting that, after electricity prices increase, firms in energy-intensive sectors that did not adopt energy efficiency measures are those that markedly reduce employment. An increase in electricity prices by 1 percent can lead to a reduction in employment by about 1.5 percent in firms within energy-intensive industries that have not adopted energy efficiency measures. Conversely, these energy-intensive firms tend to see an increase in sales and productivity by approximately 1.4 percent, regardless of whether they have or have not implemented energy efficiency measures. These findings suggest that promoting the adoption of energy efficiency measures among firms could serve as an important employment protection policy during periods of electricity price volatility, which developing countries might consider prioritizing.

The impact of energy subsidies, which could serve as a complementary policy to mitigate the effects of energy price increases, is further elucidated by incorporating double and triple interactions and considering a broader range of heterogeneity. Namely, the effect of electricity subsidies on sales and productivity remains positive, and the effect of petroleum subsidies on sales and productivity becomes significantly negative. Both electricity and petroleum negatively affect employment but only the effect of electricity is statistically significant, at the 1 percent level. Our results suggest that using energy subsidies to preserve employment during energy price shocks can be a counterproductive policy strategy. This result aligns with the literature and the possible negative effect of subsidies on the pace of structural adjustment and the long-term distortionary effect of employment. Such subsidies can distort market signals to both consumers and firms, leading to inefficient energy consumption, misdirected investments, misallocation of resources, and future resilience to energy price shocks (Coady et al., 2024; Aldasoro & Faia, 2024; Coady et al., 2024). This inefficiency can hinder economic growth and delay necessary adjustments to energy price changes. Furthermore, energy subsidies can strain public finances, limiting the government's ability to invest in other critical areas that support employment and economic growth (Clements et al., 2024).

Finally, we explore the correlation between country-level energy subsidies and the firm-level adoption of energy efficiency measures. Table 4 reports the estimation results, which suggest that the short-term (one-year-lagged (t-1)) and medium-term (the preceding five-year average (t-1 … t-5)) subsidies significantly discourage firms from adopting energy efficiency measures—with the regression controlling for firm size, subsector, and country's economic development. The medium-term effect of petroleum subsidies comes out as the strongest. However, even the short-term effect of petroleum and electricity subsidies is consistently significantly negative, highlighting that even short-term subsidies can delay the much-needed structural adjustment when possibly sustained energy price shocks hit countries, industries, and firms. These estimated correlations align with the literature highlighting that short- and medium-term subsidies negatively impact energy efficiency adoption (Stefanski, 2024; Davis, 2023). Subsidized firms often delay technological investments, worsening inefficiencies (Van den Bergh & Delarue, 2023). Subsidies risk long-term harm to growth and employment.

5. Robustness checks

This section carries out several robustness checks and reports the results. First, we test whether our results could change with the use of alternative instrumental variables and report the results in Table B1 in Annex B. Both alternative instruments—IV2 based on size-sector and IV3 based on size-subsector—confirm the robustness of our baseline results. Next, we perform a battery of other robustness checks and report them in Table B2. In columns 1-3, we include country-time fixed effects to check whether other country-level macroeconomic factors, other than energy prices, could have affected firm performance: productivity, sales, and employment, respectively. In columns 4-6, we cluster the standard errors by country-sector to allow for country- and sector-specific spillovers (the results do not change materially if we cluster only by country or only by sector). In columns 7-9, we drop the weights for country size to treat all firms in larger and smaller countries with equal importance and, in columns 10-12, we also drop India, the largest country in our sample. In columns 13-15, we replace the current monthly/quarterly price for electricity (and oil) with a 3-month lagged average (using a 6-month lagged average does not materially change the results).

Overall, the impact of electricity price shocks on productivity and sales is not robust across the considered alternative specifications. By contrast, the result that electricity price shocks significantly decrease employment at firms in energy-intensive sectors that did not adopt energy efficiency measures remains robust across all alternative specifications.

6. Conclusion

The paper examined the impact of electricity price changes on firms' labor productivity, sales, and employment across 24 developing countries from 2019 to 2023. It used business-specific country-level tariffs and considered the energy dependence of industries as per the methodology of Battiston et al. (2022), as well as the energy efficiency measures taken by individual firms. Our study corroborates the findings of Cali et al. (2022) and Cali et al. (2023), showing that, on average, firms may experience an increase in productivity and sales when electricity prices rise but these results are not sufficiently robust to alternative model specifications. By contrast, a rise in electricity prices significantly reduces employment, particularly impacting firms in energy-intensive industries that did not implement energy efficiency measures. These results underscore the critical role of integrating industry-level energy dependence with firm-level energy efficiency initiatives to fully comprehend the effects of energy price fluctuations on firm performance. To safeguard quality jobs amid energy price fluctuations, including during the green transition, policy makers must encourage widespread adoption of energy efficiency measures, especially by firms in energy-intensive sectors.

