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RESEARCH ARTICLE

How vulnerable are small firms to energy price increases? Evidence from Mexico

Hannes Greve,[1,2]* Jann Lay,[1,2] and Ana Negrete[1,3,4]

[1]German Institute for Global and Area Studies (GIGA), Hamburg, Germany; [2]University of Göttingen, Göttingen, Germany; [3]Southern Oregon University, Ashland, Oregon, USA and [4]División de Ciencias Económico Administrativas, Universidad de Guanajuato, Guanajuato, México
*Corresponding author. E-mail: hannes.greve@giga-hamburg.de

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Abstract
The vulnerability of small firms to price shocks may partly explain why fossil fuel subsidy removals in developing countries are so difficult to implement. This paper analyzes the effects of fuel and electricity price increases on profits of micro- and small-sized enterprises in Mexico. Using representative cross-sectional data, simulations of profit losses hint at potentially large short-term effects. First-order profit losses of a 1 per cent price increase are 0.2 per cent for fuels and 0.07 per cent for electricity, but are higher than 1 per cent for fuels in the transport sector. These effects are larger for formal than for informal firms, with energy-using low-profit firms being most vulnerable. Second-order impacts – predicted using estimated input-demand elasticities – indicate that firms react to price shocks by substituting labor for energy, while the self-employed appear to increase their own labor input. Reduced-form regressions show that some firms pass on higher fuel costs to customers.

Keywords: micro and small enterprises; informal sector; price shock; fuel; energy; climate change mitigation

JEL classification: D22; D24; H23; O12; O17; Q41

1. Introduction

The responses of micro- and small-sized enterprises (MSEs) to economic policies and shocks are important. Effects on firm profits and performance directly affect the livelihoods of many in developing economies, where these firms provide employment to many (Li and Rama, 2015; Kanbur, 2017). Energy price reforms have repeatedly sparked social unrest in a number of developing (and some developed) economies. While the direct negative impact on consumer welfare arguably plays an important role for opposition to subsidy reforms (Coady *et al.*, 2018; Renner *et al.*, 2018; Labeaga *et al.*, 2020), the adverse impact on MSEs could be substantial. This is why these often informal MSEs, with their entrepreneurs and (family) workers, may comprise another important opposition group to policies that increase energy prices, that is, subsidy reforms or carbon pricing, in developing countries. Indeed, among those protesting against fuel price increases – whether in Ecuador, Kenya, Mexico, or even China (Buscaglia, 2017; China Labour Bulletin, 2017; Nyambura and Ombok, 2018; Cabrera, 2019) – were truck and taxi drivers, who are often self-employed. In addition, workers engaged in other small-scale activities, such as street kitchens, may also be vulnerable to such increases.

The Mexican government phased out energy subsidies between 2012 and 2018. During this period, gasoline and liquefied petroleum gas (LPG) prices in Mexico City increased by 95 per cent and 79 per cent respectively.[1] The so-called *gasolinazo*, a price spike of almost 20 per cent within a single week in January 2017, led to riots, looting, and the arrest of hundreds of demonstrators in Mexico (Buscaglia, 2017). The national alliance of microenterprises (Anpec) reported that many MSEs struggled to remain in business and that they increased product prices by 5–15 per cent (Gonzalez, 2017). Beyond such anecdotal information, there is limited evidence on the impacts of fuel and energy price changes on firms in developing countries. This is the case despite the potential relevance of the welfare impacts on firm owners, the self-employed, and workers, as well as the related importance for the political economy of the energy sector and price reform – particularly fossil fuel subsidy reform and carbon pricing.

Only a few studies have assessed the impact of energy price changes on firms in developing countries.[2] For example, Sadath and Acharya (2015) find that the fluctuation of energy prices adversely affects investment in the Indian manufacturing industry. Abeberese (2017) shows that rising electricity prices affect industry choice and slow down the productivity growth of Indian manufacturing firms. Rentschler and Kornejew (2017) exploit regional price variation from cross-sectional data to reveal that small manufacturing firms in Indonesia rely on a number of strategies to cope with higher energy prices, namely absorption, pass-on through higher output prices, input substitution, and increasing resource efficiency.

In this paper, we use a rich representative dataset from 2012 for formal and informal MSEs in Mexico to address the important evidence gap on the impact of fuel price increases on developing country firms. To illustrate the potential effects on MSEs, we calculate first-order (FO) profit losses from energy price increases, interpreted as upper bound estimates of the direct and immediate effect.[3] Further, using a pooled cross-section with data from 2010 and 2012, we estimate input-demand substitution elasticities for labor, electricity, and fuels that form the basis of an estimate of second-order (SO) effects, admittedly under fairly restrictive assumptions. Lastly, reduced-form regressions of unit output prices on fuel prices provide evidence of the ability of MSEs to pass on input price increases to consumers.

These analyses do not allow for clean causal attribution from price changes to profit and behavioral changes. Instead they provide what we think are empirically relevant indications of the potential vulnerability of small firms to fuel price increases in a developing country. Further, the analysis delivers important descriptive insights

[1] Figure A1 in section A of the online appendix shows price development in Mexico City over time.

[2] Relatively more attention has been paid to the effects of electricity shortages and blackouts on firms in developing countries (see e.g. Falentina and Resosudarmo, 2019).

[3] Data constraints inhibit an analysis of firm reactions during the *gasolinazo*. Our estimated impacts do not capture the impact of other types of shocks that may accompany a price shock, for example closures of gas stations (that is, fuel shortages).

into the incidence of such price reforms, and is indicative of the capacity of even small firms to adjust. This is – to our knowledge – the first paper that provides such assessment with representative data from small and informal firms across all sectors.

The remainder of this paper is organized as follows. Section 2 describes the dataset and provides descriptive statistics on Mexican MSEs and their energy-use patterns. Section 3 presents the methodology for computing FO and SO effects on profits. Section 4 presents the results, while section 5 concludes.

2. Data and descriptive statistics

We merge the National Survey of Microenterprises (ENAMIN) and the National Employment Survey (ENOE), a nationally representative labor force survey, both collected by the National Institute of Statistics and Geography. ENAMIN's sampling design is based on information on informal businesses from ENOE. It is thanks to this sampling design that we can merge both datasets to include the detailed sociodemographic characteristics of the business owners from ENOE in our analyses.[4] Included are MSEs with up to 10 workers in commerce, services, transport, and construction, and up to 15 workers in manufacturing. By design, ENAMIN is representative for both formal and informal MSEs, including those that lack premises. Approximately 78 per cent of all MSEs surveyed in 2012 were informal – which is defined as not paying taxes. Sixty per cent of the firms operate in urban areas.

