When good managers face bad incentives: Management quality and energy intensity in the presence of price distortions

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Research question

Question (inspired by Bloom et al., 2010, for the UK)

1. Is energy intensity of firms correlated with the quality of their management practices across countries?

2. Does the answer depend on the availability of fossil fuel subsidies?

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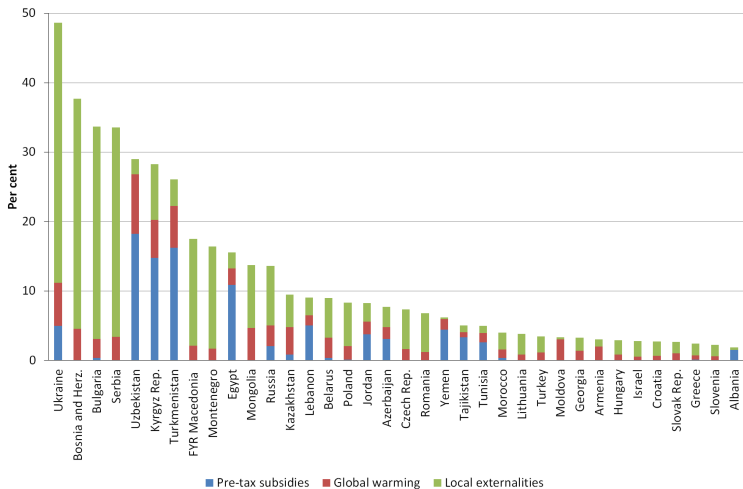2. Does the answer depend on the availability of fossil fuel subsidies?

Not possible to determine the sign of the relationship a priori

1. Better managed firms use more efficient production techniques ⇒ Reduced energy usage (Bloom et al. 2010 for UK)

2. Better managed firms might achieve higher productivity through more intensive capital utilisation ⇒ Higher energy usage

Motivation

Energy intensity of firms is one of the drivers of greenhouse gas (GHG) emissions:

- Most of the countries in central and eastern Europe and Central Asia started the transition from central planning to market economies with an economic structure focused on energy-intensive production

- In many countries in the Middle East and North Africa, production is energy-intensive thanks to fossil fuel subsidies

- A reduction in GHG emissions is an increasingly important policy objective for many governments

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Economic value of fossil fuel subsidies in 2013 as % of GDP

Source: IMF Energy Subsidies Template.

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Contribution

1. Expand the analysis to almost 40 countries in central and eastern Europe, Central Asia and Middle East and North Africa

2. Take into account comparative levels of energy prices

3. Alternative ways of identifying firms that benefit from fossil fuel subsidies: country and country-sector level

Main data sources

1. BEEPS V and MENA ES
   - Firm-level data, including questions on management quality, total annual cost of electricity and fuel and firm characteristics
     - Our focus: manufacturing firms with at least 20 employees (50 in Russia)
     - 38 economies, more than 5,000 face-to-face interviews conducted between August 2011 and August 2016, with more than half of the interviews conducted in 2013 (Sample breakdown)
     - Reference year for variables: 2011, except Russia (2010), MENA ES (2012) and Cyprus and Greece (2014)

2. IMF Energy Subsidies Template (http://www.imf.org/external/np/fad/subsidies/index.htm) (Details)

Measuring management practices

- Selection of questions from the U.S. Census Bureau's Management and Organizational Practices Survey (MOPS)