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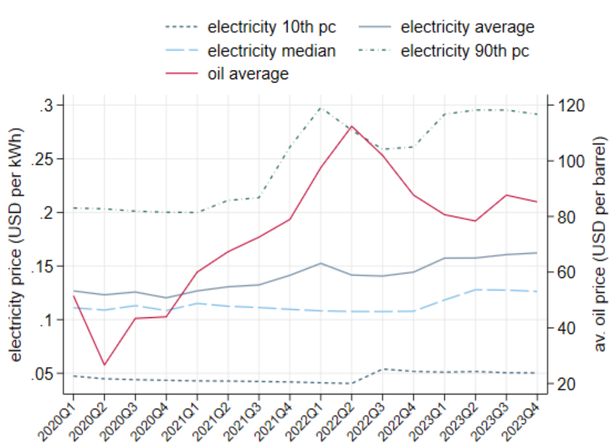
Figures

Figure 1. Average Labor Productivity, Sales, and Employment

Source: World Bank Business Pulse Survey 2020-2023

Figure 2. Energy prices



Source oil prices: OPEC, monthly average
Source electricity prices: Global Petrol Prices
https://www.globalpetrolprices.com
Quarterly electricity price, businesses rate (country level)

Figure 3a. Explicit subsidies to petroleum

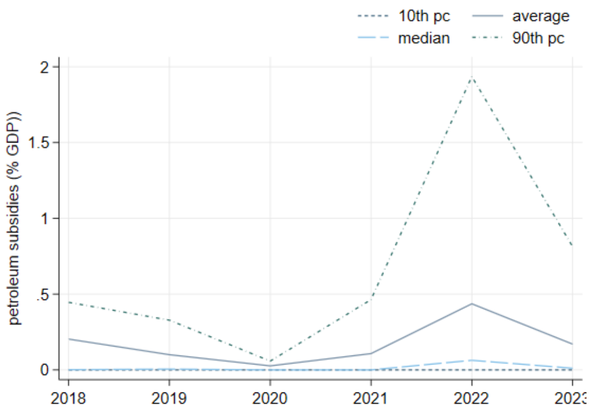
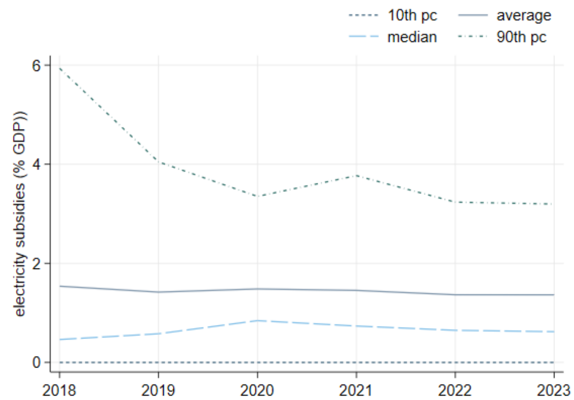


Figure 3b. Explicit subsidies to electricity



Source: Parryet al. (2021) International Monetary Fund, staff estimations.

Tables

Table 1: Estimation results based on Equation (1)

	(1) Sales per worker	(2) Sales (log)	(3) Employment (log)
Energy intense	0.240**	0.255***	0.235***
	(0.0955)	(0.0964)	(0.0320)
Price oil, log	11.64***	11.20***	-2.044***
	(0.450)	(0.452)	(0.140)
Price electricity, log	-1.818***	-1.978***	-0.734***
	(0.295)	(0.302)	(0.0987)
Explicit petroleum subsidy (% GDP)	1.468	1.469	-0.587**
	(1.010)	(1.031)	(0.298)
Explicit electricity subsidy (% GDP)	8.011***	7.852***	-0.463*
	(1.132)	(1.131)	(0.269)
Constant	-54.12***	-50.26***	7.677***
	(2.350)	(2.364)	(0.731)
Observations	21,629	21,629	21,629
R-squared	0.225	0.331	0.471
Country FE	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Weighted by country sample size

Controls for size clusters[1], age, wave, and subsector

[1] Constructed using employment in columns (1) and (2), and sales in column (3)

