Energy pricing and competitiveness: Firm level evidence from Indonesia

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Highlights

- We examine the effect of energy price changes on the competitiveness of micro, small, and medium sized firms in Indonesia
- Higher energy prices are shown to have a small adverse effect on firms' long-run competitiveness
- Fuel substitution, energy efficiency, and cost pass-on are used by firms to adapt to higher prices
- Policy measures are needed to strengthen the adaptive capacity of firms, and to avoid substitution with unsustainable fuels

Abstract[1]

This paper summarises the evidence on how firms are affected by and adapt to higher energy prices in the long-term. Using data for the manufacturing and mining sectors in Indonesia, it highlights the extent to which energy prices affect competitiveness (proxied by profitability). This study shows that energy prices have a small (but statistically significant) adverse long-run effect on competitiveness – though different energy types matter in different sectors. This study also shows that firms have the ability to respond to higher energy prices by adjusting their energy mix, i.e. substituting certain energy goods for others. Moreover, this study shows that firms also respond to higher energy prices by increasing energy efficiency, and by passing on costs to end-users. Nevertheless, these response measures are not sufficient to fully mitigate the adverse effect of energy prices on firms. Based on these results, policy recommendations are offered which are of immediate relevance for the design of energy pricing reforms.

Key words: Energy prices, firms, competitiveness, fossil fuel subsidies

1. Introduction and background

The IMF (2016) highlights that a central concern preventing governments from implementing green fiscal reforms is that the competitiveness of domestic firms may be adversely affected. Indeed, the concern that higher energy prices may harm firms features prominently in most debates on energy pricing reforms, in particular fossil fuel subsidy (FFS) removals or energy and carbon taxes. Case studies of FFS reforms for instance show that such energy price shocks have been a key reason why policy makers have struggled to win public support for reforms (Commander 2012; Strand 2013).

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However, while the adverse effects of FFS removal are increasingly well understood for households, the existing literature has largely ignored the effects of subsidy reform – and thus of higher energy prices – on firms (Rentschler and Kornejew 2016).

This micro-econometric study investigates whether higher energy prices do indeed reduce the long-term competitiveness of firms. It uses a large firm survey dataset for Indonesian small enterprises in manufacturing and mining sectors. By exploiting regional price differences, it investigates whether and to what extent energy prices affect the performance of firms; and how firms adapt to energy price differences using inter-fuel substitution, energy efficiency, and price pass-on.

For the purpose of this analysis, the Indonesia constitutes an ideal case study. While 90% of the population are located on five main islands, the country covers over 1.8 million square kilometres of archipelagic land mass with almost 1,000 permanently inhabited islands, distributed over 34 provinces. These geographic characteristics impose considerable obstacles to energy distribution and have resulted in heterogeneous supply patterns, which prevent an even transmission of prices (IEA 2014, 2015).

In particular, regions with significant infrastructure gaps are prone to face energy shortages and high distribution costs, which raise local energy prices above the national average. Firms in such locations face higher average energy prices than their competitors elsewhere, while producing under identical regulatory conditions and supplying similar markets. As these inter-regional price differences are structural and persistent, the data allows us to estimate potential long-run effects of higher energy prices on the performance of firms. As such, our setting can yield insights as to how energy price shocks – e.g. due to FFS reform – affect firms in the long run, i.e. after having exhausted possible response measures.

We find most energy prices to have a small (but statistically significant) adverse effect on the long-run performance of firms. More specifically, we observe that higher energy prices are associated with reduced profit margins, though the magnitude of the effect varies for different fuel types and industries. We find that firms respond to higher energy prices by increasing energy efficiency (i.e. reducing the energy intensity of output), and by passing energy costs on to consumers in the form of increased sales prices. Furthermore, we show that most energy types can be substituted by one another, thus allowing firms to respond to varying energy prices by adjusting their energy mix.

The remainder of this paper is structured as follows: Section 2 provides an overview of the relevant literature and existing empirical evidence. Section 3 offers a theoretical and conceptual discussion of competitiveness, and outlines firms' response measures for adapting to higher energy prices. Section 4 presents the dataset and descriptive insights. Section 5 presents the analytical methodologies and results. Section 6 offers a discussion of the robustness of results, and Section 7 concludes with observations and policy recommendations.

2. Literature

The question of whether environmental policies have an adverse effect on economic activity and competitiveness has been the subject of numerous studies. As part of this literature, research has focused on energy price regulation, in particular in the form of energy or carbon taxation, and investigated how such policy measures may affect the profitability and overall performance of firms. This section provides a brief overview of the relevant literature, its insights, and its shortcomings.

Studies on the competitiveness effects of energy and carbon taxes are of particular relevance, as these policy measures typically translate into energy price shocks. Arlinghaus (2015) reviews the empirical literature on the effects of carbon taxes on various indicators of competitiveness. Based on ex-post evaluations of a wide range of carbon and energy tax case studies, the review concludes that studies consistently fail to identify any significant adverse effects on common competitiveness indicators, such as employment, output, exports, and profits. Moreover, carbon taxes are found to significantly decrease the energy intensity of firms, while pass-on rates vary across different manufacturing sectors from 0% to over 100% of the tax.

Flues and Lutz (2015) study the effects of German electricity taxes on competitiveness. Using firm-level data for 1999 to 2005 and a regression discontinuity design, they show that electricity taxes (EUR 14.6/MWh or EUR 44.4/t CO_2) did not negatively affect common competitiveness indicators of firms, such as turnover, exports, value added, investment, and employment. Similarly, reviewing evidence for OECD countries, Zhang and Baranzini (2004) also conclude that overall, the competitiveness losses due to carbon taxes are small and in many cases not significant. However, for Egypt, Khattab (2007) estimates that a doubling of energy prices due to subsidy removal would reduce profit margins of firms in energy intensive sectors, e.g. in the cement (39% to 29% reduction), fertiliser (22%), and steel sectors (13%).

Moreover, the literature on environmental policies and regulation more generally can offer further useful insights. For instance, Dechezleprêtre and Sato (2014) review the evidence on the effect of environmental regulation on competitiveness, for a wide range of regulation types, industries and countries. They conclude that environmental regulation, including carbon taxes, has no adverse effect on indicators of international competitiveness, especially trade. At the firm-level, small adverse effects on employment and productivity may occur, especially in the short term and in energy-intensive industries.

In fact, a prominent strand of literature has investigated whether stringent environmental regulation may even have a positive effect on firm performance (Albrizio et al. 2014; Ekins & Speck 2010; Enevoldsen et al., 2009). Porter (1990) argued that well designed environmental regulation can in fact enhance competitiveness, as firms are incentivised to increase investments in efficiency and innovation. In a comprehensive review Ambec et al. (2013) reviewed the empirical evidence for this so called Porter Hypothesis, and found that its validity appears to be conflicting. In certain countries and sectors, environmental regulation and policies were found to indeed have positive effects on competitiveness – measured as productivity or profitability. However, the opposite could be found in other cases. This emphasises the importance of relying on case specific analyses for ex-ante assessments of specific policy measures.

Gonseth et al. (2015) show that "adaptive capacity" can play a key role in determining whether energy taxes (and environmental policies more generally) increase or reduce the competitiveness of firms. For a sample of six European countries and eleven industrial sectors they show that human capital is an important determinant of the ability to mitigate negative impacts of energy taxes. Besides human capital, the capacity for technological innovation and substitution has also been argued to play a key role in determining how a green tax reform (e.g. energy tax) affects competitiveness (Koskela, Sinn, and Schöb 2001). Using a CGE model for Vietnam, Willenbockel and Hoa (2011) suggest that common energy efficiency measures can play a key role in enabling firms to cope with moderate energy price increases (5-10% per year). In a qualitative study of Indonesian micro, small, and medium enterprises, Tambunan (2015) finds that firms are most strongly affected by the indirect effects of energy price increases, as the costs of transportation, raw materials, and capital increase. The study also emphasises that the net effect of high energy prices crucially depends on firms' ability to adapt (e.g. increasing the output price, or energy efficiency).

Overall, the evidence presented above suggests that effects of energy taxes (and thus of higher energy prices) on indicators of competitiveness tend to be small on average, and even insignificant in many cases. This confirms the view that other factors such as infrastructure, finance, security, competition, and regulation play a far more significant role than energy prices in determining firms' performance (Dethier, Hirn, and Straub 2011). However, it is also evident that studies focus predominantly on developed economies, and use macro-econometric approaches (based on country or sector level data), rather than analysing firm level data that can yield detailed and more nuanced insights.

Dethier et al. (2011) offer a critical review of empirical studies on the determinants of enterprise performance in developing countries. The authors argue that macro-econometric data conflates important dimensions of heterogeneity, including differences across regions and firm types (e.g. firm size) (Dethier et al. 2011). Hence, by analysing national averages or the behaviour of representative firms, macro-econometric approaches often fail to capture the heterogeneous effects of external shocks, e.g. due to changes in price or the business climate (Banerjee and Duflo. 2005; Pande and Udry 2005). Moreover, by assuming profit-maximising behaviour, some basic features of standard growth models may contradict the evidence observed in firm surveys; e.g. about marginal costs and prices of production factors (Dethier et al. 2011).

Micro-level approaches using household surveys have offered crucial insights into how energy shocks due to fossil fuel subsidy reforms can affect the livelihoods of households (Arze del Granado et al., 2012; Rentschler and Bazilian 2016; Ruggeri Laderchi et al., 2013; Verme and El-Massnaoui 2015). However, while the adverse effects of FFS removal are increasingly well understood for households, the existing literature has largely ignored the effect of subsidy reforms on firms (Rentschler and Kornejew 2016). While some studies have considered economic activity and industrial sectors, their general equilibrium modelling approach lacks the granularity to offer concrete and nuanced policy recommendations for mitigating adverse effects on firms (Durand-Lasserve et al. 2015; Plante 2014; Siddig et al. 2014; Solaymani and Kari 2014). Hence, there is a clear need for empirical studies using micro-level firm data, which investigate exposure and vulnerability to high energy prices and firms' ability to cope (e.g. by reducing energy intensity, or substituting towards cheaper energy types). Just as in the case of household studies, such studies are crucial for informing the design and implementation of energy pricing reforms in developing countries.