- Four areas: operations, monitoring, targets and incentives
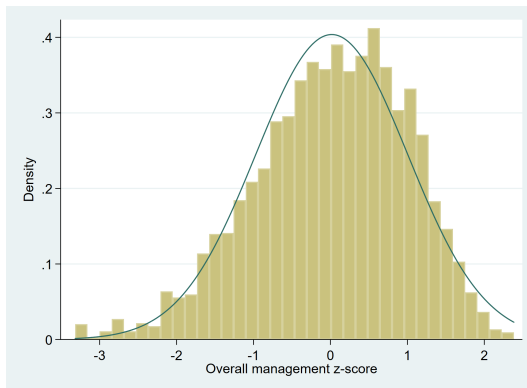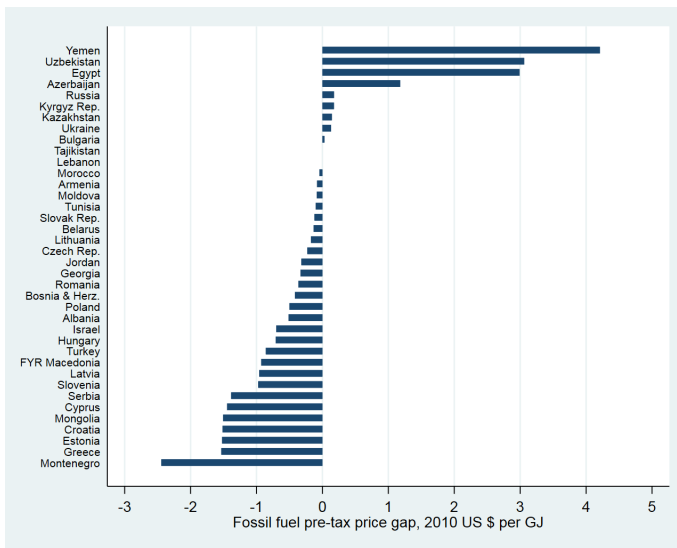

Source: BEEPS V and MENA ES.

Measuring fossil fuel subsidies: Country-level price gap

$$g_c = \frac{\sum_f e_{fc} \times (b_{fc} - r_{fc})}{t_c},$$

c	Country
f	Fuel type (gasoline, diesel, kerosene, coal, natural gas)
b	Benchmark (efficient) price
r	Real price
e	Amount of fuel consumed (IEA)
t	Amount of energy consumed (IEA)

- Real price and supply cost in constant 2010 US dollars

- Averaged over the years 2010-2014

- It does not take into account differences in energy intensity across sectors

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Pre-tax fossil fuel price gaps, US$ per GJ

Fossil fuel pre-tax price gap, 2010 US $ per GJ

Measuring fossil fuel subsidies: Country-sector level subsidy per unit of output

$$w_{sc} = \frac{\sum_f e_{fsc} \times (b_{fc} - r_{fc})}{y_{sc}}$$

s	Sector
c	Country
f	Fuel type (gasoline, diesel, kerosene, coal, natural gas)
b	Benchmark (efficient) price
r	Real price
w	Fuel subsidy per output
e	Amount of fuel consumed (IEA)
y	Output produced (UNIDO)

- When detailed sector data are not available in country c is not available, average energy intensity of sector s calculated across K countries $k \neq c$ is used

- Averaged over the years 2010-2014

Pre-tax fossil fuel subsidies heatmap

Pre-tax subsidy per '000 of output, in 2010 US $
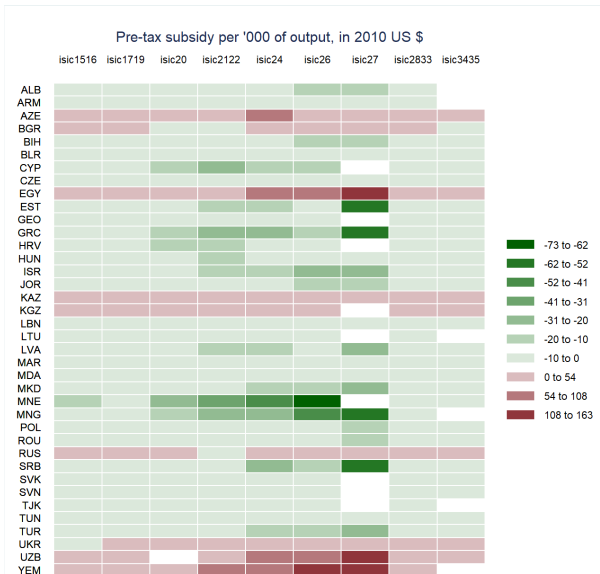
Measuring fossil fuel subsidies: Environmental externalities of fossil fuel combustion