Table 2a: Estimation results based on Equation (2) with double interactions

	(1) Sales per worker (log)	(2) Sales (log)	(3) Employment (log)
Energy intense	-0.410	-0.543	-0.579**
	(0.787)	(0.794)	(0.257)
Price oil, log	11.34***	10.90***	-1.997***
	(0.455)	(0.457)	(0.142)
Price electricity, log	-1.923***	-2.064***	-0.594***
	(0.301)	(0.308)	(0.101)
Explicit petroleum subsidy (% GDP)	1.309	1.316	-0.516*
	(1.006)	(1.027)	(0.302)
Explicit electricity subsidy (% GDP)	8.107***	7.950***	-0.469*
	(1.121)	(1.121)	(0.269)
log Price oil*Energy intense	0.483***	0.490***	-0.0398
	(0.179)	(0.179)	(0.0542)
log Price elect*Energy intense	0.689***	0.633***	-0.473***
	(0.172)	(0.174)	(0.0573)
Constant	-52.99***	-49.09***	7.733***
	(2.382)	(2.399)	(0.744)
Observations	21,629	21,629	21,629
R-squared	0.226	0.332	0.474
Country FE	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Weighted by country sample size
Controls for size clusters[1], age, wave, and subsector
Clusters constructed using employment in columns (1) and (2), and sales in column (3)

Table 2b: Estimation results based on Equation (2) with double interactions including subsidies

	(1) Sales per worker (log)	(2) Sales (log)	(3) Employment (log)
Energy intense	-0.334	-0.468	-0.590**
	(0.787)	(0.794)	(0.257)
Price oil, log	12.21***	11.74***	-2.176***
	(0.474)	(0.475)	(0.143)
Price electricity, log	-1.979***	-2.083***	-0.520***
	(0.260)	(0.266)	(0.0923)
Explicit petroleum subsidy (% GDP)	63.85***	61.58***	-13.66***
	(12.83)	(13.58)	(5.187)
Explicit electricity subsidy (% GDP)	-6.694***	-6.935***	1.567***
	(1.561)	(1.599)	(0.545)
log Price oil*Energy intense	0.476***	0.482***	-0.0394
	(0.179)	(0.180)	(0.0542)
log Price elect*Energy intense	0.712***	0.655***	-0.478***
	(0.171)	(0.173)	(0.0573)
log Price elect*Subsidy elect (% GDP)	-6.125***	-6.195***	0.783***
	(0.647)	(0.662)	(0.215)
log Price petroleum*Subsidy fuel (% GDP)	-13.59***	-13.09***	2.868***
	(2.712)	(2.868)	(1.090)
Constant	-58.61***	-54.55***	8.842***
	(2.391)	(2.404)	(0.752)
Observations	21,629	21,629	21,629
R-squared	0.230	0.335	0.474
Country FE	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Weighted by country sample size
Controls for size clusters[1], age, wave, and subsector
[1] Constructed using employment in columns (1) and (2), and sales in column (3)

Table 3: Estimation results based on Equation (2) with the triple interaction using IV approach

	(1)	(2)	(3)
	Sales per worker (log)	Sales (log)	Employment (log)
Energy intense	0.873	0.808	0.266
	(0.923)	(0.936)	(0.301)
Energy inefficient IV1	-0.745	-1.103	-4.469***
	(1.141)	(1.165)	(0.419)
Price oil, log	12.08***	11.54***	-1.974***
	(0.486)	(0.488)	(0.134)
Price electricity, log	-2.385***	-2.353***	0.217
	(0.507)	(0.517)	(0.166)
Explicit petroleum subsidy (% GDP)	-1.996***	-1.918***	-0.0712
	(0.679)	(0.679)	(0.179)
Explicit electricity subsidy (% GDP)	6.943***	6.690***	-1.092***
	(0.868)	(0.871)	(0.243)
Energy intense*Energy inefficient IV1	-1.337	-2.146*	-1.542***
	(1.249)	(1.275)	(0.495)
log Price oil*Energy intense	0.555***	0.594***	-0.110**
	(0.191)	(0.191)	(0.0505)
log Price elect*Energy intense	1.368***	1.421***	-0.141
	(0.322)	(0.327)	(0.118)
log Price elect*Energy inefficient IV1	-0.833	-1.008*	-0.835***
	(0.548)	(0.559)	(0.192)
log Price elect*Energy intense*Energy inefficient IV1	-0.401	-0.839	-0.702***
	(0.601)	(0.612)	(0.229)
Constant	-48.26***	-43.55***	10.10***
	(2.628)	(2.656)	(0.787)
Observations	19,237	19,237	19,237
R-squared	0.233	0.335	0.571
Country FE	YES	YES	YES

Firm-level adoption of efficiency measures instrumented by average adoption of the measures by other firms in the same sector, of similar size and location.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Weighted by country sample size
Controls for size clusters[1], age, wave, and subsector
[1] Constructed using employment in columns (1) and (2), and sales in column (3)

Table 4: Correlation of country-level energy subsidies and firm-level adoption of energy efficiency measures