3. Competitiveness and Energy Price Impacts

Despite being a frequently cited policy objective, competitiveness remains a concept which is neither clearly defined, nor fully understood. For the purpose of this study, we focus on the impact of energy price variations on the competitiveness of firms, which is often understood as a firm's "ability to sell" or "ability to earn" (Arlinghaus 2015). Observing and quantifying this "ability" can be difficult in practice and there is no single generally accepted approach.

Yet, for evaluating the impact of energy price variations on firms, an indicator of firm performance or competitiveness is indispensable. Recognising the difficulty of measuring the elusive concept of competitiveness per se, past empirical studies have used a variety of so called "outcome indicators", which are thought to measure outcomes or "symptoms" of competitiveness. Such indicators include revenues, profits, market share, employment, investments, exports, patents, productivity growth and others (Arlinghaus 2015; Dechezleprêtre and Sato 2014; Ekins and Speck 2010; Flachenecker 2017; Neary 2006; Siggel 2006; WEF 2016; Zairi 1994).

In practice, the choice of an adequate competitiveness indicator is driven by the considered policy issue, and limited by data availability (Arlinghaus 2015). For the purpose of this study, we use profit margins as an indicator of the performance and competitiveness of firms. Profit margins reflect both the success in cost competition, as well as potential mark-ups based on distinctive characteristics (e.g. location, product quality). Other common indicators of competitiveness, are either only weakly linked to energy price variations (such as employment or output), meaningless for micro and small enterprises (e.g. market share), or not observed in the data (e.g. exports, technology, innovation). The conceptual and theoretical underpinnings for our choice of competitiveness indicator are outlined in this section.

3.1. Using profit and cost shares to estimate competitiveness

In practice, large positive profits (above sector average) indicate that a firm is outperforming its competitors producing similar products. On the contrary, prolonged periods of negative profits eventually lead to a firm's exit. Moreover, profits are directly influenced by costs, and thus are particularly suited for assessing the effect of varying energy input prices.

The most basic profit-based competitiveness indicator are *absolute profits*, i.e. the size of firms' profit margins. However, absolute profits do not indicate whether and to what extent a firm is outperforming competitors. Instead, *relative profits* can be computed which normalise individual profits by the sectors' average profits. This approach reflects the notion that competitiveness is necessarily a relative concept, and cannot be assessed for any given firm in isolation (Zairi 1994).

Moreover, profits typically grow with firm size, thus – without standardisation – would bias competitiveness as measured by *relative profits*. Scaling profits according to the number of employees would be consistent with the definition of 'firm size' in enterprise surveys (BPS Statistics Indonesia 2015). However, by focusing on labour inputs, this approach fails to account for other factors of production, which can play an important role in defining the size (i.e. output) of a firm.

Profit shares are a consistent competitiveness indicator that addresses these shortcomings. Profit shares (or cost shares) are defined as the percentage share of profits (or costs) in total revenues. By definition, profit and cost shares always add to unity, thus considering profit shares as a measure of competitiveness is equivalent to considering cost shares (which directly depend on energy prices):

$$\frac{\pi_i}{R_i} = \frac{R_i - C_i}{R_i} = 1 - \frac{C_i}{R_i} \quad (1)$$

where π_i denotes the total profit of firm i, and R_i and C_i denote revenues and aggregate costs respectively. By definition, cost shares (C_i/R_i) for profitable firms will fall between 0 (no costs, positive revenues) and 1 (costs equal to revenues, i.e. zero profits); for firms operating at a loss the indicator will exceed 1 (costs exceed revenues). Note that the cost share is always positive, while the profit share is negative for loss-making firms. To be able to use a log regression specification we thus use the cost share for further analysis.

Note that normalising costs by total revenues controls for firm size more accurately than employee numbers, thus yielding a consistently scaled indicator of competitiveness. This can easily be shown, as revenues R_i can be expressed as a function of all production factors – not just labour:

$$\frac{C_i}{R_i} = \frac{C_i}{p_i^s Q_i} = \frac{C_i}{p_i^s\, f_i(K_i, L_i, N_i, F_i)} \quad (2)$$

where p_i^s denotes the sales price and Q_i output quantity, which is given by a production function f_i of various production factors including capital (K_i), labour (L_i), natural capital (N_i), and other factor inputs (F_i). This confirms that scaling by overall revenues more accurately reflects the range of production factors, which determine a firm's economic size. This argument is particularly relevant in manufacturing industries, where the capacity of a firm is crucially determined by assets and machinery, or in agriculture, where the size of cultivated land significantly influences output.

Overall, cost shares measure how cost-effectively production factors are utilised to generate output, thereby yielding an indicator of a firm's overall productivity that implies cost competition. Additionally, cost shares help to address endogeneity in the regression analysis, as discussed in section 6.

3.2. Response measures determine impacts

In addition to considering the effect of energy price variation on the competitiveness of firms, we also investigate whether firms have deployed measures to mitigate the effect of high energy prices. Such measures can be crucial for determining whether and to what extent an energy price change translates into competitiveness losses. Rentschler and Kornejew (2016) identify four main response measures that firms apply to mitigate the effect of energy price changes:

1. **Absorption:** Firms may choose to accept smaller profit margins, in order to absorb increases in energy costs. The level of absorption can be analysed by considering the effect of energy price changes on profit (or cost) shares – which is also an indicator of the net effect on competitiveness as discussed above.
2. **Substitution:** In response to changes in relative prices, firms may choose to substitute towards relatively cheaper energy types or production factors. The ability of firms to substitute depends on a series of factors (including the availability and affordability of alternative energy sources), and can be estimated using elasticities of (inter-fuel) substitution.
3. **Energy efficiency:** When facing higher energy prices, firms may increase the efficiency with which energy inputs are converted into output. Energy efficiency adjustments by firms can be estimated by analysing whether the energy intensity of revenue depends on energy price variation.
4. **Pass-on:** Firms may choose to pass on high energy costs to consumers in the form of higher unit sales prices. Firms' pass-on rate can be estimated by analysing whether unit sales prices depend on energy price variation.

In practice, firms will choose a combination of up to four of these measures. In order to understand the overall impact of energy prices changes on competitiveness, this study offers an empirical analysis of each of these response measures (Section 5).

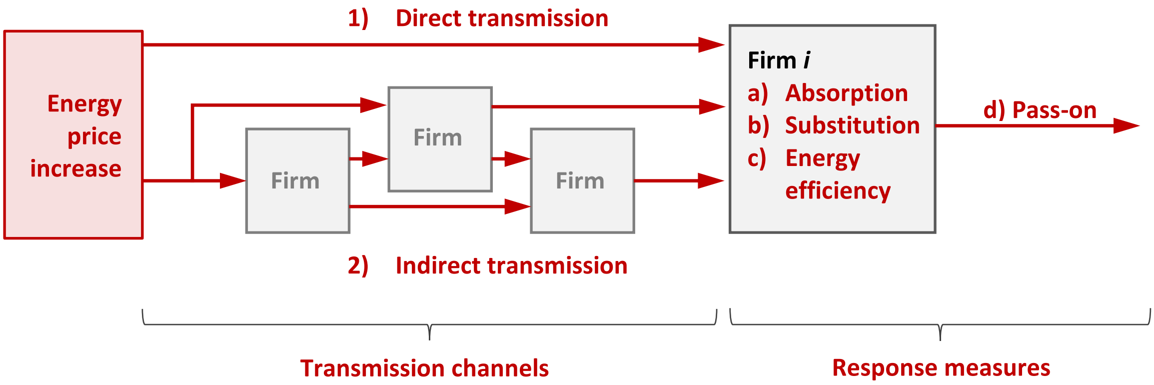

Figure 1 Energy price shocks due to subsidy removal: Channels for price shock transmission along value chains and response measures. Illustration based on Rentschler, Kornejew, and Bazilian (2017)

4. Data and descriptive observations

This study is based on a large firm survey from Indonesia for 2013, entitled Survei Industri Mikro dan Kecil (BPS Statistics Indonesia, 2015). The firm survey covers 41,402 small and micro enterprises, ranging in size from 1 to 19 employees, and distributed across all Indonesian provinces[2]. The survey provides a detailed breakdown of firms' characteristics, including employment patterns, inputs, costs, sales prices, revenues, and assets. Specifically, inputs cover various types of energy, reported in both physical and monetary units, thus enabling us to compute firm-specific prices for different energy types. This preserves price variation *within* provinces – a key for identification under confounded province level effects. Similarly, we obtain wages from total worker remuneration and employment. Revenues comprise (without distinction) domestic and international sales. However, the latter can be assumed to play a minor role due to the small and localised nature of the considered firms. Additionally, we obtain data on provincial minimum wages (BPS 2016).

4.1. Data preparation

Several data cleaning measures were taken. Specifically, we omit 3,543 firms that the survey identifies to operate only seasonally, since the reported data may not adequately reflect average business activity (e.g. profits from active seasons may be systematically larger than the sectoral average, to compensate for inactive seasons). Additionally, 1,100 observations that do not report any costs or sales figures are dropped.

While the remaining 36,759 firms all report expenditure on materials, energy, and capital, 63% of them lack data on labour costs. To avoid massive cuts in sample size, we construct missing wage data by multiplying a firm's employee number with the province-specific minimum wage (set and reported by local governments; BPS, 2016). For cross-validation we compute average wages based on reported wage bills (i.e. for the 37% of firms that report wages), and find that their cross-province variation closely reflects the profile of province-specific minimum wages. We find individual observations to frequently undercut the respective province minimum wage. This can be observed for firms with two or three employees in particular, thus suggesting informal employment. Section 6 shows that the overall results are not sensitive to alternative methods of constructing labour costs.

Moreover, based on reported cost and quantity data, we compute prices for the five main types of energy: electricity, petrol, diesel, kerosene, and LPG, which collectively account for 78.4 % of total energy costs in this sample.[3] Since prices are susceptible to potential measurement errors in either cost or quantity figures, we replace price outliers by the 2.5th (or 97.5th) percentile value of the respective provincial price distribution.[4]

Whenever firms do not use a certain type of energy – hence preventing the computation of a firm-specific energy price – the province's average price is assigned instead. This maintains substantial and meaningful variation in energy price variables, because inter-regional differences are considerable and of statistical significance: Regressing firm-individual energy prices on the full set of province fixed effects explains up to 59% of price variation for certain energy types, and finds more than half of all province averages to deviate significantly ($p < 0.05$) from the respective national average.