We use the latest round of the survey, ENAMIN 2012, to simulate both FO and SO profit losses caused by energy price increases. To estimate own- and cross-price elasticities underlying the SO profit losses, we use a pooled cross-section of the two latest rounds of the survey, ENAMIN 2010 and ENAMIN 2012, to capitalize on temporal variation in fuel prices. For the analysis of output price adjustments, we can add ENAMIN 2008, which is not suitable for the elasticity estimation due to data gaps. The descriptive statistics here are based on the ENAMIN survey of 2012.

The 2012 sample comprises 23659 observations (excluding those with missing profit values), representing about 7.1 million MSEs in Mexico. Figure 1 shows the average cost structures of these firms by industry after applying sample weights. The relative importance of electricity and fuel inputs measured by their cost share varies considerably across industries. We group these enterprises into six industries, with retail and wholesale trade dominating the universe of MSEs, but with clearly less than half of the production units (39 per cent).

Firms engaged in the transport sector spend nearly 60 per cent of their total cost on fuels and little on electricity. Typically, in a range between 15 and 20 per cent of total cost, combined fuel and electricity expenditure share is relatively high across all industries – except in retail and wholesale trade, where it is about 5 per cent. Fuel costs are clearly more important than electricity costs: for all firms, fuel costs account for 18 per cent of total cost on average, while electricity accounts for 6 per cent thereof (see table 1). This implies an average monthly expenditure of US$63 on fuels and US$15 on electricity. The firms with the greatest electricity expenditure share can be found in the manufacturing sector.

[4]For details on the construction of price data, see online appendix B.

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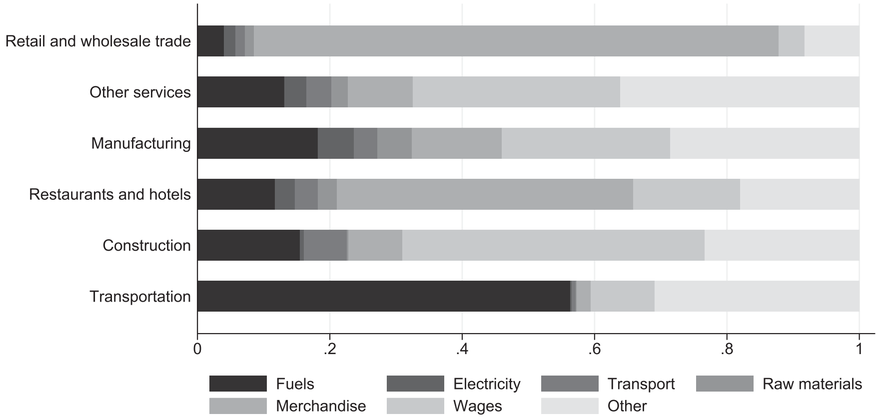

Figure 1. Input cost structure in 2012, by industry.

Table 1 presents key summary statistics regarding MSEs (columns 1-3). On average, businesses generate monthly profits of approximately US$321.[5] The median firm size is 1, hence most are one-person firms. Slightly more than half of firms are owned by females, and most firms (about 80 per cent) are informal. It is slightly more common that MSEs have nonzero expenditure on electricity (47 per cent) than on fuels (45 per cent), despite the higher share of the latter in total costs. This means that, for users of the respective energy type, expenditure shares are much higher than the reported averages of 6 per cent (electricity) and 18 per cent (fuel). For those that actually use fuels for production, the average expenditure share is 38 per cent (12 per cent for electricity) of total costs.

Table 1 also shows descriptive statistics by profit quartiles (columns 4-7). The higher the profits, the more common it is for them to have non-zero expenditures on electricity and fuels. The take-up rate is higher for the case of fuels. Also, there is a positive correlation between profits and the consumption of electricity (kWh). Correspondingly, the greater monthly profits are, the higher monthly expenditure on electricity will be in absolute terms. In relative terms, however, firms with high profits pay less for electricity relative to total costs. Hence, firms with small profit margins that use energy are likely to experience the largest shock when energy prices rise.

One feature of small firms in developing countries – including in Mexico – is that they often operate informally: that is, they do not follow government regulation (e.g., tax payments or enrollment of workers in social security schemes).[6] In contrast to the formal sector, the informal one is typically characterized by an abundance of small firms operating at low levels of productivity (*survivalists*), although some firms stand out in

[5]We use monthly profits, as captured by the question: "How much do you normally earn after deducting expenses?" This is because the measurement error is smaller than the computation of income minus costs (de Mel *et al.*, 2009).

[6]A further distinction can be made between "informality" and "illegality" (Busso *et al.*, 2012). Firms may not need to adhere to a particular regulation, and hence are informal but legal, whereas other firms may evade regulation, therefore operating both informally and illegally. Constituting a third type of informality are those firms that avoid regulation: for example, choosing to remain small to avoid a certain regulation from applying to them (Kanbur, 2017).

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Table 1. Firm characteristics and energy expenditure in 2012

	Mean (1)	Median (2)	SD (3)	Profit Quartiles (mean) 1st (4)	2nd (5)	3rd (6)	4th (7)	Formality (mean) Formal (8)	Informal (9)
General Characteristics									
Monthly profits	321	197	557	44	147	312	906	585	251
Labor (weekly hours)	63	48	62	34	54	69	103	103	52
Firm size (total staff)	1.59	1.00	1.09	1.21	1.43	1.61	2.26	2.24	1.42
Female owner	0.51	1.00	0.50	0.80	0.59	0.35	0.23	0.40	0.54
Informal firm	0.79	1.00	0.41	0.93	0.84	0.76	0.57		
Electricity									
Share of users	0.47	0.00	0.50	0.33	0.46	0.50	0.61	0.83	0.37
Exp. share (full sample)	0.06	0.00	0.13	0.07	0.06	0.05	0.05	0.06	0.06
Exp. (users)	0.12	0.06	0.16	0.19	0.13	0.10	0.07	0.08	0.14
Avg. exp. (USD)	15	0	69	4	10	16	35	46	7
kWh (estimate)	101	0	211	41	84	109	186	244	62
Fuels									
Share of users	0.45	0.00	0.50	0.20	0.37	0.55	0.72	0.60	0.40
Exp. (full sample)	0.18	0.00	0.29	0.11	0.15	0.23	0.25	0.15	0.19
Exp. share (users)	0.38	0.29	0.31	0.45	0.38	0.40	0.34	0.25	0.43
Avg. exp. (USD)	63	0	181	9	28	70	165	118	48
Sectors									
Retail and wholesale trade	0.39			0.49	0.44	0.32	0.29	0.45	0.37
Services	0.23			0.17	0.20	0.24	0.30	0.29	0.21
Manufacturing	0.15			0.21	0.14	0.13	0.13	0.10	0.17
Restaurants and hotels	0.13			0.10	0.15	0.14	0.10	0.10	0.13
Construction	0.07			0.01	0.04	0.11	0.12	0.02	0.08
Transportation	0.04			0.01	0.02	0.05	0.06	0.04	0.03
N	23659			6008	6640	6087	4924	4988	18671
N with sample weights (millions)	7.1			1.9	2.0	1.8	1.4	1.3	5.8

Notes: Exp. = expenditure. As explained in appendix B, electricity consumption in kWh was estimated by taking block tariffs into consideration. Nominal values correspond to 2016 MXP and are reported in USD. The considered MXP-USD exchange rate is 18.102 which, just as with the GDP deflator (INPC), corresponds to February 2016.