	(1)	(2)
	Energy Efficiency	Energy Efficiency
Petroleum subsidies (average previous 5 years)	3.091***	
	(0.274)	
Electricity subsidies (average previous 5 years)	0.215***	
	(0.0131)	
Petroleum subsidies (lagged)		0.602***
		(0.190)
Electricity subsidies (lagged)		0.275***
		(0.0187)
Micro	-0.300***	-0.449***
	(0.0344)	(0.0339)
Medium	1.003***	1.040***
	(0.0394)	(0.0390)
Large	1.188***	1.181***
	(0.0678)	(0.0679)
Age (log)	0.287***	0.279***
	(0.0227)	(0.0235)
Agriculture	0.0340	-0.0498
	(0.0618)	(0.0647)
Construction	0.232***	0.165**
	(0.0802)	(0.0801)
Retail	-0.162***	-0.164***
	(0.0381)	(0.0375)
Transportation	0.0695	0.0113
	(0.0803)	(0.0792)
Accommodation	0.138*	0.155**
	(0.0714)	(0.0690)
Restaurants	-0.0186	-0.0413
	(0.0557)	(0.0540)
IT	0.535***	0.513***
	(0.0929)	(0.0933)
Financial	0.741***	0.751***
	(0.0828)	(0.0836)
Education	-0.0861	-0.232**
	(0.0911)	(0.0925)
Health	0.267**	0.196*
	(0.119)	(0.117)
Other Services	-0.0513	-0.0858**
	(0.0416)	(0.0413)
Constant	-1.230***	-1.029***
	(0.0774)	(0.0750)
Observations	13,706	13,706
Pseudo R2	0.3142	0.3027

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Weighted by country sample size. Controls for GDP per capita; Omitted variables: small and manufacturing

Annex A

Table A1a: Sample by Year

	2020	*2021*	*2022*	*2023*	*Total*
Argentina	524	525	1019	0	2068
Armenia	92	1041	707	0	1840
Bangladesh	483	523	1026	0	2032
Bulgaria	867	864	550	0	2281
Comoros	0	0	0	600	600
Croatia	39	52	379	0	470
Ghana	4193	2068	0	3157	9418
Greece	0	0	1123	0	1123
India	2539	2526	3087	0	8152
Kenya	3539	1567	1819	0	6925
Kyrgyzstan	299	224	1075	0	1598
Malawi	842	0	2033	0	2875
Malaysia	63	134	1500	0	1697
Nepal	1430	1503	1506	0	4439
Pakistan	354	821	1527	0	2702
Paraguay	204	221	413	0	838
Philippines	0	0	3839	0	3839
Poland	726	808	0	0	1534
Romania	823	593	666	0	2082
Senegal	322	0	0	407	729
Tajikistan	403	245	1031	0	1679
Tunisia	1074	0	0	1996	3070
Uzbekistan	264	201	1017	0	1482
Vietnam	92	98	53	0	243
Total	19172	14014	24370	6160	63716

Table A1b. Sample by Subsector

	Agric.	Manuf.	Constr.	Retail	Transp.	Hotels	Food	IT	Fin.	Edu.	Health	Other
Argentina	0	601	2	1092	153	0	0	49	0	0	0	169
Armenia	0	746	64	516	51	57	128	109	0	0	0	36
Bangladesh	103	1439	21	285	21	3	47	9	2	2	0	97
Bulgaria	109	359	261	456	93	76	66	168	266	71	86	270
Comoros	106	127	125	109	60	66	0	0	0	0	0	0
Croatia	4	56	37	64	10	8	7	20	23	0	1	137
Ghana	352	1963	514	1692	172	172	310	196	92	211	164	2652
Greece	28	75	55	315	25	43	158	27	64	57	47	229
India	29	3218	165	1644	162	762	461	266	531	23	42	849
Kenya	458	1045	729	1011	434	470	602	146	413	643	162	812
Kyrgyzstan	310	422	75	452	26	10	75	5	18	33	9	163
Malawi	128	381	66	1272	81	112	178	15	4	63	35	528
Malaysia	72	323	120	432	38	61	0	55	180	87	41	190
Nepal	850	985	91	1012	70	135	688	23	18	42	39	486
Pakistan	87	348	154	227	73	38	285	77	37	46	89	1241
Paraguay	0	147	0	212	47	23	24	27	53	38	40	227
Philippines	153	134	177	1067	117	57	768	100	93	103	96	825
Poland	21	503	163	422	18	27	44	33	79	1	32	187
Romania	29	396	248	474	157	16	201	24	29	9	53	446
Senegal	152	218	9	187	15	9	25	2	3	6	5	96
Tajikistan	352	295	141	579	21	16	28	13	28	11	28	167
Tunisia	0	1213	63	883	259	0	102	66	0	0	67	417
Uzbekistan	203	362	81	423	52	11	64	21	22	17	38	188
Vietnam	11	97	0	50	0	0	0	0	0	0	4	68
Total	3557	15453	3361	14876	2155	2172	4261	1451	1955	1463	1078	10480