Country level:

$$E_c = \frac{\sum_f e_{fc} \times (w_f + p_{fc})}{t_c}$$

Country-sector level:

$$E_{sc} = \frac{\sum_f e_{fsc} \times (w_f + p_{fc})}{y_{sc}}$$

E	Environmental cost of fossil fuel combustion
s	Sector
c	Country
f	Fuel type (gasoline, diesel, kerosene, coal, natural gas)
w	Cost of global warming
p	Cost of local pollution externalities
e	Amount of fuel f consumed (IEA)
t	Amount of energy consumed (IEA)
y	Output produced (UNIDO)

Empirical specification

1. Including pre-tax fossil fuel subsidies:

$$(FE/S)_{isc} \times 100 = \beta_0 + \beta_1 M_{isc} * P + \beta_2 M_{isc}$$
$$+ \gamma' \mathbf{Z_{isc}} + \nu' \mathbf{W_{ic}} + \sum_{sc=1}^{SC} \delta_{sc} D_{sc} + \epsilon_{isc},$$

2. Including post-tax energy subsidies:

$$(FE/S)_{isc} \times 100 = \beta_0 + \beta_1 M_{isc} * P + \beta_2 M_{isc} + \beta_3 M_{isc} * E$$
$$+ \gamma' \mathbf{Z_{isc}} + \nu' \mathbf{W_{ic}} + \sum_{sc=1}^{SC} \delta_{sc} D_{sc} + \epsilon_{isc},$$

i	Firm	M	Management practices (z-score)
s	Sector	P	Pre-tax energy subsidy measure
c	Country	E	Environmental costs of fossil fuel combustion
FE	Fuel expenditure	Z	Firm-level characteristics matrix
S	Total sales	D_{sc}	Country*sector fixed effects
E	Cost of environmental externalities of fuel combustion		
W	Climate and economic conditions around the firm matrix		

Baseline specification

Dep. var.: Fuel intensity	(1)	(2)
Management (z-score)	-0.302*	-0.426**
	(0.162)	(0.174)
Management (z-score) *		0.440
High energy intensity sectors		(0.378)
High energy intensity sectors		0.945
		(25.305)
Estimate for high energy intensity sectors		
Management (z-score)		0.013
		(0.335)
R^2	0.669	0.679
Observations	2,246	2,246

Source: BEEPS V, MENA ES and authors' calculations.
Note: Simple OLS using survey-weighted observations (using Stata's svy prefix). *, ** and *** denote significance at the 10, 5, and 1% level, respectively. Taylor-linearised standard errors that account for survey stratification are reported in parentheses. The dependent variable, fuel intensity, is calculated as fuel expenditure over total sales and winsorised at 5%. Sectors are split into high vs. moderate & low energy-intensive sectors according to Upadhyaya (2010). All regressions include country*sector fixed effects and control for other firm characteristics (sales, no. of employees, capital, log of firm age, percentage of employees with a college degree, % of self-generated electricity, longitude and latitude of the firm's location, January and July mean temperatures and night-lights around the firm, as well as indicators for listed firms, credit constrainedness, 25% foreign and state ownership, exporter status and electricity as a major or very severe obstacle).
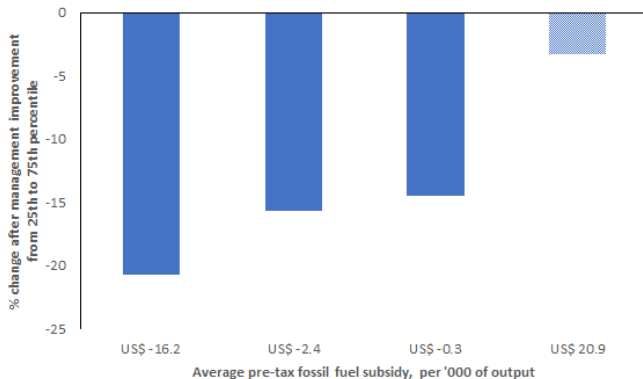
Country-level pre-tax fuel subsidies