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terms of productivity (*top performers*) or potential for productivity (*constrained gazelles*) (Grimm *et al.*, 2012). In columns 8 and 9 of table 1, we present descriptive statistics for formal and informal firms respectively. Average profits of formal firms are more than twice as large, and these firms are also larger (2.24 workers versus informal firms 1.42 on average). Further, energy use is more common among formal firms, with 83 (60) per cent using any electricity (fuel) compared to 37 (40) per cent among informal firms. However, those of the latter that use electricity or fuels have higher energy cost shares than formal firms that do so. Electricity makes up 14 per cent of total costs for electricity-using informal firms on average, compared to 8 per cent for formal firms. Fuel cost shares are even higher: fuels make up 43 per cent of total costs for informal firms, compared to 25 per cent of formal firms on average (only fuel-using firms).

3. Methodology

In theory, firms have several options to avoid profit losses when energy prices rise (Rentschler *et al.*, 2017): (i) They can substitute toward other factor inputs; (ii) pass on the price shock; and (iii) increase both material and energy efficiency. We analyze the first and second types of reaction, which we believe are indicative of the vulnerability to price shocks in the short term. Large efficiency increases are unlikely in the short run in response to energy price changes among the smallest firms due to capital constraints inhibiting quick investments (Hernandez-Trillo *et al.*, 2005), although implementing measures that require minimal investment may still be feasible. Firms may also switch their contracted electricity tariffs in response to related increases, but although this comes at little cost to the firm the impacts of such adjustment are expected to be only minor.

We examine both the FO and SO impacts of price changes, with the latter allowing firms to change the input composition. Both these analyses look at direct effects only: that is, we only examine fuel and electricity price changes and ignore the potential subsequent ones in transport costs and intermediate inputs that will, again, also affect firm profits. FO impacts will be largest for those firms with small profit margins and significant energy cost shares. For SO effects, we expect some behavioral differences with regard to formal and informal firms (see section 3.2).

3.1. *First-order profit losses*

As a first approximation to the effects of energy price changes, we compute the FO impacts: that is, the impacts under the assumption that firms do not change the input composition or the output quantity, and that they cannot pass the burden on to their customers in the form of increased prices regarding products or services. This simplification ignores firms' adjustments of production after price increases, so the FO effects should be thought of as an upper-bound estimate to the direct short-term profit loss. We obtain the FO estimate via subtracting decreased profits from initial profits, and then express it as the percentage share of additional costs in initial profits:

$$FO_{fj} = \frac{\Pi_f - (\Pi_f - \Delta C_{fj})}{\Pi_f} \times 100 = \frac{\Delta C_{fj}}{\Pi_f} \times 100 \tag{1}$$

with

$$\Pi_f = y_f - C_f = q_f \times p^{\text{output}} - C_f \tag{2}$$

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and

$$\Delta C_{fj} = C_{fj,1} - C_{fj,0} = (1 + \Delta p_j) \times C_{fj,0} - C_{fj,0} = \Delta P_j \times C_{fj,0} \tag{3}$$

where Π are profits; y are revenues, defined as output quantity (q) times output price (p^{output}); and C are total costs. ΔC is the cost increase: that is, the difference in costs in $t = 1$ and $t = 0$ caused by price change ΔP_j (expressed as a ratio of initial price, i.e., $\Delta P_j = p_{j,t=1}/p_{j,t=0}$). Subscript j denotes either fuels or electricity, and f indicates the firm. Thus, ceteris paribus, profits of firm f decrease by FO per cent when the price of energy input j increases by ΔP_j.

3.2. Input-demand elasticities

Substitution effects can provide valuable information about the SO effects of energy policies on economic agents (Berndt and Wood, 1975). As the MSE sector is a key employer in Mexico and many other developing economies, we are particularly interested in the effect of rising energy prices on labor demand. In theory, labor and fuels can be substitutes or complements, depending on the production technology. The substitution possibilities between electricity and fuel are also relevant for labor demand: when a fuel price increase is mainly adjusted for by increasing electricity demand, labor demand might not be significantly affected. If electricity and fuel are complements and energy is not easily substituted by labor, labor demand would fall with higher fuel (or electricity) prices. Two recent studies of substitution possibilities between labor and energy for European firms found that these two inputs are indeed substitutes (Haller and Hyland, 2014; Bardazzi *et al.*, 2015). Furthermore, labor seems to be more easily substitutable by energy inputs than the other way around.

We suggest three rationales for the substitutability of labor and energy that seem particularly relevant in our context. First, firms might change from using motorized forms of transportation (for example, via motorbike) to using public or manual transportation (on foot or by bicycle). This may be particularly important for informal firms. Second, firms within industries might change technology and/or specific activity toward less energy-intensive production. In particular informal firms with very low fixed capital may be able adjust technologies quickly and exhibit high labor demand elasticities with respect to energy. Yet, if firms adjust by investment in more energy-efficient technologies, we may observe more rapid and bigger adjustments in larger (formal) firms with better access to capital. Third, the entry and exit of firms are also implicitly reflected in the estimated elasticities, because we pool ENAMIN 2010 and ENAMIN 2012. Hence, we observe different firms in these two years. As such, what looks like flexibility of existing firms may actually be driven by high rates of entry and exit within specific sectors, and we may overestimate actual behavioral reactions with respect to cross-price elasticities. This churn may be more prevalent among informal MSEs.

To derive input-demand elasticities, we estimate a translog cost function for three inputs, namely fuels, electricity, and labor using external, regionally-disaggregated price data (see section B of the online appendix for details on price data and section C for the technical details of the cost function and elasticity estimation). It is common to estimate a full input-demand system that also includes capital and materials (Haller and Hyland, 2014; Bardazzi *et al.*, 2015), although there are examples that exclude some of these inputs (Woodland, 1993). Due to a lack of high-quality data on intermediate inputs and capital prices,we opt to exclude these inputs and instead rely on the assumption

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of separability between capital and material inputs on the one hand and fuels, electricity, and labor on the other. Further, not all MSEs employ all of the three inputs of our model specification. To avoid problems arising from the censored nature of the data, we follow Woodland (1993) and estimate the model for two subsamples of firms – each with positive expenditure for all three inputs.[7] The first sample includes firms employing hired labor. The second sample consists of one-person MSEs, that is, the self-employed. For these firms, we estimate substitution elasticities for own labor instead of hired labor under the assumption that the prevailing median regional wage rate is the shadow price. This elasticity determines the extent to which the self-employed increase their own-labor supply as a response to rising energy prices.