Table A1c: Sample by Size

	Micro	Small	Medium	Large
Argentina	1083	476	393	116
Armenia	379	583	388	213
Bangladesh	685	797	416	132
Bulgaria	958	612	393	130
Comoros	434	130	20	8
Croatia	198	112	93	55
Ghana	6534	1988	540	77
Greece	705	310	85	23
India	304	2971	4031	846
Kenya	2643	1857	1109	452
Kyrgyzstan	542	572	264	32
Malawi	2183	480	169	43
Malaysia	337	292	502	566
Nepal	2985	982	251	88
Pakistan	1569	504	263	90
Paraguay	452	230	98	35
Philippines	2243	713	216	207
Poland	305	467	547	213
Romania	748	691	488	154
Senegal	300	294	90	29
Tajikistan	460	692	366	5
Tunisia	1196	785	569	472
Uzbekistan	443	553	348	30
Vietnam	32	97	53	61
Total	27718	17188	11692	4077

Table A2. Summary Statistics

	N	Mean	SD	Min	Max
Sales (000 USD)	23639	9.1e+09	1.0e+12	0.01	1.4e+14
Employment	60675	119220	11767238	1	2.0e+09
Sales per worker (000 USD)	23487	1.4e+09	1.7e11	2.5e-7	2.4e+13
Age	50219	17.7	13.3	1	203
Monthly oil price (USD)	63716	76.1	27.8	33.7	113
Quarterly electricity price (USD)	55762	0.14	0.06	0.03	0
Energy efficient	48964	0.62	0.49	0	1
Explicit petroleum subsidy (% GDP)	63716	0.21	0.68	0	3.58
Explicit electricity subsidy (% GDP)	63716	1.02	1.98	0	9.76

Country: Argentina

	N	Mean	SD	Min	Max
Sales (000 USD)	1320	965	3736	0	65770
Employment	2068	25	81	1	2124
Sales per worker (000 USD)	1320	23	83	0	2603
Age	2065	22	18	1	96
Monthly oil price (USD)	2068	85	30	44	113
Quarterly electricity price (USD	2068	0	0	0	0
Energy inefficient	0	.	.	.	.
Armenia					
Sales (000 USD)	415	1149	10192	0	204458
Employment	1563	58	193	1	4001
Sales per worker (000 USD)	402	21	56	0	964
Age	1569	17	10	2	85
Monthly oil price (USD)	1840	83	23	34	113
Quarterly electricity price (USD	1840	0	0	0	0
Energy inefficient	1662	0	0	0	1
Bangladesh					
Sales (000 USD)	1525	151	905	0	27248
Employment	2030	39	192	1	5101
Sales per worker (000 USD)	1525	11	43	0	730
Age	1999	19	12	2	113
Monthly oil price (USD)	2032	83	29	34	113
Quarterly electricity price (USD	2032	0	0	0	0
Energy inefficient	2032	1	0	0	1
Bulgaria					

Sales (000 USD)	661	3790	70818	0	1818182
Employment	2093	26	66	1	1001
Sales per worker (000 USD)	661	100	1399	0	35651
Age	1657	20	18	1	203
Monthly oil price (USD)	2281	68	26	34	106
Quarterly electricity price (USD	2281	0	0	0	0
Energy inefficient	2208	0	0	0	1
Comoros					
Sales (000 USD)	0	.	.	.	.
Employment	592	11	56	2	801
Sales per worker (000 USD)	0	.	.	.	.
Age	0	.	.	.	.
Monthly oil price (USD)	600	81	0	81	81
Quarterly electricity price (USD	0	.	.	.	.
Energy inefficient	0	.	.	.	.
Croatia					
Sales (000 USD)	77	7813	26759	0	208176
Employment	458	52	162	1	2001
Sales per worker (000 USD)	77	74	143	0	817
Age	0	.	.	.	.
Monthly oil price (USD)	470	100	22	44	113
Quarterly electricity price (USD	0	.	.	.	.
Energy inefficient	470	0	0	0	1
Ghana					
Sales (000 USD)	0	.	.	.	.
Employment	9139	8	30	1	1201
Sales per worker (000 USD)	0	.	.	.	.
Age	4193	16	12	1	119
Monthly oil price (USD)	9418	58	17	34	75
Quarterly electricity price (USD	9418	0	0	0	0
Energy inefficient	9394	1	0	0	1
Greece					
Sales (000 USD)	0	.	.	.	.
Employment	1123	20	168	1	5001
Sales per worker (000 USD)	0	.	.	.	.
Age	0	.	.	.	.