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[2] Following the official administrative classification, there are 34 provinces (provinsi) in Indonesia. As part of an administrative reform in 2012, Kalimantan Timur was split into two new provinces: Kalimantan Timur and Kalimantan Utara. The dataset does not distinguish these new provinces, but applies the old classification of 33 provinces instead.

[3] Excluding firewood

[4] Robustness checks in section 6 find results to be insensitive to alternative outlier treatment.

4.2. Sectors

The surveyed firms operate in the Indonesian mining and manufacturing industries. The 24 sectors distinguished in the dataset have been aggregated to 9 individual sectors on the basis of their ISIC denomination, in order to obtain robust sample sizes. Table 1 provides an exact summary of the sector coverage and aggregation used in this study.

Industry classification (ISIC)	*No.*	Aggregated sector	Number of firms	Contained subsectors (ISIC)
Mining & quarrying	*1*	Coal, lignite, peat	9,836	-
	2	Crude oil, gas, uranium	1,457	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction (excluding surveying)
				Mining of uranium & thorium ores
	3	Metal ores & others	7,224	Mining of metal ores
				Other mining and quarrying
Manufacturing	*4*	Food & beverages	1,046	-
	5	Tobacco products	6,802	-
	6	Light consumption goods	1,628	Manufacture of textiles
				Manufacture of wearing apparel; dressing and dyeing of fur
				Manufacture of wood & of products of wood & cork, except furniture; manufacture of articles of straw & plaiting materials
				Manufacture of paper & paper products
				Publishing, printing & reproduction of recorded media
	7	Coke & refined petroleum products	4,686	-
	8	Intermediate materials	2,159	Manufacture of chemicals & chemical products
				Manufacture of rubber & plastics products
				Manufacture of other non-metallic mineral products
				Manufacture of basic metals
				Manufacture of fabricated metal products (except machinery & equipment)
	9	Technical products	3,572	Manufacture of machinery & equipment
				Manufacture of office, accounting and computing machinery
				Manufacture of medical, precision & optical instruments, watches & clocks
				Manufacture of radio, television & communication devices
				Manufacture of other electrical machinery

***Table 1** Sector classification and aggregation (BPS Statistics Indonesia, 2015)*

4.3. Energy prices: regional variation

Energy prices tend to display large regional variations even within countries, not least due to local supply constraints and variable distribution costs. This issue is particularly stark in Indonesia due to its geographical characteristics.

Prices for subsidised petrol, diesel, kerosene and LPG – distributed and sold by the state-owned oil company – are set by the national government, and thus supposedly homogenous throughout the country. Similar conditions apply to electricity supply. However, inadequate infrastructure frequently causes supply shortages, particularly in peripheral and rural regions, thus creating price pressures (IEA 2015; Inchauste and Victor 2017). Existing infrastructure gaps are perpetuated by energy subsidies, which dis-incentivise investments in energy and transport infrastructure. As for electricity, missing high-voltage transmission prompt authorities to approve higher tariffs in order to unlock local small-scale supply from independent utilities (IEA 2014). These price pressures due to infrastructure gaps are reinforced by large distances and natural barriers (e.g. inland sea).

Using data on firm-specific energy usage and expenditure, firm-specific energy prices can be computed – and hence provincial average energy prices:

Electricity: In the case of electricity, challenges of distributing centrally generated power between islands are particularly large; local electricity prices thus depend strongly on the availability of local power generation capacity and off-grid solutions. Provinces in the most developed island of Java (central Indonesia) have consistently lower electricity prices than provinces in Sumatra (western Indonesia), Borneo (North), Kalimantan (North East), or Papua (East) (see Figure 1**Error! Reference source not found.**). This pattern closely reflects the position of high-voltage transmission grid lines in Indonesia (IEA 2014). Average electricity prices range from 716 R/kWh in Yogyakarta to 2,376 R /kWh in Kalimantan Tengah.

Kerosene: For further illustration, Figure 3 presents the provincial variation of kerosene prices. In contrast to electricity, kerosene prices are consistently lower in Eastern provinces. Average kerosene prices within the Eastern provinces range between 4,427 R/litre in Papua Barat to 6,067 R/litre in Maluku Utara. In the West, prices range from 7,293 R/litre (Kepulauan Riau) to 11,570 R/litre (Jawa Timur).

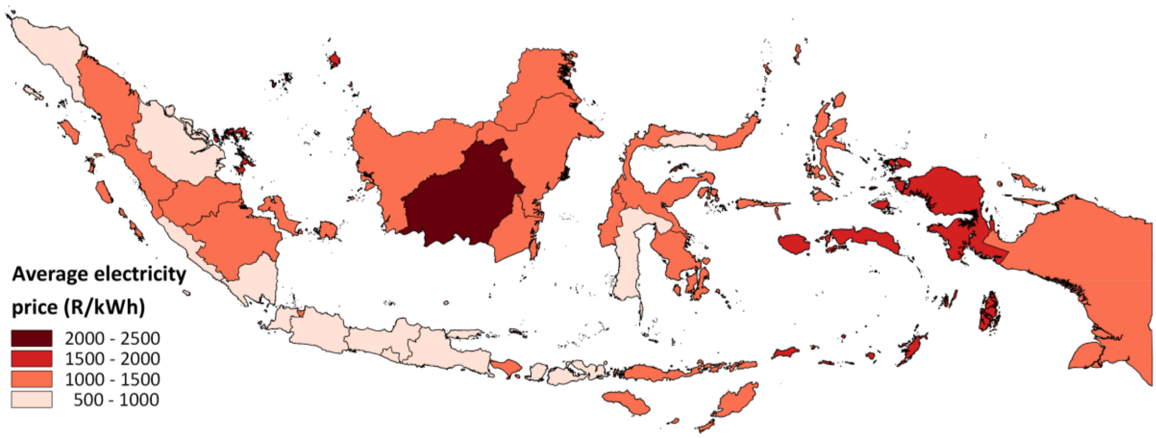

Figure 2 Average electricity prices in provinces of Indonesia (in Rupiah/kWh). R 10,000 correspond to roughly US $1 in 2013.

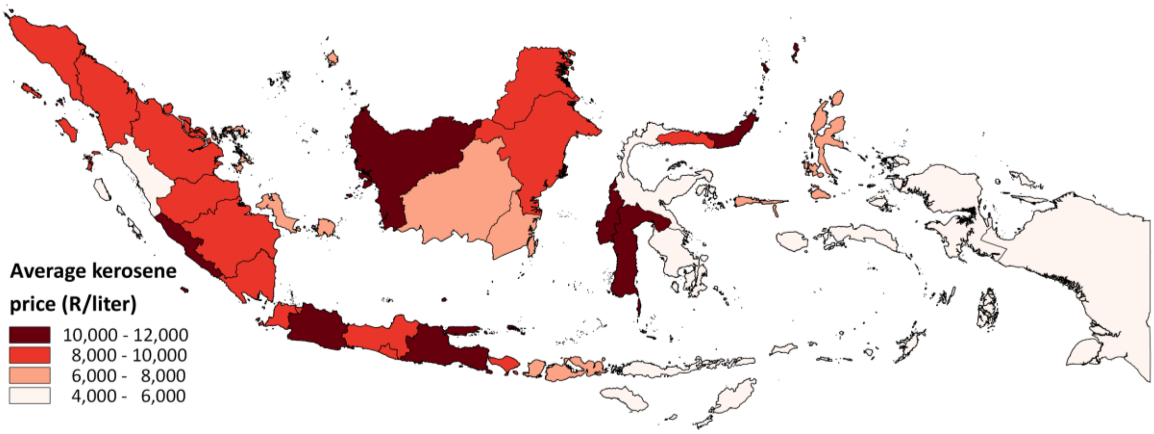

Figure 3 Average kerosene prices in provinces of Indonesia (in Rupiah/litre).

Regional price variation is also significant for other major energy types (including LPG petrol, and diesel; see Annex A). This highlights that firms operating in the same industrial sector, may face starkly differing energy prices depending on their location.

4.4. Competitiveness: regional variation

For the purpose of illustration, *relative* cost shares can be computed by normalising a firm's individual cost share with regard to its respective sector's average cost share (Section 3.1). Plotting these relative cost shares on a map illustrates that this indicator of competitiveness varies significantly across and within all major Indonesian islands (Figure 4). In a nutshell, this study investigates whether and to what extent this variation in competitiveness can be attributed to energy price differences (Section 5.1).

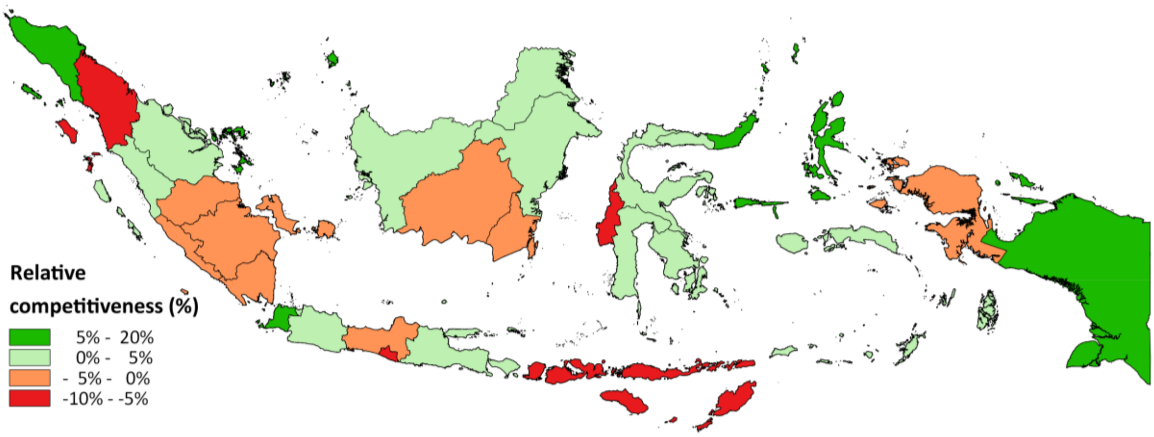

Figure 4 The average percentage deviation from national average competitiveness (defined as the relative cost share of revenue) across all Indonesian provinces. The percentage deviation is relatively small for most provinces, and competitive firms are located across the entire country.