Dep. var.: Fuel intensity	(1)	(2)
Management (z-score)	-0.319**	-0.433**
	(0.162)	(0.173)
Management (z-score) * High		-0.014
energy intensity sectors		(0.423)
Management (z-score) *	0.166	-0.114
Fuel price gap	(0.109)	(0.110)
Management (z-score) * Fuel price		0.741***
gap * High energy intensity sectors		(0.232)
High energy intensity sectors		2.099
		(24.540)
Estimates for high energy intensity sectors		
Management (z-score)		-0.447
		(0.386)
Management (z-score) *		0.626***
Fuel price gap		(0.204)
R^2	0.670	0.683
Observations	2,246	2,246

Note: Simple OLS using survey-weighted observations (using Stata's svy prefix). *, ** and *** denote
significance at the 10, 5, and 1% level, respectively. Linearised Taylor standard errors clustered on strata are
reported in parenthesis. The dependent variable, fuel intensity, is calculated as fuel expenditure over total sales
and winsorised at 5%. Sectors are split into high vs. moderate & low energy-intensive sectors according to
Upadhyaya (2010). Other control variables are the same as those listed under baseline specification table.

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Country-level pre-tax fuel subsidies: Magnitude of the effect

Source: BEEPS V, MENA ES and authors' calculations.
Note: Fuel intensity is calculated as the fuel cost per US dollar of sales. Solid bars denote estimates that are statistically significant at at least 10 per cent level.

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Country- and sector-level pre-tax fuel subsidies: Magnitude of the effect

Regression estimates

Source: BEEPS V, MENA ES and authors' calculations.
Note: Fuel intensity is calculated as the fuel cost per US dollar of sales. Solid bars denote estimates that are statistically significant at at least 10 per cent level.

Environmental externalities and post-tax subsidy

	Fuel subsidy		
	Price gap		Subsidy/output
Dep. var.: Fuel intensity	(1)	(2)	(3)
Management (z-score)	0.196	0.086	-0.107
	(0.256)	(0.289)	(0.192)
Management (z-score) * High		0.349	
energy intensity sectors		(0.571)	
Management (z-score) * Pre-tax fuel subsidy	0.054	-0.232**	0.013*
	(0.113)	(0.116)	(0.007)
Management (z-score) * Pre-tax fuel subsidy *		0.687***	
High energy intensity sectors		(0.219)	
Management (z-score) * Environmental costs	-0.142**	-0.138**	-0.012*
	(0.056)	(0.062)	(0.006)
Management (z-score) * Environmental costs *		-0.147	
High energy intensity sectors		(0.182)	
Post-tax estimates			
Management (z-score) * Post-tax fuel subsidy	-0.088	-0.370**	0.001
	(0.141)	(0.151)	(0.010)
Management (z-score) * Post-tax fuel subsidy *		0.540*	
High energy intensity sectors		(0.306)	
Management (z-score) * Post-tax fuel subsidy		0.170	
estimate for high energy intensity sectors		(0.266)	
R-squared	0.672	0.686	0.661
Observations	2,246	2,246	2,038

Conclusion

- Pre-tax fossil fuel subsidies, whether measured at the country-
  or country- and sector-level, matter for the relationship
  between fuel intensity and the quality of management
  practices:
  - Substantial magnitude of the relationship in high
    energy-intensive sectors

- The effects of pre-tax fossil fuel subsidies and environmental
  costs are similar in magnitude and opposite in direction:
  - Better managed firms take into account indirect effect of
    global warming and local pollution
  - Overall effect of post-tax fossil fuel subsidies is negligible

Policy implications

- Although existing research shows that higher-quality management practices are associated with improvements in firms' productivity, they may be linked to declines in environmental performance in the absence of incentives to economise on energy usage

- Governments that wish to reduce GHG emissions and their country's carbon footprint should consider not only adopting climate change related legislation, but also bear in mind the profound impact that energy prices can have on firms' behaviour

Descriptive statistics

- For all control variables, with the exception of GPS coordinates, average January and July temperatures and average intensity of night lights