Monthly oil price (USD)	1123	111	4	106	113
Quarterly electricity price (USD	0	.	.	.	.
Energy inefficient	1116	0	0	0	1
India					
Sales (000 USD)	5321	3888	89489	0	5152672
Employment	8152	57	192	2	8601
Sales per worker (000 USD)	5321	87	1918	0	109631
Age	8152	21	14	1	184
Monthly oil price (USD)	8152	78	29	34	113
Quarterly electricity price (USD	8152	0	0	0	0
Energy inefficient	8152	0	0	0	1
Kenya					
Sales (000 USD)	3303	321	1144	0	11453
Employment	6061	51	487	1	25001
Sales per worker (000 USD)	3224	21	117	0	2818
Age	6813	18	15	1	173
Monthly oil price (USD)	6925	61	21	34	90
Quarterly electricity price (USD	6925	0	0	0	0
Energy inefficient	5779	0	0	0	1
Kyrgyzstan					
Sales (000 USD)	62	44	129	0	738
Employment	1410	22	108	1	3001
Sales per worker (000 USD)	56	5	14	0	82
Age	822	11	8	1	32
Monthly oil price (USD)	1598	93	28	44	113
Quarterly electricity price (USD	1598	0	0	0	0
Energy inefficient	1382	0	0	0	1
Malawi					
Sales (000 USD)	2310	25	235	0	8544
Employment	2875	9	37	1	740
Sales per worker (000 USD)	2310	3	12	0	380
Age	2863	13	10	1	121
Monthly oil price (USD)	2875	77	22	43	107
Quarterly electricity price (USD	2875	0	0	0	0
Energy inefficient	2875	1	0	0	1

Malaysia					
Sales (000 USD)	1325	0	0	0	0
Employment	1697	164	606	2	13001
Sales per worker (000 USD)	1325	0	0	0	0
Age	0	.	.	.	.
Monthly oil price (USD)	1697	101	15	43	106
Quarterly electricity price (USD	1697	0	0	0	0
Energy inefficient	0	.	.	.	.
Nepal					
Sales (000 USD)	2830	313	3423	0	131789
Employment	4306	12	55	1	1501
Sales per worker (000 USD)	2810	17	112	0	3889
Age	4439	16	10	3	55
Monthly oil price (USD)	4439	75	30	34	113
Quarterly electricity price (USD	4439	0	0	0	0
Energy inefficient	4077	0	0	0	1
Pakistan					
Sales (000 USD)	1924	89	435	0	7810
Employment	2426	27	262	1	8001
Sales per worker (000 USD)	1923	14	65	0	1464
Age	2702	26	3	22	44
Monthly oil price (USD)	2702	88	25	34	113
Quarterly electricity price (USD	2702	0	0	0	0
Energy inefficient	2702	0	0	0	1
Paraguay					
Sales (000 USD)	535	17387899	47489599	0	2.86E+08
Employment	815	23	94	1	1366
Sales per worker (000 USD)	530	5136440	18771421	0	1.86E+08
Age	838	21	16	3	118
Monthly oil price (USD)	838	84	28	44	113
Quarterly electricity price (USD	838	0	0	0	0
Energy inefficient	769	1	0	0	1
Philippines					
Sales (000 USD)	0	.	.	.	.
Employment	3379	2140156	49827371	2	2.00E+09
Sales per worker (000 USD)	0	.	.	.	.

Age	3430	10	14	1	173
Monthly oil price (USD)	3839	106	0	106	106
Quarterly electricity price (USD	0	.	.	.	.
Energy inefficient	0	.	.	.	.
Poland					
Sales (000 USD)	575	4432	7443	0	67358
Employment	1532	43	55	2	301
Sales per worker (000 USD)	575	103	245	0	3333
Age	1520	24	11	1	93
Monthly oil price (USD)	1534	56	17	34	77
Quarterly electricity price (USD	1534	0	0	0	0
Energy inefficient	1529	0	0	0	1
Romania					
Sales (000 USD)	326	6.60E+11	8.887E+12	0	1.44E+14
Employment	2081	28	50	1	551
Sales per worker (000 USD)	326	1.01E+11	1.417E+12	0	2.40E+13
Age	1702	18	9	1	101
Monthly oil price (USD)	2082	69	29	34	106
Quarterly electricity price (USD	2082	0	0	0	0
Energy inefficient	1966	0	0	0	1
Senegal					
Sales (000 USD)	382	85	356	0	4613
Employment	713	19	61	1	1001
Sales per worker (000 USD)	379	11	70	0	1253
Age	642	18	9	3	54
Monthly oil price (USD)	729	61	20	34	81
Quarterly electricity price (USD	729	0	0	0	0
Energy inefficient	0	.	.	.	.
Tajikistan					
Sales (000 USD)	159	243	1175	0	13157
Employment	1523	16	18	1	181
Sales per worker (000 USD)	146	13	52	0	572
Age	1040	12	9	1	62
Monthly oil price (USD)	1679	90	30	44	113
Quarterly electricity price (USD	0	.	.	.	.
Energy inefficient	1475	0	0	0	1