4.5. Energy intensity

In principle, energy intensive firms will be particularly exposed to variation in energy input costs. More specifically, firms' direct exposure to particular energy prices depends on the share of particular energy goods (e.g. electricity, petrol) in total costs (Table 2**Error! Reference source not found.**). As different energy types are subject to different regulation (e.g. subsidies, taxes), supply constraints, transport costs, and other factors, energy cannot be treated as a homogenous input (Figure 5). Overall, the energy intensity of a firm will determine the magnitude of the *direct* impact of energy prices on competitiveness.

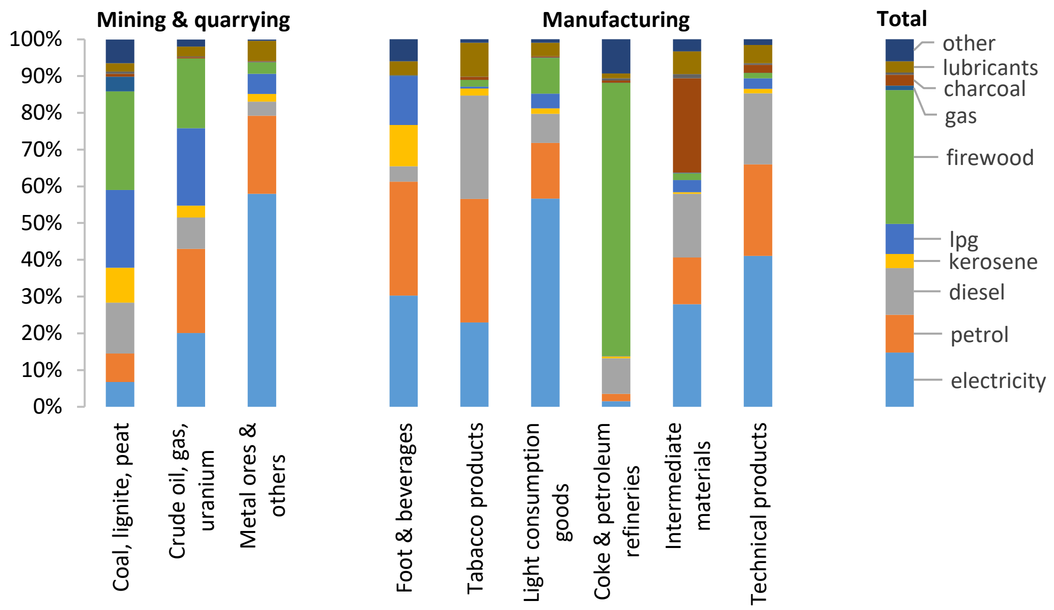

Figure 5 Composition of energy expenditure in manufacturing and mining sectors.

Despite covering the relatively energy intensive mining and manufacturing industries, the considered sample of Indonesian enterprises shows that energy inputs only account for 1% to 6% of total costs in all considered sectors, except for coke and petroleum refineries (12%; Table 2**Table 2**). The energy share of total costs can vary substantially across sectors and firm sizes (here approximated by total costs), but relative to non-energy inputs, the cost of energy inputs tends to be significantly lower (Figure 5).

Table 2 Energy intensity by sector: mean, standard deviation and percentiles.

	Sector	Mean	SD	1st	99th
Mining & quarrying	Mining of coal, lignite, peat (1)	0.06	0.06	0	0.32
	Extraction of crude oil, gas, uranium (2)	0.06	0.06	0	0.28
	Mining of metal ores & others (3)	0.01	0.02	0	0.11
Manufacturing	Foot & beverages (4)	0.02	0.03	0	0.12
	Tabacco products (5)	0.02	0.04	0	0.24
	Light consumption goods (6)	0.03	0.05	0	0.23
	Coke & petroleum refineries (7)	0.12	0.12	0	0.49
	Intermediate materials (8)	0.06	0.07	0	0.34
	Technical products (9)	0.02	0.03	0	0.16

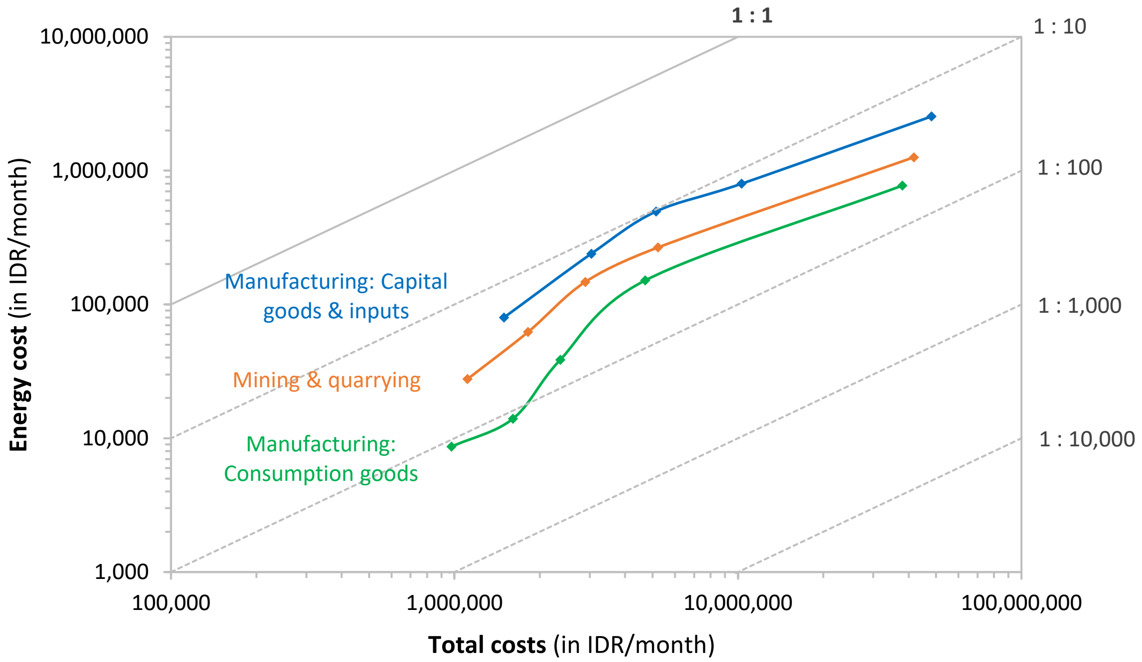

Figure 6 The relationship between total and energy input costs for different sector groups. Each sectoral group is represented by quintiles of total cost; i.e. the right-most point on each line marks the top 20% of the group in terms of total costs, the left-most point marks the bottom 20%. The *Consumption goods* group comprises sectors 4, 5, and 6; the *Capital goods & inputs* group comprises sectors 7, 8, and 9 (see Table 1). IDR 10,000 correspond to about US $1 in 2013.

However, it must be recognised that the focus on direct energy costs necessarily neglects the embodied, i.e. indirect, energy costs of other production inputs. For instance, even if a firm does not rely on energy as a direct production input, it will still rely on other goods or services (e.g. transportation, manufacturing, intermediate materials, and other parts of the local economy) – all of which rely on energy and may pass down energy price changes. This implies that especially in the longer term, a larger share of overall costs is affected by energy prices than these numbers suggest.

5. The effects of energy prices on competitiveness

Based on the discussion in Section 3 and Rentschler & Kornejew (2016), this section empirically assesses the link between energy price variation and competitiveness – and explores the role of response measures in determining this link. Section 5.1 investigates the long-term effect of high energy prices on competitiveness, using the absorption into profit shares as a proxy. Section 5.2 estimates firms' ability to adapt to high prices of certain fuels by substituting energy types and other inputs. Section 5.3 explores the role of energy efficiency as a response measure to high energy prices. Section 5.4 analyses to what extent firms pass on high energy costs to end-users.

5.1. Long-run competitiveness: Energy prices and cost shares

By exploiting inter-regional energy price differentials, this section investigates whether energy prices have an enduring impact on the competitiveness of firms. The underlying argument is that high energy prices drive up production costs (directly and indirectly), thus jeopardising firms' ability to operate competitively. By basing the estimation on structural and thus persistent regional price differentials, our model measures the net effect of energy prices on firms' per-unit cost in the long run: i.e. after indirect price effects have unfolded, and after firms have implemented adaption measures. Moreover, analysing small and micro firms – which predominantly draw on regional supply chains – ensures that the associated regional price indeed shapes indirect impacts.

5.1.1. Regression set-up

Specifically, we regress the natural logarithm of the cost share of firm i on logged prices for electricity, petrol, diesel, kerosene and LPG, indexed by e. Intuitively, we expect that higher energy prices are associated with higher cost shares, i.e. that parameter β_e is positive.

$$\ln\left(\frac{C_i}{R_i}\right) = \beta_0 + \sum_{e=1}^{5} \beta_e \ln\left(price_{e,i}\right) + \sum_{s=1}^{21} \gamma_s sector_{s,i} + \sum_{p=1}^{32} \delta_p province_{s,i} + \varepsilon_i \quad (3)$$

Common sector impacts such as market demand shocks or the degree of competition which determines mark-ups, are controlled for by sector fixed effects.[5] Moreover, the full set of province dummies is included, as regional characteristics that drive energy prices might otherwise directly or indirectly affect cost shares.

Note that no further controls are included to isolate the *direct* energy price effect. The reason is that in order to estimate the total effect of energy prices on competitiveness, the reduced-form effect must be preserved, i.e. including both direct and indirect price effects. The indirect effect captures that energy costs are passed on along value chains, thus affecting the cost of non-energy inputs such as materials, capital, and labour. In other words, to assess the total effect of energy prices on firm performance, the energy-intensity of non-energy inputs cannot be disregarded.

The choice of the dependent also makes the regression set-up robust to issues of reverse causality or simultaneity, which are common with price regressions. Typically, prices and quantities form an endogenous link, thus biasing the analysis. Rather than focussing on absolute energy demand (which may affect energy prices, e.g. in the case of large firms), we focus on cost and profit shares, which are independent of firm size, and thus not systematically linked to absolute factor demand.