For the estimation, we pool the ENAMIN survey waves of 2010 and 2012 and merge these with regional price data (except for electricity prices of formal firms, where we only have national prices; see section B in the online appendix for details). As fuel and electricity prices were heavily regulated by the Mexican government (IEA, 2016) and MSEs can be assumed to be price-takers, the variation is arguably exogenous. In most cases, the identifying variation is a price increase. Only in a very few cases does the regional average of the residential electricity price decline between 2010 and 2012. We are able to obtain more variation in electricity prices by matching estimated consumption levels with the price schedule of the residential block tariff. This procedure is not without problems: Firms choose their level of electricity consumption and thus self-select the consumption block. If they take the block-tariff structure into account this specification potentially suffers from endogeneity, as the amount of electricity consumed determines the price and vice versa. There are some hints in the literature (Ito, 2014) that electricity users react to average rather than marginal prices in nonlinear price schedules, which suggests that the endogeneity bias may be attenuated. However, the bias may still be large regardless.[8]

There are a few additional points that one needs to be aware of when interpreting the estimated elasticities, and hence SO effects. First, as mentioned above, we assume separability between electricity, fuels, and labor on the one hand and all other inputs – including capital – on the other. Since we thus assume that investment decisions cannot be affected by price increases, the elasticities are to be interpreted as short-term. Second, we control for a number of firm characteristics and include several sets of fixed effects.[9] Our controls include dummies that capture the block structure of electricity prices and we thus compare firms that have a similar (but not identical) level of electricity consumption. Third, we implicitly assume that MSEs do not exit the market due to higher energy prices (albeit this may not fully hold) and that microenterprises continue to use specific inputs (such as paid labor). Hence, the labor demand decision is only evaluated at the intensive margin, and elasticity estimates will reflect entry and exit of firms to an unknown extent.

[7] Overall, 23.6 per cent of the MSEs in our sample used both energy inputs in 2012. The estimated elasticities are thus specific to a subsample with firms that tend to be larger and have higher profits.

[8] Attempts to consider the block-price structure in the context of cost-function estimation are nonexistent, to our knowledge, although some authors do model consumer demand under multipart pricing (Reiss and White, 2005).

[9] We include age of entrepreneur, age of entrepreneur squared, sex-dummy of entrepreneur, age of the firm, years of education of the owner, whether or not it is a one-person firm, capital stock, a year dummy, regional dummies, industry dummies, and electricity block-tariff dummies as additional explanatory variables. All continuous variables are logarithmic.

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3.3. Second-order effects

We compute SO profit losses using estimated substitution elasticities. The change in costs (when the price of input j increases) consists of three parts: changes in fuel, electricity, and labor input costs.

$$\begin{aligned}\Delta C_f &= \Delta C_{fg} + \Delta C_{fe} + \Delta C_{fl} \\ &= (E_{fg,1} - E_{fg,0}) + (E_{fe,1} - E_{fe,0}) + (E_{fl,1} - E_{fl,0}) \\ &= (p_{g,1}x_{fg,1} - p_{g,0}x_{fg,0}) + (p_{e,1}x_{fe,1} - p_{e,0}x_{fe,0}) + (p_{l,1}x_{fl,1} - p_{l,0}x_{fl,0})\end{aligned} \tag{4}$$

Subscripts g, e, and l denote fuels, electricity, and labor respectively. E denotes the value of expenditures, x is the input quantity consumed, and 0 and 1 indicate the periods before and after the price change. The quantity of input k after a price change for input j in period 1 is given by

$$x_{kj,1} = (1 + \frac{\eta_{kj}}{100}) \times \frac{E_{k,0}}{p_{k,0}} \tag{5}$$

where η denotes the elasticity between two inputs. The SO estimate represents the percentage reduction of profits of firm f when the respective energy price of energy input j increases by $(\Delta p \times 100)$ per cent. The elasticities used for the computation are industry-specific, except for the construction and transportation ones. Here, sample sizes are too small to estimate industry-specific elasticities, so we use those from the full sample estimation. For one-person firms, we provide two types of SO effects: one without labor input and one with imputed costs of additionally employed own labor.

3.4. Output price adjustment

The above FO and SO effects are computed under the assumption that output prices remain constant. However, some firms will also be able to pass on the increased input costs to consumers by raising prices. The capacity to do this will differ between industries and products, and will generally be lower for tradables than for nontradables. Further, formal and informal firms may differ in their ability to increase output prices: informal firms are likely to operate in very atomistic markets with little price-setting power, but they also have very low margins and may operate close to a subsistence floor. In other words, they may not have any options other than raising prices or exiting.

We estimate – in reduced form – the reaction of output prices to fuel price changes (plus firm characteristics X_{frt}, regional η_r, and time fixed effects τ_t). That is, we estimate the following regression equation:

$$ln(p_{frt}^{\text{output}}) = \beta_0 + \beta_1 ln(p_{rt}^{\text{fuels}}) + \beta_2 X_{frt} + \eta_r + \tau_t + \theta_{pu} + \mu_{frt} \tag{6}$$

We will only be able to estimate this equation for a small subset of firms that produce relatively homogenous products without major quality differences. We refrain from converting units of quantity, and instead include product-unit fixed effects θ_{pu}. In contrast to the above analyses, this reduced-form estimate implicitly takes into account the price changes in intermediates and transport costs induced by the fuel/electricity price change.

Table 2. FO estimates by sectors

Sector		Fuels		Electricity	
		Full sample	Users only	Full sample	Users only
Retail and wholesale trade	Mean	0.14	0.46	0.10	0.21
	SD	(0.45)	(0.72)	(0.30)	(0.42)
	N	9214	2820	9201	4133
Services	Mean	0.14	0.33	0.05	0.09
	SD	(0.38)	(0.53)	(0.13)	(0.15)
	N	5347	2274	5326	3161
Manufacturing	Mean	0.22	0.46	0.06	0.12
	SD	(0.63)	(0.86)	(0.18)	(0.23)
	N	3652	1746	3637	2018
Restaurants and hotels	Mean	0.23	0.30	0.05	0.10
	SD	(0.44)	(0.48)	(0.14)	(0.18)
	N	2978	2268	2978	1534
Construction	Mean	0.14	0.34	0.00	0.05
	SD	(0.32)	(0.43)	(0.02)	(0.08)
	N	1602	681	1602	88
Transportation	Mean	1.27	1.42	0.01	0.21
	SD	(2.29)	(2.38)	(0.11)	(0.61)
	N	832	743	833	27
Formal	Mean	0.25	0.42	0.15	0.17
	SD	(0.76)	(0.94)	(0.33)	(0.35)
	N	4979	3003	4967	4130
Informal	Mean	0.19	0.47	0.04	0.12
	SD	(0.63)	(0.92)	(0.17)	(0.27)
	N	18646	7529	18610	6831
Total	Mean	0.20	0.46	0.07	0.14
	SD	(0.66)	(0.93)	(0.22)	(0.30)
	N	23625	10532	23577	10961

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4. Results

4.1. *First-order profit losses*

We first divide average estimates into a full sample and sub-samples containing MSEs with strictly positive electricity or fuel demand ("users only"). We then provide impact measures over profit percentiles. Table 2 depicts averages of FO estimates for a 1 per cent price increase by sector. On average, the FO estimate is 0.2 per cent for fuels and

0.07 per cent for electricity. Hence the *gasolinazo* price increase of about 20 per cent within a single week would have translated into a 4 per cent profit reduction, a sizable effect. This indicates MSEs' considerable vulnerability to fuel price increases – less so to electricity prices. In addition, MSEs exhibit considerable heterogeneity. For both fuel and electricity price increases, the standard deviation of the FO estimate is three times its mean for the full sample, and two times its mean for users.