	Obs.	Mean	Std. Error
Fuel costs, % total sales	2,246	3.271	0.224
Total energy costs, % total sales	2,205	7.356	0.380
Management (z-score)	2,246	0.029	0.047
Total sales, '000 USD	2,246	22,807.693	15,242.706
Number of PFT employees	2,246	105.715	6.383
Net book value of equipment, '000 USD	2,246	8,601.413	3,549.658
Credit-constrained firm, dummy	2,246	0.180	0.016
Exporting firm, dummy	2,246	0.431	0.021
Firm age	2,246	19.342	0.554
25+% foreign ownership, dummy	2,246	0.162	0.015
25+% state ownership, dummy	2,246	0.017	0.005
% employees with a university degree	2,246	17.430	0.691
Listed firm, dummy	2,246	0.043	0.008
% self-generated electricity	2,246	4.433	0.555
Electricity is major or severe obstacle	2,246	0.240	0.019

Sample breakdown Back

	No. of obs.				No. of obs.		
Country	All	With fuel expenditures and sales	With all control variables	Country	All	With fuel expenditures and sales	With all control variables
Albania	42	42	12	Latvia	50	45	9
Armenia	61	43	19	Lebanon	116	106	57
Azerbaijan	68	54	2	Lithuania	52	49	20
Belarus	74	66	33	Moldova	52	46	16
Bosnia and Herz.	59	53	33	Mongolia	58	56	25
Bulgaria	51	50	34	Montenegro	15	10	4
Croatia	52	50	38	Morocco	116	110	27
Cyprus	24	18	5	Poland	98	72	13
Czech Rep.	51	47	25	Romania	101	95	70
Egypt	1,132	1,003	790	Russia	439	372	134
Estonia	39	36	19	Serbia	43	41	28
FYR Macedonia	50	48	42	Slovak Rep.	51	37	16
Georgia	45	42	21	Slovenia	35	34	21
Greece	42	39	18	Tajikistan	50	34	17
Hungary	43	29	12	Tunisia	230	228	195
Israel	113	101	54	Turkey	656	429	128
Jordan	199	192	107	Ukraine	363	278	73
Kazakhstan	120	99	24	Uzbekistan	88	81	65
Kyrgyz Rep.	63	54	19	Yemen	32	26	21
Total					**4,973**	**4,215**	**2,246**

Source: BEEPS V and MENA ES.

Note: Control variables used are management practices, number of permanent, full-time employees, net book value of equipment, firm age, % of employees with a university degree, % of firms owning/sharing a generator, % of self-generated electricity, exporter status, indicators for listed firms and firms where electricity is major or severe obstacle.

IMF Energy Subsidies Template Back

- Annual data for gasoline, diesel, kerosene, coal, natural gas and electricity prices in 188 countries
  - Price paid by consumers (real price)
  - Supply cost
  - Cost of environmental externalities from fuel combustion (global warming and local pollution)

- Pre-tax benchmark price=supply cost

Classification of manufacturing sectors by energy input ratio

Intensity of energy consumption	ISIC	Description of activities
High energy-intensive	17	Manufacture of textiles
	21	Paper and paper products
	23	Coke and refined petroleum products
	24	Chemical products
	26	Non-metallic mineral products
	27	Manufacture of basic metals
Moderate energy-intensive	15	Food products and beverages
	18	Wearing apparel; dressing and dyeing
	19	Manufacture of leather products
	20	Wood and wood products
	22	Printing and publishing
	25	Rubber and plastic products
	28	Fabricated metal products
Low energy-intensive	16	Tobacco products
	29	Machinery and equipment n.e.c.
	30	Office, accounting and computing machinery
	31	Electrical machinery and apparatus n.e.c.
	32	Radio, TV and communication equipment
	33	Medical, precision and optical instruments
	34	Motor vehicles, trailers and semi-trailers
	35	Other transport equipment
	36	Furniture and other manufacturing n.e.c.
	37	Recycling

Source: Upadhyaya (2010).