5.1.2. Results

Overall, the results – as summarised in Table 3 – show that higher energy prices have a small but significant adverse effect on the competitiveness of firms. Specifically, following observations can be made:

Small, but significant effect: Higher energy prices reduce competitiveness. The estimates for the total sample (first column of estimated coefficients) suggest that – on average – higher energy prices are indeed associated with higher long-run unit costs, i.e. lower levels of competitiveness. Effects are small, but significant for four out of five types of energy. Across all sectors and energy types significant coefficients are positive, thus confirming the qualitative nature of the effect.

Some energy types matter more than others. While the prices for all energy types are associated with positive coefficients, the size of the effect differs considerably across energy types. Most notably, the largest impacts come from differences in diesel and LPG prices. This pattern holds not only in the total sample but also in many sectors. On average, 1% higher diesel prices result in a 0.35% higher cost share, and 0.23% higher in the case of LPG prices. Kerosene and electricity are estimated to affect cost shares least of all, though kerosene matters greatly in certain sectors.

Different energy types matter in different sectors. Disaggregating the sample into nine sectors (as defined in section 4.2) reveals heterogeneity masked by the overall effects. For instance, kerosene is estimated to be important for the mining of coal, lignite and peat, and the production of tobacco and technical goods – but not in other sectors. The rank order of importance of energy types varies across

[5] Note that the inclusion of sector dummies supersedes any sector-related normalisation for the dependent variable. It is easy to show that the log-linear setting brings about algebraic equivalence.

sectors, though the role of either LPG or diesel is estimated to be substantial in almost all sectors. The impact of electricity is relatively weak across all subsamples.

In combination, the above observations show that effects can differ significantly depending on which sector and which energy type is considered. This is despite sectors being similar (i.e. manufacturing or mining sectors), and demonstrates that increasing prices of certain energy types is likely to have disproportionately large effects on certain sectors, due to the inherent (technological) characteristics of their production processes, which determine their ability to implement response measures.

	Total sample	**Mining:** Coal, lignite, peat	**Mining:** Crude oil, gas, uranium	**Mining:** Metal ores & others	**Manufac.:** Food & beverages	**Manufac.:** Tobacco products	**Manufac.:** Light consumption goods	**Manufac.:** Coke & refined petroleum	**Manufac.:** Inter-mediate materials	**Manufac.:** Technical products
ln (**electricity** price)	0.052***	0.077***	0.081	0.028	0.016	0.089**	-0.087	0.015	0.016	0.023
	0.009	*0.014*	*0.050*	*0.022*	*0.047*	*0.028*	*0.047*	*0.028*	*0.027*	*0.021*
ln (**kerosene** price)	0.043	0.167**	-0.363	-0.263	-0.082	0.589*	-0.015	0.105	-0.245	0.128
	0.043	*0.055*	*0.222*	*0.176*	*0.310*	*0.284*	*0.296*	*0.104*	*0.142*	*0.259*
ln (**LPG** price)	0.232***	0.198***	0.124	0.458***	0.290	0.767**	0.091	0.568	0.095	0.059
	0.036	*0.045*	*0.141*	*0.132*	*0.149*	*0.300*	*0.228*	*0.406*	*0.088*	*0.147*
ln (**petrol** price)	0.160**	0.234*	0.207	0.400**	-0.002	-0.033	0.225	0.450**	0.229	-0.038
	0.050	*0.094*	*0.170*	*0.150*	*0.169*	*0.156*	*0.193*	*0.145*	*0.135*	*0.105*
ln (**diesel** price)	0.373***	0.568**	0.542	0.450	-0.636	0.685*	0.701	-0.117	0.564*	0.266
	0.098	*0.212*	*0.494*	*0.536*	*0.481*	*0.250*	*0.575*	*0.155*	*0.222*	*0.153*
industry dummies	YES	NO	IN PARTS	IN PARTS	NO	NO	IN PARTS	NO	IN PARTS	IN PARTS
province dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	36,759	9,371	1,165	7,197	1,052	6,576	1,592	4,102	2,178	3,526
adjusted R^2	0.214	0.061	0.106	0.293	0.073	0.134	0.139	0.069	0.065	0.087

Table 3 Estimated coefficients. Robust standard errors are reported in italics, significance levels indicated by asterisks: *** p<0.001; ** p<0.01; * p< 0.05. YES and NO specify the introduction of industry and province dummies. IN PARTS denote the introduction of those industry dummies that apply to the given aggregate sector; see Table 1 for sector classifications and aggregations.

5.2. Inter-fuel substitution

The extent to which regional energy price differences affect the long-run competitiveness of a firm, depends crucially on whether firms are able to respond by substituting away from comparably expensive energy types (Rentschler and Kornejew 2016). Similarly, if firms upstream the value chain are able to substitute away from expensive energy types this can dampen indirect cost propagation. In principle, substitution can refer to the replacement of energy inputs with other factors of production (e.g. labour), as well as inter-fuel substitution. In either case, the substitutability of energy will depend on firm specific technological limitations, operational requirements, and on the general availability of and access to alternative energy types.

The price coefficients obtained in the previous subsection are linked to the respective *gross input price elasticity of costs,* and can hence be interpreted as an indicator of a fuel's overall substitutability. By considering inter-fuel substitution, this subsection assesses the extent to which firms are able to substitute away from certain energy types, i.e. adapt to high energy prices by adjusting their energy mix.

The ability to substitute fuels is also of importance from an environmental perspective. It determines to what extent price based environmental policy (such as energy taxes or subsidy removal) can cause consumers to switch towards cleaner energy goods, and thus contribute to the reduction of environmental burdens such as air pollution or greenhouse gas emissions.

5.2.1. Partial price elasticities and elasticities of substitution

In order to quantitatively assess (inter-) fuel substitutability, we estimate trans-log cost functions – a common approach used for example by Pindyck (1979), Andrikopoulos et al. (1989), Cho et al. (2004), and Banda and Verdugo (2007). As suggested by Blackorby and Russell (1989), Chambers (1988), and Frondel (2010) we focus on partial own and cross price elasticity combinations to assess the extent to which firms are able to substitute (or complement) one energy type with another.

In line with a standard two-stage cost minimisation problem, we consider a trans-log cost function which is homothetically separable in the production factors, i.e. labour, capital and five types of energy (Christensen et al. 1973; Pindyck 1979):[6]

$$\begin{aligned}\log C = \alpha_0 + \alpha_Q \log Q + \sum_i \alpha_i \log p_i + \frac{1}{2}\gamma_{QQ}(\log Q)^2 \\ + \frac{1}{2}\sum_i \sum_i \gamma_{ij} \log p_i \log p_j + \sum_i \gamma_{Qi} \log Q \log p_i \qquad (4)\end{aligned}$$

$$where \;\; Q = f(K, L, E(electricity, petrol, diesel, kerosene, lpg))$$
$$and \; i, j \in \{K, L, E\}$$

For a discussion of the parameters in the trans-log cost function see Annex D, Pindyck (1979), and Banda & Verdugo (2007). Note that the nested structure of the production function comprises capital K, labour L, and an energy aggregate E, which is a function of various energy types whose mix are optimized in the first stage. Under homotheticity, the unit cost function for aggregate energy (p_E) resulting from this first-stage-optimization can be modelled as:

6

$$\log p_E = \beta_0 + \sum_m \beta_m \log p_m + \sum_m \sum_n \gamma_{m,n} \log p_m \log p_n$$
$$where\ m,n \in \{electricity, petrol, diesel, kerosene, lpg\}$$

Following Shephard's Lemma, expenditure shares are obtained by differentiating respective cost functions with respect to log factor prices. Accordingly, the share s_m of fuel m in total energy expenditure can be expressed as

$$\frac{\partial \log p_E}{\partial \log p_m} = s_m = \beta_m + \sum_n \gamma_{m,n} \log p_n \qquad (5)$$

Note that this equation is identified in observable variables and thus estimable. Using the estimator for $\gamma_{m,n}$, we obtain partial price elasticities η (Pindyck, 1979)

$$\eta_{m,m} = \frac{\left(\gamma_{m,m} + s_m(s_m - 1)\right)}{s_m}$$
$$\eta_{m,n} = \frac{(\gamma_{m,n} + s_m s_n)}{s_m}. \qquad (6)$$

Note that, due to the two-stage-structure, the partial price elasticities only account for the substitution between fuels (hence *partial*), i.e. under the constraint that total energy usage remains unchanged. In other words, it neglects substitution of aggregate energy by labour and capital as well as possible output changes, and measures relative changes in the energy mix only.

In addition, we compute Uzawa-Allen and Morishima partial elasticities of substitution, which measure the extent to which the ratio (i.e. shares) of two particular energy types change in response to a change in their relative prices (Blackorby and Russell 1989; Uzawa 1962). Uzawa-Allen partial elasticities of substitution σ^{AES} can be written as (Uzawa 1962, Pindyck, 1979)

$$\sigma^{AES}_{m,n} = \sigma^{AES}_{n,m} = \frac{(\gamma_{m,n} + s_m s_n)}{s_m s_n} = \frac{\eta_{m,n}}{s_n}, \qquad (7)$$

and Morishima partial elasticities of substitution σ^{MES} (Blackorby & Russell, 1989, Frondel 2010) as

$$\sigma^{MES}_{m,n} = \eta_{m,n} - \eta_{n,n}$$
$$\sigma^{MES}_{n,m} = \eta_{n,m} - \eta_{m,m}. \qquad (10)$$

5.2.2. Results

Estimated partial price elasticities for the whole sample are presented in table 4 (for individual sectors see Annex E). Most notably, the estimated **partial cross price elasticities** (off- diagonal entries) indicate that all pairs of energy types are substitutes, i.e. elasticities that are larger than 0, except petrol and LPG. This suggests that – when certain energy prices increase – firms can indeed replace most energy types for others. Kerosene and diesel are estimated to be the strongest substitutes, while petrol and LPG are the strongest complements.

Own price elasticities (diagonal entries) for all energy types are estimated to be negative, and hence are consistent with standard microeconomic theory. Demand for petrol is estimated to be most inelastic, while demand for kerosene and LPG is estimated to be most elastic.

According to the estimates in table 4, electricity can be substituted by a mix of all other types of energy. In contrast, electricity plays a minor role in replacing any other energy types. Moreover, while being an important source of energy for most manufacturing firms, petrol is estimated to be the least substitutable one. This may be attributed to the fact that only three suitable substitutes exist, as LPG and petrol are complements. Instead, diesel and kerosene are the most important substitutes.