We also find substantial heterogeneity among MSEs by sector. The highest FO effects – at 1.27 per cent – are in the transport industry, in which profit reduction is even higher than price increases. The restaurants and hotels industry (e.g., street kitchens) is also relatively vulnerable to fuel price increases, with a 0.23 per cent profit reduction. For electricity, the highest short-term effects of price increases on profits are found in the retail and wholesale trade industry (0.1 per cent). When looking at fuel users in this industry, the effect is also large with 0.46 per cent. This pronounced difference between the full and the users-only sample estimates is because only around 45 per cent of firms in the retail and wholesale sector use fuel.

Average FO estimates for formal firms are generally larger than for informal ones. The higher share of energy costs of formal firms, which, ceteris paribus, leads to higher profit losses, thus outweighs the effect of larger profit margins that mitigates the adverse impacts on costs. The only exception are FO estimates for fuel users, which stand at 0.47 among informal firms compared to 0.42 per cent for formal firms. For electricity, the average FO estimate is much higher for formal firms at 0.15, compared to 0.04 for informal ones, while the difference between estimates for users is less pronounced (0.17 compared to 0.12 respectively). Hence, the electricity FO estimate for the full sample of informal firms exhibits considerable dispersion, with a standard deviation that is more than four times larger than the estimate. This reflects the relatively large impacts on fuel-using informal firms combined with the relatively high share of informal firms that do not use any fuel (details below).

Figure 2 shows the incidence of estimated FO effects as well as the average energy usage rate across profit percentiles for the full sample.[10] The profit losses are hefty for fuel or electricity users at the bottom of the profit distribution, with FO estimates for fuel reaching 2 per cent. Even for electricity users (about 20 per cent among low-profit firms), a 1 per cent electricity price increase translates into a 0.5 per cent profit loss. For these firms, low profits meet a high share of fuel or electricity costs. While the effects are thus highly regressive among users, the average FO estimates – including nonusers – are stable across the profit distribution (or slightly progressive for fuels and slightly regressive for electricity).

Figure 3 shows the incidence of estimated FO effects as well as the average energy usage rate across profit percentiles, separated into formal and informal firms. The incidence curves of FO effects of fuel price increases are similar for both types of firms. The usage rate is slightly lower among informal firms, and FO estimates for users higher, especially at the bottom of the profit distribution. We observe significant differences for electricity price increases however. Since the usage rate of electricity is constant at a very high level among formal firms (on average, around 83 per cent of them use electricity), the incidence of FO estimates for the full and users-only sample are similar across the whole profit distribution. Moreover, both average and users-only FO estimates

[10] Figure 2 shows nonparametric distributional curves with a 95 per cent confidence interval, calculated with a kernel-weighted local polynomial regression using the Epanechnikov kernel function.

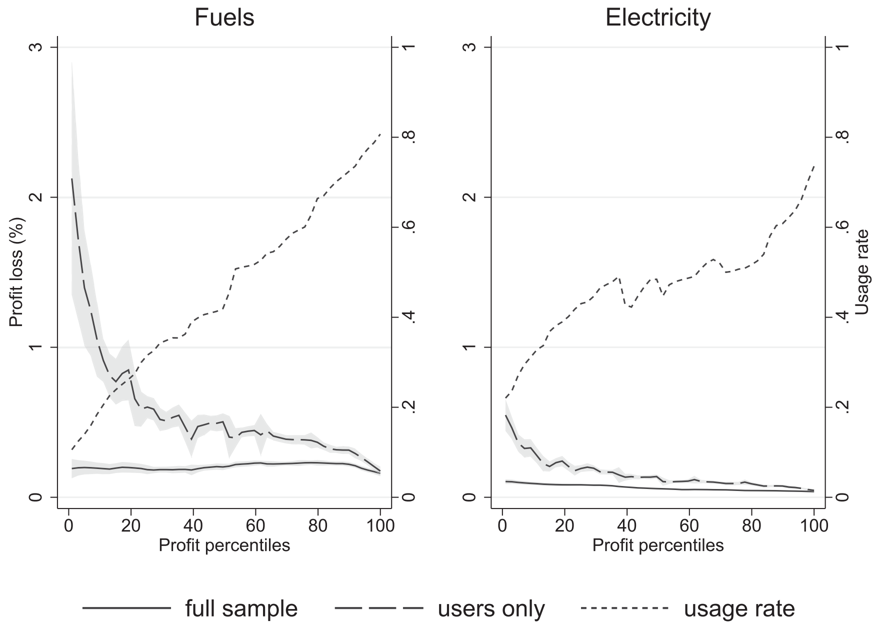

Figure 2. FO estimates across profit percentiles.

are higher for formal firms. Hence, the latter are more heavily affected by electricity price increases because more formal firms use electricity, including those that operate with small profit margins.

4.2. Elasticity estimates

Table 3 shows own- as well as cross-price elasticities of input-demand for MSEs with hired labor and for the self-employed in all industries.[11] MSEs react to fuel price increases by increasing labor input rather than electricity input quantities, as the cross-price elasticities for fuels and electricity are not significantly different from zero. Fuels exhibit the highest responsiveness to price increases. Among firms using hired labor, the fuel quantity falls by an average of 0.84 per cent for a 1 per cent price increase (compared to 0.45 and 0.37 per cent for electricity and labor respectively). When fuel (electricity) prices rise by 1 per cent, the quantity of labor employed goes up by 0.28 (0.09) per cent on average. By way of comparison, studies of European firms have found labor elasticities with respect to energy of 0.07 for Italian manufacturing firms (Bardazzi *et al.*, 2015) and 0.01 for Irish manufacturing firms (Haller and Hyland, 2014). We observe a larger increase in quantities of fuels and electricity employed in production when wage rates rise – namely 0.78 and 0.59 per cent respectively – for a 1 per cent price increase. This is reasonable since – as long as no new equipment is required – energy inputs can be adjusted more flexibly than labor.