Tunisia					
Sales (000 USD)	250	30388	264704	0	3131673
Employment	3022	79	495	1	22001
Sales per worker (000 USD)	250	525	4940	0	55923
Age	3044	17	12	1	124
Monthly oil price (USD)	3070	66	21	34	81
Quarterly electricity price (USD	3070	0	0	0	0
Energy inefficient	0	.	.	.	.
Uzbekistan					
Sales (000 USD)	108	838	3621	0	30162
Employment	1374	22	107	1	3101
Sales per worker (000 USD)	96	62	272	0	1809
Age	729	9	8	1	77
Monthly oil price (USD)	1482	95	28	44	113
Quarterly electricity price (USD	1482	0	0	0	0
Energy inefficient	1376	0	0	0	1
Vietnam					
Sales (000 USD)	231	0	0	0	1
Employment	243	112	211	1	1399
Sales per worker (000 USD)	231	0	0	0	0
Age	0	.	.	.	.
Monthly oil price (USD)	243	66	26	34	106
Quarterly electricity price (USD	0	.	.	.	.
Energy inefficient	0	.	.	.	.

Table A3. Energy Intense Classification using Battiston et al. (2022) CPRS classification methodology

Agriculture	Direct CO2 emissions from fossil fuel but reductions via afforestation and low carbon farming; low substitutability as for transport	Not energy intense
Manufacturing	Intensive use of energy according to EU classification Carbon Leakage; mostly direct CO2 emissions (fuel mix); no fuel substitutability	Energy intense
Construction	Mostly direct CO2 emissions (fuel mix - heating); no fuel substitutability	Energy intense
Retail and wholesale	Low CO2 emissions	Not energy intense

Transportation	Mostly direct CO2 emissions (fuel mix); no fuel substitutability, but this is changing	Energy intense
Accommodation	low CO2 emissions	Not energy intense
Food services	low CO2 emissions	Not energy intense
Information and communication	low CO2 emissions	Not energy intense
Financial services or real state	low CO2 emissions	Not energy intense
Education	low CO2 emissions	Not energy intense
Health	low CO2 emissions	Not energy intense
Other services	low CO2 emissions	Not energy intense

Table A4: Instruments' correlation based on Equation (4)

	(1)	(2)	(3)
	Energy inefficient	Energy inefficient	Energy inefficient
Energy inefficient IV-1 (size-subsector-location)	1.615***		
	(0.0951)		
Energy inefficient IV-2 (size-subsector)		0.791**	
		(0.361)	
Energy inefficient IV-3 (size-sector)			2.261***
			(0.623)
Constant	-1.384***	-1.790***	-2.208***
	(0.144)	(0.196)	(0.242)
Observations	13,706	13,706	13,706
Country FE	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Weighted by country sample size

Controls for size, age, wave, subsector, and fuel and electricity average subsidies of the previous 5 years

Controls for size[1], age, wave, subsector r, and fuel and electricity average subsidies of the previous 5 years

[1] Constructed using employment in columns (1) and (2), and sales in column (3)

Appendix B: Robustness checks

Table B1: Summary estimation results based on Equation (3) with triple interaction using an instrumental variable for energy inefficiency