Quantitatively, kerosene is estimated to be an important substitute for all other main energy types. This does not necessarily imply that it is technologically superior to other alternatives, but rather that it is economically attractive given relative prices. However, the fact that it reacts most sharply to own price changes and is substituted easily by moderate quantities of other inputs emphasises economical attractiveness rather than technical significance.

The estimates for Uzawa-Allen and Morishima elasticities of substitution are reported in Annex F, and confirm the overall conclusions derived above from price elasticities.

		Price change				
		Electricity	**Petrol**	**Diesel**	**Kerosene**	**LPG**
Quantity response	**Electricity**	-1.51***	0.17***	0.16**	0.09***	0.05**
	Petrol	0.24***	-0.93	0.48***	0.11*	-0.29***
	Diesel	0.18**	0.37***	-1.06**	0.32***	0.39***
	Kerosene	0.37***	0.30*	1.12***	-5.68***	1.17***
	LPG	0.09**	-0.38***	0.64***	0.45***	-2.90***

Table 4 *Partial own and cross price elasticities for the five main energy types. Asterisks indicate the confidence level (***0.1%; ** 1%; * 5%) of the underlying estimate for* $\gamma_{m,n}$ *and* $\gamma_{m,m}$, *respectively. Insignificant estimates of own-price elasticities are statistically indistinguishable from* $s_m - 1$ *(equation 6; in particular in the case of petrol,* $s_{petrol} - 1 = -0.897$*).*

5.3. Energy efficiency

Firms may also respond to energy cost increases by increasing energy efficiency, i.e. reducing the energy intensity of output. Formally, energy (or material) efficiency relates to the marginal product of energy (or material inputs), i.e. the output obtainable from the last unit of energy input given the current production technology. This implies that gains in energy efficiency require an adjustment to the production function, for instance by updating production processes or technology. Thus, from a policy making perspective, improvements in energy efficiency are a desirable and welfare improving response to FFS reforms, as they are associated with modernisation, innovation, and reduction of negative externalities of inefficient energy usage such as air pollution (Flachenecker et al. 2016).

Similar to the case of substitution, the ability of firms to increase energy efficiency depends on a variety of factors, all of which mandate dedicated policy measures: e.g. to improve the availability and affordability of modern technology, and to provide support programmes for identifying, financing, and implementing efficiency enhancing measures (Rentschler, Bleischwitz, and Flachenecker 2016; Rohdin, Thollander, and Solding 2007; Trianni et al. 2013).

5.3.1. Regression set-up

This section investigates whether firms do use energy efficiency improvements as a response to higher energy prices; i.e. whether firms facing higher energy prices, systematically display lower energy intensity of output compared to competitors in the same sector. For this purpose, a measure for the energy intensity of revenue is constructed in two steps:

First, for a given firm, the energy content of different energy inputs is computed (in MJ) based on the reported energy usage and the physical conversion factors summarised in Table 5. These figures for different energy types are then aggregated to yield the total energy content used by the firm. Second, the total energy content is divided by the firm's total revenues, in order to obtain a measure of the energy intensity of revenue (in MJ/IDR); i.e. an indicator of energy efficiency. Table 6 summarises the variation of energy efficiency across and within sectors.

***Table 5** Energy content of different fuels (in terms of energy density or specific energy), based on (BP 2016; EIA 2016; IPCC 2006)*

	Energy content	
Petrol	33.36	MJ/litre
Diesel	36.25	MJ/litre
Electricity	3.60	MJ/kWh
Kerosene	34.95	MJ/litre
LPG	47.30	MJ/kg
Coal	28.20	MJ/kg
Gas	35.00	MJ/m^3

***Table 6** Energy efficiency: Total energy content divided by revenues (in KJ/INR). Mean, standard deviation, percentiles.*

Sector	Mean	SD	1st	99th
Mining of coal, lignite, peat	0.31	2.79	0.00	2.62
Extraction of crude oil, gas, uranium	0.26	2.68	0.00	1.64
Mining metal ores & others	0.15	1.34	0.00	1.29
Food & beverages	0.16	1.85	0.00	0.79
Tabacco products	0.12	1.40	0.00	1.11
Light consumption goods	0.23	1.40	0.00	2.50
Coke & petroleum refineries	0.13	1.15	0.00	1.63
Intermediate materials	0.22	3.01	0.00	1.35
Technical products	0.26	4.25	0.00	1.24
Total	**0.20**	**2.35**	**0.00**	**1.73**

Regression equation (3) is then modified by replacing the dependent variable with the firm-specific energy efficiency measure.

$$\frac{E_i}{R_i} = \alpha_0 + \sum_{e=1}^{5} \alpha_e \ln\left(price_{e,i}\right) + \sum_{s=1}^{21} \sigma_s sector_{s,i} + \sum_{p=1}^{32} \pi_p province_{s,i} + \varepsilon_i \qquad (8)$$

This set-up can then capture the extent to which energy price levels determine the energy efficiency of firms; i.e. whether firms facing high energy prices have systematically adapted by reducing the energy intensity of revenue.

5.3.2. Results

Table 7 reports the estimated coefficients for the full sample. Overall, the negative signs of the estimates confirm the intuition that higher prices for all energy types are associated with lower energy intensity of revenue – i.e. higher energy efficiency. On average, increasing electricity prices by 1% prompt firms to use 60 KJ less energy from all fuel types per 10,000 IDR (about US $1) of revenue.

Table 7 *Sensitivity of energy efficiency to fuel prices. Standard errors (in italics) are robust to heteroscedasticity, *** p<0.001; ** p<0.01; * p< 0.05.*

	$\hat{\alpha}_e$
ln (**electricity** price)	-0.624***
	0.118
ln (**kerosene** price)	-0.196**
	0.072
ln (**LPG** price)	-0.138
	0.186
ln (**petrol** price)	-0.245
	0.214
ln (**diesel** price)	-0.155
	0.093
industry dummies	YES
province dummies	YES
N	36,758
adjusted R^2	0.021

It should be noted that controlling for wages has no notable effect on the results reported in Table 7. The estimates indicate that wages have an insignificant positive impact on energy efficiency.

5.4. Pass-on

The net impact of energy prices on competitiveness also depends on whether firms can pass on high energy costs to end-users (Rentschler and Kornejew 2016). Essentially, this channel refers to firms' ability to adjust the unit sales price of output in response to changing input costs (without incurring excessive reductions of sales quantities).

5.4.1. Regression set-up

This section investigates whether firms do pass on high energy prices; or more specifically, whether firms facing higher energy prices, systematically charge higher unit sales prices compared to competitors in the same sector. The sales prices and quantities required for this purpose are reported in the dataset. Since firms frequently sell multiple goods, an average unit sales price is computed for each firm, weighted by the goods' relative shares in overall sales.

Regression equation (3) is again modified by replacing the dependent variable with the natural logarithm of the firm-specific average sales price asp_i.

$$\ln(asp_i) = \theta_0 + \sum_{e=1}^{5} \theta_e \ln\left(price_{e,i}\right) + \theta_c \ln(total\ cost_i) + \theta_w \ln(wage_i) + \sum_{s=1}^{21} \tau_s sector_{s,i} + \sum_{p=1}^{32} \omega_p province_{p,i} + \varepsilon_i \qquad (9)$$

In this sample, larger firms tend to produce goods and services that are more valuable, e.g. due to either higher quality or simply larger scale. Moreover, the IEA (2015) suggest that larger firms are more likely to operate in areas with better energy infrastructure or to receive preferential supply of subsidised fuel in the event of shortages. To avoid an omitted variable bias, the regression controls for firm size, approximated by (the natural logarithm of) a firm's total cost.[7]

Additionally, the regression controls for wages as these can offer an important reference point: Labour costs typically exceed energy costs and may be passed on to consumers at a higher rate, since higher wages are typically associated with higher purchasing power *ceteris paribus*. Overall, this regression set-up can capture the extent to which energy price levels determine the average unit sales price charged by firms; i.e. whether firms facing high energy prices have adapted by systematically passing on these costs.

5.4.2. Results

Table 8 reports the estimated pass-on coefficients for the full sample. The positive signs of the estimates confirm that higher prices for all energy types are indeed associated with higher long-run sales prices – i.e. that firms pass on (direct and indirect) energy costs to consumers. Due to the sample's focus on certain economic sectors and on small firms, no concrete conclusion can be drawn about the effect on overall consumer price levels. However, significant pass-on estimates highlight that indirect transmission of energy costs along value chains can be significant, and must be taken into consideration for understanding the net effect of energy prices on firms.

It is noteworthy that on average the pass-on of wage costs occurs at a higher (and more significant) rate than for energy. This confirms the intuition that wages are more easily and thus more often passed on, since they are – contrary to energy costs – associated with higher purchasing power of consumers.

Table 8 *Sensitivity of unit sales prices to fuel prices. Standard errors (in italics) are robust to heteroscedasticity, *** p<0.001; ** p<0.01; * p< 0.05.*

	Control for total costs	**Controls for total costs & wages**
ln (**electricity** price)	0.051*	0.052*
	0.020	*0.020*
ln (**kerosene** price)	0.166	0.184*
	0.090	*0.089*
ln (**LPG** price)	0.180*	0.186*
	0.086	*0.086*
ln (**petrol** price)	0.231*	0.185
	0.114	*0.114*
ln (**diesel** price)	-0.027	-0.016
	0.177	*0.177*
ln (total **costs**)	0.453***	0.445***
	0.010	*0.010*
ln (**wage**)	-	0.361***
		0.036
industry dummies	YES	YES
province dummies	YES	YES
N	36,742	36,742
adjusted R^2	0.490	0.491

[7] Using *employment* or *total revenue* instead yield very similar results.