For the sample of one-person firms, we include own-labor input at shadow wages, approximated by regional average wages computed from the survey. These

[11] Note again that these elasticities are estimated for a subsample of firms that use both fuels and electricity.

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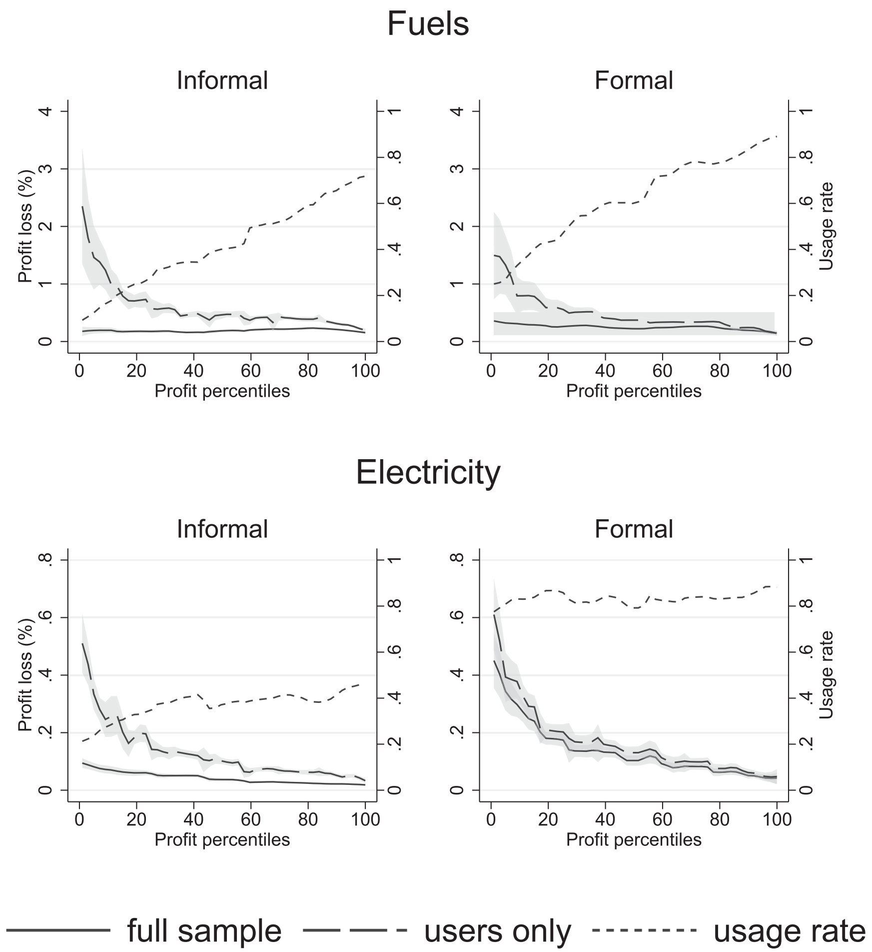

Figure 3. FO estimates, formal versus informal firms.

entrepreneurs may have less capacity to adapt to rising energy prices than firms employing workers. Indeed, we find higher own-price elasticities of both energy goods and comparatively small energy-labor cross-price elasticities. Firm owners increase their labor supply to the firm by only 0.07 per cent as a response to a 1 per cent fuel price increase – compared to 0.28 per cent for firms that hire labor.

The presented elasticities are average estimates for all industries. It is more common to estimate a cost function for a less diverse sample of firms due to differing production technologies, which can imply different own- and cross-price elasticities. When estimating the model for the manufacturing, service, trade, as well as restaurant and hotel industries separately, elasticity estimates differ slightly for some cases.[12]

[12]See tables A2–A5 in section D of the online appendix for elasticities by industry. For example, the labor demand elasticity with respect to fuel prices ranges between 0.22 and 0.32 for large firms and from 0.05 to 0.09 for one-person firms.

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Table 3. Own- and cross-price input-demand elasticities

	Price of fuels	Price of electr.	Price of labor
Firms with hired labor			
Fuels	−0.84	−0.04	0.78
	(0.03)	(0.03)	(0.02)
Electricity	−0.09	−0.45	0.59
	(0.06)	(0.05)	(0.03)
Hired labor	0.28	0.09	−0.37
	(0.01)	(0.01)	(0.01)
Self-employed			
Fuels	−1.15	0.06	0.53
	(0.04)	(0.04)	(0.05)
Electricity	0.12	−0.41	0.32
	(0.08)	(0.06)	(0.07)
Own labor	0.07	0.02	−0.09
	(0.01)	(0.00)	(0.01)

Notes: Standard errors in parentheses, computed using the delta method. Elasticity estimates are obtained after the fourth iteration for hired labor and after the tenth for one-person firms. This reduced the sample size from 2973 to 1758 and from 4303 to 1,363 respectively. The labor-energy cross-price elasticities remained fairly close to the first estimations (maximum magnitude change is 0.3 in point estimates).

Table 4 presents elasticity estimates for both formal and informal firms. Probably contrary to expectations, we find no differences in reactions to price increases based on that status for either the self-employed or for firms with hired labor. However, this result may partly reflect selection in the subsample of firms that use both fuel and electricity. Among informal firms, about 17 per cent use both types of energy, compared to about 49 per cent of formal firms. These two subsets of firms thus react similarly to energy or labor price shocks. The following simulation of SO profit losses – which again only covers those firms that use both energy types – therefore does not distinguish between formal and informal firms.

4.3. Second-order profit losses

Figure 4 shows both FO and SO effects of a 1 per cent price increase at percentiles of the profit distribution for the sample containing firms with workers that use both fuels and electricity. The difference between FO and SO estimates of profit losses is moderate for most firms with hired labor. When fuel prices increase, the bottom 10 per cent of firms mitigate up to 35 per cent of the losses by hiring more labor (panel A). On average, the SO effect is 21 per cent lower than the FO effect for fuel price increases. Yet, even when accounting for behavioral adjustments on the input side, average profits for firms with hired labor still decrease by 0.31 per cent – and by more than 0.53 per cent for the bottom 10 per cent – in the case of a 1 per cent increase in fuel prices. For electricity, the profit loss is about 0.12 per cent on average, with little difference between FO and SO effects (panel B).