	(1) Sales per worker (log)	(2) Sales per worker (log)	(3) Sales per worker (log)	(4) Sales (log)	(5) Sales (log)	(6) Sales (log)	(7) Employment (log)	(8) Employment (log)	(9) Employment (log)
log Price elect*Energy intense*Energy inefficient IV1	-0.401			-0.839			-0.702***		
	(0.601)			(0.612)			(0.229)		
log Price elect*Energy intense*Energy inefficient IV2		0.135			-0.420			-0.666**	
		(1.461)			(1.484)			(0.321)	
log Price elect*Energy intense*Energy inefficient IV3			-1.367			-1.965			-0.801**
			(1.568)			(1.592)			(0.329)
log Price elect*Energy inefficient IV1	-0.833			-1.008*			-0.835***		
	(0.548)			(0.559)			(0.192)		
log Price elect*Energy inefficient IV2		0.307			-0.0870			-0.596***	
		(1.109)			(1.123)			(0.219)	
log Price elect*Energy inefficient IV3			1.935			1.680			-0.483**
			(1.214)			(1.230)			(0.232)
log Price elect*Energy intense	1.368***	1.190**	1.690***	1.421***	1.283**	1.809***	-0.141	0.260**	0.306**
	(0.322)	(0.516)	(0.554)	(0.327)	(0.522)	(0.559)	(0.118)	(0.121)	(0.121)
log Price electricity	-2.385***	-3.092***	-3.693***	-2.353***	-3.068***	-3.726***	0.217	-0.0739	-0.0294
	(0.507)	(0.494)	(0.515)	(0.517)	(0.501)	(0.522)	(0.166)	(0.102)	(0.0998)
Constant	-48.26***	-51.50***	-51.39***	-43.55***	-47.00***	-46.93***	10.10***	8.543***	8.076***
	(2.628)	(2.303)	(2.346)	(2.656)	(2.327)	(2.370)	(0.787)	(0.480)	(0.417)
Observations	19,237	19,237	19,237	19,237	19,237	19,237	19,237	19,237	19,237
R-squared	0.233	0.232	0.232	0.335	0.334	0.334	0.571	0.803	0.848
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Weighted by country sample size; Controls for size[1], age, wave, and subsector

[1] Sales if dependent variable is employment

Table B2: Summary estimation results based on Equation (3) with different specifications regarding FEs, clustering, weights, and energy price

	Country-Year FE			Clustered by country-sector			Not weighted by country size			Not weighted excl. India			3-month MA energy price		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
	Sales per worker (log)	Sales (log)	Employment (log)	Sales per worker (log)	Sales (log)	Employment (log)	Sales per worker (log)	Sales (log)	Employment (log)	Sales per worker (log)	Sales (log)	Employment (log)	Sales per worker (log)	Sales (log)	Employment (log)
Price electricity, log	0.199	-0.248	-0.915**	-2.711**	-2.842**	-0.538**	-2.290***	-2.336***	-0.190	-0.741	-0.859*	-0.0628	3.796***	3.828***	-0.608***
	(1.699)	(1.734)	(0.390)	(1.152)	(1.175)	(0.231)	(0.481)	(0.488)	(0.143)	(0.483)	(0.490)	(0.146)	(0.624)	(0.630)	(0.188)
log Price elect*Energy intense	0.308	0.362	-0.109	1.662**	1.611**	-0.316	0.762***	0.807***	-0.109	0.399	0.465*	-0.169*	1.649***	1.625***	-0.276**
	(0.299)	(0.305)	(0.119)	(0.755)	(0.735)	(0.219)	(0.271)	(0.274)	(0.0876)	(0.278)	(0.280)	(0.0876)	(0.341)	(0.345)	(0.123)
log Price elect*Energy inefficient	-1.976***	-2.188***	-0.981***	0.155	0.176	0.151	-0.727	-0.811	-0.380**	-1.927***	-1.867***	-0.425***	-0.718	-1.012*	-0.970***
	(0.574)	(0.586)	(0.211)	(0.426)	(0.432)	(0.227)	(0.488)	(0.495)	(0.155)	(0.497)	(0.504)	(0.155)	(0.587)	(0.597)	(0.211)
log El. Price*Energy intense*Energy inefficient	0.566	0.126	**-0.678*** **	-0.644	-0.729	**-0.516***	0.675	0.404	**-0.443*** **	1.074*	0.792	**-0.463*** **	-0.512	-0.741	**-0.441***
	(0.580)	(0.594)	(0.229)	(0.470)	(0.466)	(0.305)	(0.582)	(0.588)	(0.159)	(0.583)	(0.588)	(0.159)	(0.629)	(0.640)	(0.231)
Constant	-0.103	1.907	-1.077	-30.01***	-26.29***	6.583***	-36.97***	-32.74***	7.530***	-13.86***	-10.23***	6.389***	-6.419***	-3.465	1.993***
	(5.092)	(5.187)	(1.310)	(7.498)	(7.595)	(1.018)	(2.267)	(2.294)	(0.672)	(2.306)	(2.337)	(0.703)	(2.261)	(2.292)	(0.675)
Observations	19,237	19,237	19,237	19,237	19,237	19,237	19,237	19,237	19,237	13,916	13,916	13,916	19,237	19,237	19,237
R-squared	0.306	0.396	0.580	0.215	0.321	0.490	0.212	0.310	0.552	0.215	0.321	0.466	0.225	0.330	0.567
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Weighted by country sample size
Controls for size[1], age, wave, and subsector
[1] Sales if dependent variable is employment