6. Robustness tests and limitations

We have tested the sensitivity of results to following variations of the regression set-up:[8]

- Overall, estimates are robust to alternative approaches to account for missing labour cost data (Annex C). Specifically, we constructed missing data by averaging peer wage bills (same province and employment), or obtained out-of-sample predictions from a regression of existing labour costs (logged) on dummies for numbers of employees, sector and province.
- Excluding the regionally concentrated food and beverages sector makes no statistically significant difference to the estimates (not least due to the small sub-sample size of this sector).
- Including outliers in the energy price distributions makes no significant difference to estimates.
- Excluding one or more energy types from the regression equations leaves standard errors and point estimates stable, thus suggesting that multi-collinearity is no issue. Moreover, regressing only one single price on cost shares at a time and restricting the sample to those firms for which individual prices are available yield similar coefficients for all five energy types. Applying a Heckman selection model does not alter conclusions.
- Including seasonally operating firms leads to a minor increase in the estimated coefficients of the cost share regression (Section 5.1) for all energy prices, except kerosene. Price impacts on energy efficiency (Section 5.3) stay the same apart from a doubling of the diesel coefficient, which becomes significant at the 5% level. Pass-on estimates (Section 5.4) remain qualitatively unchanged.
- Controlling for firm size – as measured by either total cost, employment or total revenue – in the cost share (Section 5.1) and energy efficiency model (5.3) has no considerable effect on energy price coefficients.
- Clustering structural errors at the province or industry level slightly inflates the coefficients' standard errors in all regression set-ups. However, p-values of formerly significant estimates again remain well below 5% in virtually all cases.

Two limitations to the validity of this study should be highlighted:

Estimates for sector *4* (food and beverages) need to be interpreted with caution. This sector represents the smallest subsample in terms of number of observations; moreover, almost 50% of firms in this subsample are concentrated in two provinces (over 80% in 5 provinces), thus the regional variations which this analysis relies on are not pronounced. This is likely to cause the negative (though insignificant) coefficients for kerosene, petrol, and diesel (table 3). In all other sectors, the sampled firms are far more evenly distributed across provinces.

Interpretation in the context of FFS reforms: Since regional energy price differences in Indonesia are persistent, firms in this sample will have adjusted to existing local energy prices. By comparing provinces with high and low energy prices, results in this study provide an estimate of the orders of magnitude of how FFS reforms may affect firm level outcomes in the long-term. However, regional price differences in this cross-section setting do not necessarily reflect potential sudden and simultaneous energy price shocks due to a FFS reform. Firms and value chains require time to respond and adjust to energy price increases, e.g. by enabling energy substitution and efficiency increases through capital investments, technological updates, and reallocation of resources. Thus, results should be interpreted as long term effects. Moreover, a FFS reform will affect the economy as a whole rather

[8] For the sake of brevity, not all these results are reported (available upon request).

single provinces or islands; as a consequence, indirect effects and post-reform dynamics may differ as the entire economy adapts to the shock.

7. Conclusion and policy implications

In this paper, we analyse to what extent energy prices can affect the performance of firms. We consider cross section data for micro and small enterprises in the manufacturing and mining sectors in Indonesia. We provide a detailed analysis of the effect of energy prices on the long-term profitability of firms, and of the measures used by firms to adapt to higher prices. Overall, the analysis in this paper yields following key results:

- **Energy prices & competitiveness:** Exploiting regional price differences, we estimate that higher energy prices have a small (but statistically significant) adverse effect on long-term competitiveness – proxied by profitability. This observation is valid for almost all considered sectors and energy types. We find that different energy types matter in different sectors with diesel showing the largest and most stable effect, presumably due to its importance for commercial freight and on-site power generation.
- **Response measures:** We show that firms use a mix of response measures to mitigate the adverse effect of high energy prices on profitability. In particular, we show that firms are able to respond to higher energy prices by adjusting their energy mix, i.e. substituting certain energy types for others. Moreover, we show that firms increase energy efficiency in response to higher energy prices, as well as passing on energy cost increases to end-users. The estimates suggest that these response measures play a significant role, but cannot fully mitigate the adverse effect of energy prices on long-term profitability.

By considering the effects on firms and competitiveness, this study contributes to the literature on FFS reform, which has focused predominantly on the effect on households and consumption. The observations made in this paper allow several conclusions which are of immediate relevance for policy makers that design and implement energy pricing reforms, such as FFS reforms, or carbon and energy taxes. In particular:

- **Drastic competitiveness losses unlikely in the long-term:** Firms in this sample have adapted to large differences in energy prices. Energy price increases due to subsidy reform are unlikely to cause drastic long-run reductions of competitiveness for the considered sample; yet different fuels matter in different sectors.
- **Consider indirect effects:** Non-energy inputs (incl. materials, labour) account for far higher shares in firms' total costs. Energy price increases may (through indirect price effects) affect the price of these inputs, which may in turn have significant effects on competitiveness. While the total price effect (i.e. direct & indirect) has been estimated to be small for the sample in this paper, policy makers need to consider this possibility on a case-by-case basis.
- **Enabling substitution:** Ensuring the availability of alternative energy types is crucial to enable firms to substitute from subsidised fossil fuels to cleaner alternatives. Complementary policy measures are needed to ensure that (i) firms are able to substitute fuels, in order to cope with high energy prices, and (ii) fossil fuels are not substituted with other unsustainable fuels (including charcoal or firewood).
- **Enabling efficiency gains:** The ability of firms to implement efficiency enhancing measures can be obstructed by a variety of barriers (such as information or financial constraints). Dedicated policy measures may be needed to support firms in implementing efficiency enhancing measures, e.g. through modernisation and technological updates. If efficiency measures are

successfully implemented, excessive pass-on of energy price increases to end-users can be avoided.

All of these specific conclusions highlight that energy pricing reforms – such as the removal of fossil fuel subsidies – must be accompanied by a number of complementary policy measures. Policy measures that strengthen general conditions for the "ease of doing business", or that promote cleaner and more efficient production processes will not only mitigate potential adverse effects on competitiveness, but strengthen a reform's contribution towards sustainable development.

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Annex A: Regional energy prices

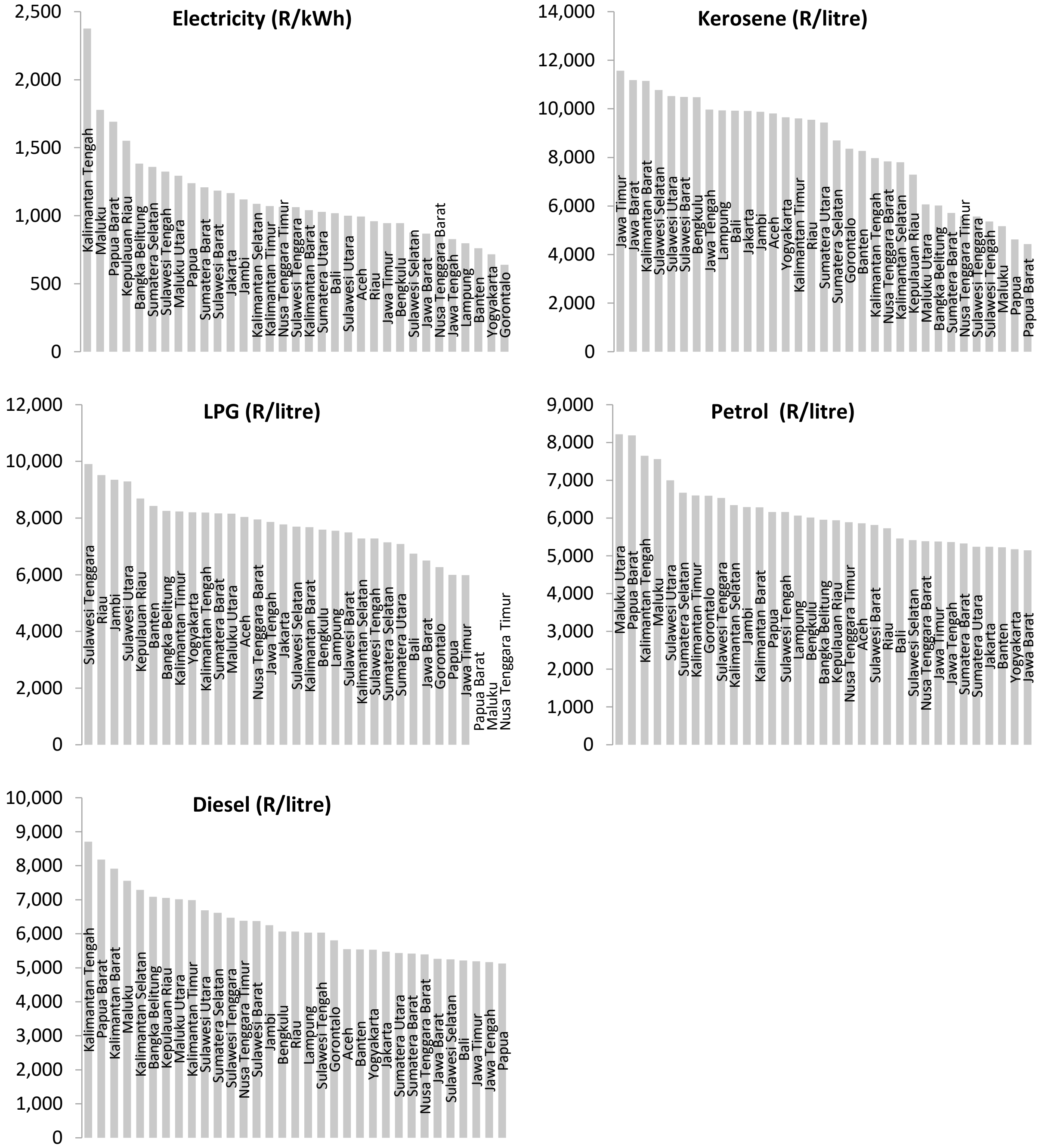

Figure 7 Average energy price for each province, inferred from quantity and expenditure data contained in the 2013 Micro & Small Enterprise Survey for Indonesia (BPS Statistics Indonesia 2015)

Annex B: Theoretical derivation of regression equation

The regression equation can be derived analytically from a standard CES production function:

$$Q_j = \gamma_j \left[\sum_h \delta_{hj} \, \mathrm{F}_{\mathrm{hj}}^{\eta_j} \right]^{\frac{1}{\eta_j}}$$

Note that the parameter η_j is defined through the elasticity σ_j:

$$\eta_j = \frac{\sigma_j - 1}{\sigma_j}$$

The associated profit function is expressed as revenue minus the sum of factor costs:

$$\pi_j = p^Q Q_j - \sum_h p_h^f \, F_{hj}$$

Standard profit optimisation yields optimal factor demand:

$$\mathrm{F}_{\mathrm{hj}}^* = \left[\gamma_j^{\eta_j} \delta_{hj} \frac{p_j^Q}{p_h^f} \right]^{\frac{1}{1-\eta_j}} Q_j$$