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Table 4. Own- and cross-price input-demand elasticities, formal versus informal firms

Formal firms	Price of fuels	Price of electr.	Price of labor
Firms with hired labor			
Fuels	−0.83	−0.05	0.79
	(0.03)	(0.03)	(0.02)
Electricity	−0.12	−0.45	0.63
	(0.07)	(0.05)	(0.04)
Hired labor	0.28	0.10	−0.37
	(0.01)	(0.01)	(0.01)
Self-employed			
Fuels	−1.12	0.02	0.84
	(0.04)	(0.04)	(0.04)
Electricity	0.04	−0.44	0.43
	(0.09)	(0.07)	(0.07)
Own labor	0.10	0.02	−0.12
	(0.01)	(0.00)	(0.01)
Informal firms	Price of fuels	Price of electr.	Price of labor
Firms with hired labor			
Fuels	−0.81	−0.04	0.76
	(0.04)	(0.04)	(0.05)
Electricity	−0.09	−0.41	0.50
	(0.11)	(0.08)	(0.08)
Hired labor	0.30	0.08	−0.38
	(0.02)	(0.01)	(0.02)
Self-employed			
Fuels	−1.15	0.06	0.53
	(0.05)	(0.05)	(0.04)
Electricity	0.12	−0.41	0.32
	(0.13)	(0.18)	(0.08)
Own labor	0.07	0.02	−0.09
	(0.00)	(0.00)	(0.01)

Notes: Standard errors in parentheses, computed using the delta method. Elasticity estimates are obtained after the fifth iteration for formal hired labor and after the eighth for formal one-person firms. This reduced the sample size from 2143 to 1391 and from 2266 to 1,024 respectively. Elasticity estimates for informal firms obtained after the ninth iteration for hired labor and after the eighth for one-person firms. This reduced the sample size from 830 to 436 and from 2266 to 1024 respectively.

For one-person firms that use both fuel and electricity, we see a stark difference between first- and second-order estimates, particularly for fuel price increases (figure 5, panel A). The profit loss reduces to zero for fuel (and close to zero for electricity) across the whole distribution. As the elasticity estimates indicated, these firms shift away from electricity or fuel in almost exact proportion to the price increase and they substitute

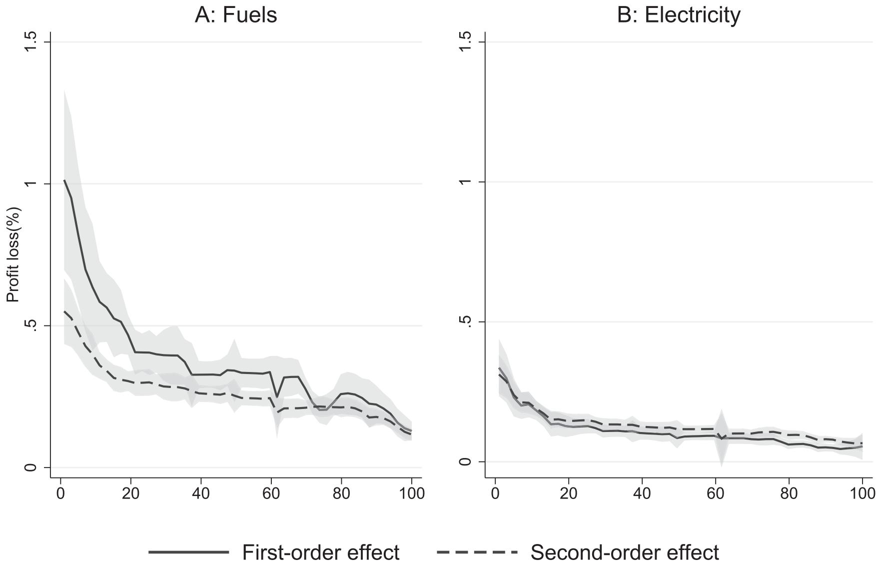

Figure 4. FO and SO estimates for a 1 per cent price increase for firms with workers.

own-labor supply for energy. As this increase in own-labor supply does not cause direct and observable monetary losses, we compute an estimated profit loss assuming that the owner would pay himself or herself the prevailing regional average wage – only for the additional labor input. Shadow wages for the self-employed are likely to be very heterogenous and, probably, lower on average than the average regional wage. Further inquiry into shadow wages goes beyond our paper, but the results of this exercise have to be interpreted with caution. Under this assumption, the loss due to fuel or electricity price increases is almost twice as large as the FO effect on average, with entrepreneurs at the low end of the profit spectrum being particularly affected. This holds for both fuel and electricity. The profit losses associated with electricity price increases are somewhat more pronounced for one-person firms compared to those with hired labor. The average FO effect is around 0.22 per cent for a 1 per cent price increase, while the SO effect is about half as big.

These results on SO effects show that the relatively strong behavioral reactions tend to mitigate negative impacts on profits for the self-employed. These entrepreneurs raise their own labor supply. Although the costs of doing this are difficult to quantify precisely, considering imputed additional labor costs suggests that they are substantial. For larger firms with employees, behavioral adjustments are also important for fuels, but not for electricity.

4.4. Output prices

To test whether MSEs pass on fuel price increases, we now regress unit output prices on fuel prices, both normalized using the national producer price index (excluding oil).[13] We focus on fuels because both direct and (expected) indirect effects are larger than

[13] Remember that we can pool the surveys of 2008, 2010, and 2012 for this analysis.

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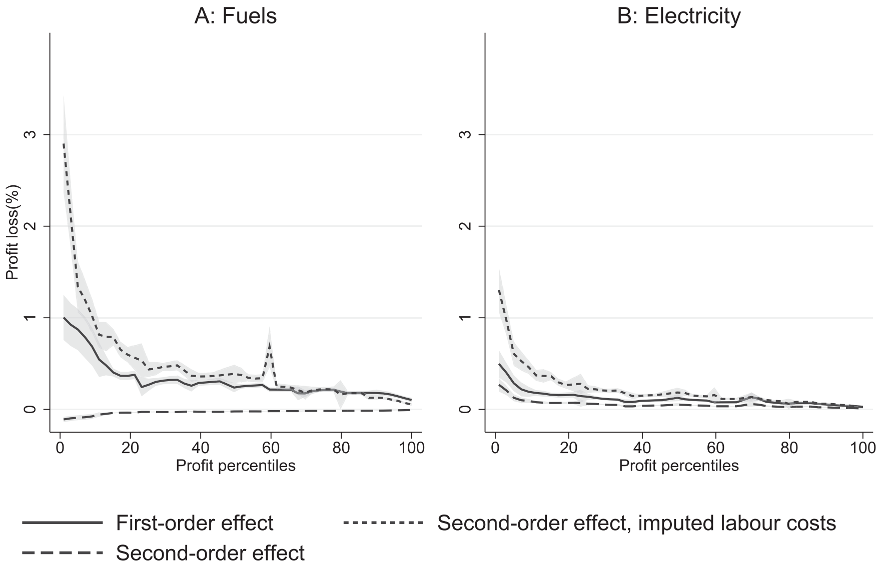

Figure 5. FO and SO estimates for a 1 per cent price increase for firms without workers.

for electricity price increases. Most important for this empirical analysis is a sufficiently large number of producers of the same products in our sample. To maintain statistical power, we set the cutoff point for observations per product and year to 50. This leaves producers of tortillas, tacos, and tamales in the estimation sample.[14] These products are supposedly of similar quality across producers and time. Hence, unobserved differences in product quality are expected to be small. Since tortilla prices were from time to time regulated in Mexico (see e.g. Barrera, 2007), we show two sets of regression results: one using a sample including tortilla producers and one excluding them respectively.