The profit share PS (i.e. percentage share of profits in total revenue, as outlined in section 4) can be expressed as:

$$PS = \frac{\pi_j^*}{p_j^Q Q_j^*}$$

$$= \frac{p^Q Q_j^* - \sum_h p_h^f \, F_{hj}^*}{p_j^Q Q_j^*}$$

By inserting the expression for optimal factor demand, and rearranging further we obtain an estimable equation for the profit share:

$$PS = 1 - \frac{\sum_h p_h^f \left[\gamma_j^{\eta_j} \delta_{hj} \frac{p_j^Q}{p_h^f} \right]^{\frac{1}{1-\eta_j}} Q_j^*}{p_j^Q Q_j^*}$$

$$= 1 - \sum_h \frac{p_h^f}{p_j^Q} \left[\gamma_j^{\eta_j} \delta_{hj} \frac{p_j^Q}{p_h^f} \right]^{\frac{1}{1-\eta_j}}$$

$$= 1 - \sum_h \left[\frac{p_h^f}{p_j^Q} \right]^{\frac{\eta_j}{1-\eta_j}} \left[\gamma_j^{\eta_j} \delta_{hj} \right]^{\frac{1}{1-\eta_j}}$$

$$= 1 - (p^E)^{\frac{\eta_j}{1-\eta_j}} (p_j^Q)^{\frac{-\eta_j}{1-\eta_j}} \left[\gamma_j^{\eta_j} \delta_{Ej} \right]^{\frac{1}{1-\eta_j}} - \sum_{h \backslash E} \left[\frac{p_h^f}{p_j^Q} \right]^{\frac{\eta_j}{1-\eta_j}} \left[\gamma_j^{\eta_j} \delta_{hj} \right]^{\frac{1}{1-\eta_j}}$$

$$= 1 - A \, (p^E)^{\beta} \; - B$$

Where we have defined:

$$A = \left(p_j^Q\right)^{\frac{-\eta_j}{1-\eta_j}} \left[\gamma_j^{\eta_j} \delta_{Ej}\right]^{\frac{1}{1-\eta_j}}$$

$$B = \sum_{h \setminus E} \left[\frac{p_h^f}{p_j^Q}\right]^{\frac{\eta_j}{1-\eta_j}} \left[\gamma_j^{\eta_j} \delta_{hj}\right]^{\frac{1}{1-\eta_j}}$$

$$\beta = \frac{\eta_j}{1-\eta_j}$$

The profit share can be rearranged to obtain the regression equation for the cost share CS:

$$\frac{\pi_j^*}{p_j^Q Q_j^*} = 1 - A\,(p^E)^\beta - B$$

$$\frac{p^Q Q_j - \sum_h p_h^f F_{hj}}{p_j^Q Q_j^*} = 1 - A\,(p^E)^\beta - B$$

$$CS = \frac{\sum_h p_h^f F_{hj}}{p_j^Q Q_j^*} = A\,(p^E)^\beta + B$$

Annex C: Alternative approaches to accounting for missing labour cost data

Table 9 *The first column reports baseline estimates as obtained in Section 5.1. Column (1) uses fitted values from the labour cost regression. Column (2) uses labour costs as derived from peers. Standard errors (in italics) are robust to heteroscedasticity, *** p<0.001; ** p<0.01; * p< 0.05.*

	Baseline	**(1)**	**(2)**
ln (**electricity** price)	0.052***	0.034***	0.045***
	0.009	*0.008*	*0.009*
ln (**kerosene** price)	0.043	0.053	0.048
	0.043	*0.039*	*0.044*
ln (**LPG** price)	0.232***	0.180***	0.237***
	0.036	*0.031*	*0.037*
ln (**petrol** price)	0.160**	0.110*	0.209***
	0.050	*0.046*	*0.052*
ln (**diesel** price)	0.373***	0.206*	0.333**
	0.098	*0.094*	*0.102*
industry dummies	YES	YES	YES
province dummies	YES	YES	YES
N	36,759	36,742	36,742
adjusted R^2	0.214	0.173	0.230

Annex D: Parameter restrictions for the translog cost function

As discussed by Banda and Verdugo (2007), following parameter restrictions on the translog cost function are required for it to be homogeneous of degree 1 in prices; in other words, at a given level of output, total costs increase proportionally in line with prices.

$$\sum_i \alpha_i = 1$$

$$\sum_i \gamma_{QQ} = 0$$

$$\sum_i \sum_i \gamma_{ij} = 0$$

Additional parameter restrictions could be applied in order to impose assumptions on technology. For homotheticity the cost function is separable in output and input prices. This is the case for

$$\gamma_{Qi} = 0, \qquad \forall i.$$

For homogeneity in output, the elasticity of costs with respect to output is constant. This is the case for

$$\gamma_{Qi} = 0 \quad and \quad \gamma_{QQ} = 0.$$

Annex E: Partial own and cross price elasticities (by sector)

		Electricity	Petrol	Diesel	Kerosene	LPG
Mining of coal, lignite, peat	**Electricity**	-1.52***	0.13**	0.18***	0.25	0.10*
	Petrol	0.11**	-2.17***	0.51***	0.31***	-0.81*
	Diesel	0.08**	0.26***	-1.03	0.72***	0.87
	Kerosene	0.18	0.26***	1.21***	-5.79***	2.85***
	LPG	0.03*	-0.31*	0.66	1.28***	-2.14***
Extraction of crude oil, gas, uranium	**Electricity**	-1.65***	0.38	0.10	0.08	0.10
	Petrol	0.33	-1.63***	0.27*	0.10	-0.81
	Diesel	0.23	0.75*	-2.05***	0.24	0.87
	Kerosene	0.54	0.77	0.64	-5.00***	2.85***
	LPG	0.10	-0.91	0.35	0.43***	-2.52***
Mining of metal ores & others	**Electricity**	-0.59***	0.35***	0.04	0.06**	0.03
	Petrol	0.97***	-1.93***	0.12**	0.08	-0.22***
	Diesel	0.69	0.70**	-3.25***	0.18**	0.24***
	Kerosene	1.57**	0.72	0.29**	-1.40	0.78**
	LPG	0.29	-0.85***	0.16***	0.31**	-2.82***
Food & beverages *caveats due to regional concentration*	**Electricity**	-0.84**	0.51	0.05	0.30	0.07
	Petrol	0.51	-0.98	0.14**	0.38**	-0.53*
	Diesel	0.36	1.02**	6.05***	0.88	0.56
	Kerosene	0.83	1.05**	0.33	1.02***	1.84
	LPG	0.15	-1.24*	0.18	1.56	-2.75***
Tobacco products	**Electricity**	-1.84***	0.57**	0.33	0.05*	0.00*
	Petrol	0.38**	0.59***	0.92	0.06*	-0.02*
	Diesel	0.27	1.13	-0.42***	0.15	0.02*
	Kerosene	0.62*	1.16*	2.20	-1.75*	0.07**
	LPG	0.11*	-1.38*	1.20*	0.26**	10.13***
Light consumption goods	**Electricity**	-0.59***	0.24	0.09	0.04	0.02
	Petrol	0.91	-1.88***	0.25**	0.05	-0.15
	Diesel	0.64	0.49**	-2.39***	0.12	0.16
	Kerosene	1.47	0.50	0.60	-9.05***	0.53**
	LPG	0.27	-0.59	0.32	0.22**	-2.75***
Coke & refined petroleum products	**Electricity**	-7.59***	0.03	0.11	0.01	0.00
	Petrol	0.03	-4.69**	0.31	0.02*	0.00
	Diesel	0.02	0.06	-1.85***	0.04	0.00
	Kerosene	0.04	0.06*	0.74	-0.80	0.01
	LPG	0.01	-0.08	0.40	0.08	-19.95**
Intermediate materials	**Electricity**	-0.83*	0.21**	0.20	0.01	0.02
	Petrol	0.47**	-1.71**	0.57	0.02	-0.13
	Diesel	0.33	0.42	-1.28*	0.04	0.14
	Kerosene	0.76	0.43	1.37	-6.08**	0.46**
	LPG	0.14	-0.51	0.74	0.07**	-1.69*
Capital goods and technology	**Electricity**	-0.83***	0.41***	0.22	0.03**	0.01
	Petrol	0.69***	-0.27***	0.63	0.04	-0.11***
	Diesel	0.49	0.82	-0.53*	0.09	0.12
	Kerosene	1.12**	0.84	1.50	-2.68**	0.39
	LPG	0.21	-1.00***	0.82	0.17	-1.74*

Table 10 *Partial own and cross price elasticities by industrial sectors. Asterisks indicate the confidence level (***0.1%; ** 1%; * 5%) of the underlying estimate for $\gamma_{m,n}$ and $\gamma_{m,m}$ respectively.*

Annex F: Partial elasticities of substitution (total sample)

m\n	Electricity	Petrol	Diesel	Kerosene	LPG
Electricity	-	1.66***	1.18**	2.70***	0.50**
Petrol		-	3.31***	3.39*	-4.02***
Diesel			-	7.89***	4.30***
Kerosene				-	14.05***
LPG					-

Table 11 *Allan-Uzawa partial elasticities of substitution for the five main energy types and the total sample. Asterisks indicate the confidence level (***0.1%; ** 1%; * 5%) of the underlying* estimate for $\gamma_{m,n}$. *Note that Allen-Uzawa partial elasticities of substitution are symmetrical.*

m\n	Electricity	Petrol	Diesel	Kerosene	LPG
Electricity	-	1.04	1.22	5.59	2.95
Petrol	1.79	-	1.50	5.62	2.59
Diesel	1.72	1.21	-	5.78	3.24
Kerosene	1.93	1.21	2.09	-	4.00
LPG	1.62	0.47	1.63	6.01	-

Table 12 *Morishima partial elasticities of substitution for the five main energy types and the total sample. As* $\sigma_{m,n}^{MES} = \eta_{m,n} - \eta_{n,n}$, *significance depends on both* $\hat{\eta}_{m,n}$ *and* $\hat{\eta}_{n,n}$ *(reported in table 8).*