Table 5 shows the regression results for different specifications. In columns (1) and (4), we control for product type and unit to control for self-induced spurious correlation, while in columns (2) and (5) we add state fixed effects, and in columns (3) and (6) firm-level controls respectively. In the sample including tortilla producers, a gasoline price increase of 1 per cent (relative to the general price level) leads to a rise of about 0.72–0.73 per cent in unit output price (relative to the general price level). The estimated price elasticity is even larger when excluding tortilla producers, at around 0.82-0.96. This is a sizeable effect, and indicative that at least the firms in the selected sectors are able to deal with rising fuel prices by increasing output prices. Again, note that this estimate reflects not only the reaction to fuel prices but also to fuel-price induced price increases in transportation costs and intermediate input prices.

To put these reactions into perspective, we compute FO profit loss estimates of a 1 per cent price increase for firms in the estimation sample used here (including tortilla

[14]Further lowering the cutoff value would for example include producers of blouses, doors and hammocks. Since these items can be produced with marked differences in quality, we expect significant heterogeneity in product prices due to unobserved differences in product quality. Unfortunately we do not have panel data, so we cannot control for firm-product fixed effects (which would capture differences in quality to some extent). We therefore do not include these in our estimation sample.

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Table 5. OLS regression results for price transmission

	Log(unit output price/PPI)					
	Including tortilla producers			Excluding tortilla producers		
Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)
Log(fuel price/PPI)	0.717	0.741	0.734	0.822	0.889	0.955
	(0.204)	(0.174)	(0.185)	(0.296)	(0.262)	(0.275)
Observations	1389	1389	1311	708	708	670
Adjusted R-squared	0.657	0.742	0.738	0.01	0.251	0.254
Product-unit FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE		Yes	Yes		Yes	Yes
Firm characteristics[x]			Yes			Yes

Notes: FE = fixed effects; PPI = producer price index. Robust standard errors in parentheses. Intercept included but not reported. [x]Firm characteristics include one-person firm (dummy), age and years of education of the entrepreneur, and age of the establishment. Status of informality excluded due to data gaps in the ENAMIN 2008 survey.

producers). This loss is estimated at 0.45 per cent for a 1 per cent fuel price increase in 2012 (N = 483).[15] To compensate for this loss, output prices would need to change by the exactly the same percentage, given that there are negligible economies of scale (marginal cost does not depend on quantity produced in the vicinity of current production levels). Thus, according to the estimated output price elasticities, firms more than compensate for the estimated direct profit loss. This indicates that the full (direct plus indirect) cost increase is – either wholly or to a large extent – passed on to consumers. It is nevertheless possible that some firms absorb parts of the price increase initially, especially those with larger profit margins.[16]

5. Conclusion

This paper is the first to provide evidence on the considerable impact of energy price increases on small firms in developing countries using a representative dataset of both formal and informal MSEs from Mexico. We find sizable potential effects. Our estimates of FO effects indicate that a 20 per cent increase in fuel prices – as previously once experienced in Mexico in the course of a single week – can translate into an average 4 per cent direct profit loss for MSEs if they are unable to adjust. The effects of fuel price changes are much more pronounced than those of electricity, reflecting higher cost shares of fuels.

Examining these potential immediate effects by industry, we detect notable differences. The effects extend well beyond the transport sector, where fuels account for about 56 per cent of total costs. While fuel and electricity use are correlated with higher profits, it is the fuel- and/or electricity-using firms at the bottom of the profit distribution that are affected most by energy price increases. For them, a fuel price increase of 1 per cent can cause profits to decline by even more than 1 per cent, as a result of low profit margins in combination with high fuel cost shares. The average direct impact of

[15]SO profit loss estimates are only available for firms with positive expenditures on both fuels and electricity: they stand at 0.09 per cent, down from 0.68 per cent (N = 151).

[16]Figure A2 in section E of the online appendixl illustrates that FO profit loss estimates are below the point estimate of the price transmission, but within the range of the 95 per cent confidence interval.

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fuel price increases on formal firms is larger than for informal ones (0.25 versus 0.19 per cent respectively for a 1 per cent price increase), as the former use fuels more often. The same holds for electricity. The somewhat higher profit margins of formal firms thus cannot protect against higher losses due to a greater share of energy costs.

The FO effects should be interpreted as very short-term and immediate ones that will be quickly followed by adjustments on the part of firms, and by increases in intermediate input prices. We believe these effects to be still important and informative from a political economy perspective, as they play a role in how potential losses arising from price reforms are perceived. However, as noted, firms do adjust. Our analysis of behavioral reactions shows that even though larger (but still small) firms with hired workers are able to reduce fuel consumption somewhat, their profits decrease by 0.27 per cent in response to a 1 per cent fuel price increase. Behavioral reactions to fuel price increases are particularly strong for one-person firms that respond to the price shock by increasing their labor supply. Thus the negative impacts on profits are mitigated, but including the 'shadow' costs of a higher own-labor supply would probably leave many entrepreneurs worse off. Somewhat unexpectedly, we find no behavioral differences between formal and informal firms. However this is true in subsamples that only include firms that use both fuels and electricity for production, which is more often the case with formal ones.

The indicative computations of the SO effects rest on the assumption that MSEs are cost-minimizing, choose to maintain production levels, change labor demand only at the intensive margin, and do not pass on prices. Given the large simulated profit losses, however, entrepreneurs may well choose to change the type of activity, search for other employment opportunities, or increase output prices. We find evidence of relatively large output price elasticities with respect to fuel prices for food-processing firms compensating for estimated profit losses. This suggests that at least some MSEs adjust to fuel price increases by increasing output prices, a claim corroborated by news reports following the *gasolinazo* (Gonzalez, 2017).

The results of our analysis call for policy measures that mitigate the effects of energy price policies, whether in the context of fossil fuel subsidy reform or of the introduction of carbon taxes. While we expect general welfare gains from, for example, subsidy removals, we show that the immediate impact on the profits of small firms can be – and is likely to be perceived as – substantial for both formal and informal small firms. We thus propose increasing transfers to poor households and linking them explicitly to the implemented energy price policy, thus potentially increasing political support for fossil fuel subsidy removal or carbon pricing. Ideally, such transfers would be temporary, particularly as our analysis suggests that even small firms have the capacity to adjust. Despite the heterogeneity in impacts, we consider lump-sum transfers likely to be more efficient than more targeted compensation measures (for example, toward certain sectors) in light of the multiple adjustments by firms – including input substitution and output price changes. The financial means are often there: in Mexico, not long ago, energy subsidies amounted to 10 times the budget of "Prospera" (formerly "Oportunidades"), the main transfer program in the country (Andretta, 2011).

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1355770X22000080.

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Competing interests. The authors declare none.

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