Country- and sector-level pre-tax fuel subsidies: Table Back

| Dep. var.: Fuel intensity	(1)	(2)
Management (z-score)	-0.364**	-0.264
	(0.170)	(0.191)
Management (z-score) * Use		-0.725
self-generated electricity		(0.477)
Management (z-score)	0.014**	0.014
* Fuel subsidy/output	(0.007)	(0.009)
Management (z-score) * Fuel subsidy/		-0.001
output * Use self-generated electricity		(0.014)
Use self-generated electricity		4.753
		(13.032)
Estimates for firms that use self-generated electricity		
Management (z-score)		-0.989**
		(0.428)
Management (z-score) *		0.012
Fuel subsidy/output		(0.011)
R^2	0.659	0.666
Observations	2,038	2,038

Note: Simple OLS using survey-weighted observations (using Stata's svy prefix). *, ** and *** denote significance at the 10, 5, and 1% level, respectively. Linearised Taylor standard errors clustered on strata are reported in parenthesis. The dependent variable, fuel intensity, is calculated as fuel expenditure over total sales and winsorised at 5%. Other control variables are the same as those listed under baseline specification table.

Energy intensity and pre-tax fossil fuel subsidies

Dep. var.: Energy intensity	Fuel subsidy measure		
	(1)	(2)	(3)
Fuel subsidy measure	Price gap		Subsidy/output
Management (z-score)	-0.201	-0.399	-0.181
	(0.268)	(0.284)	(0.279)
Management (z-score) * Fuel	0.340*	-0.068	0.026**
subsidy	(0.181)	(0.177)	(0.012)
Management (z-score)		-0.048	
* High energy intensity sectors		(0.687)	
Management (z-score) * Fuel price		1.098***	
gap * High energy intensity sectors		(0.388)	
High energy intensity sectors		13.057	
		(43.761)	
R^2	0.686	0.700	0.670
Observations	2,205	2,205	2,002

Note: Simple OLS using survey-weighted observations (using Stata's svy prefix). *, ** and *** denote significance at the 10, 5, and 1% level, respectively. Taylor-linearised standard errors that account for survey stratification are reported in parentheses. The dependent variable, energy intensity, is calculated as fuel and electricity expenditures over total sales and winsorised at 5 per cent. Fossil fuel subsidy is measured at the country level (price gap) in columns 1 and 2 and at the country-sector level (subsidy/output) in column 3. Sectors are split into high vs. moderate & low energy-intensive sectors according to Upadhyaya (2010). Other control variables are the same as those listed under baseline specification table.

Energy intensity and country-level pre-tax fuel subsidies: Magnitude of the effect
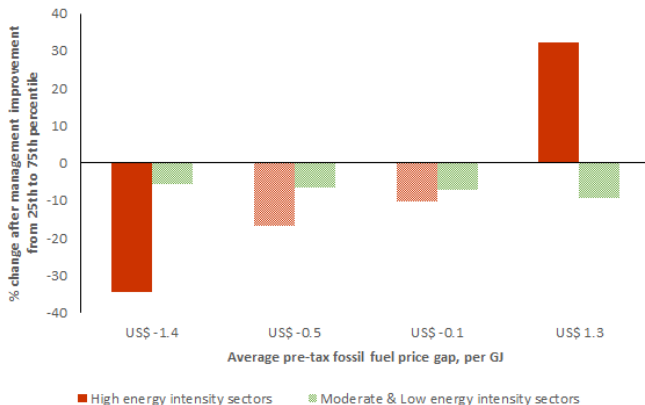
Source: BEEPS V, MENA ES and authors' calculations.
Note: Energy intensity is calculated as the cost of fuel and electricity per US dollar of sales. Solid bars denote estimates that are statistically significant at at least 10 per cent level.

Estimated coefficient on the quality of management interacted with fuel subsidy/output and 90 per cent confidence intervals, excluding one country at a time
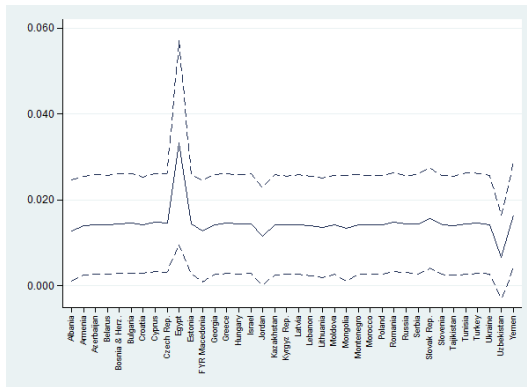
Source: BEEPS V, MENA ES, IMF Energy Subsidies Template and authors' calculations.
Note: Dashed lines represent the 90 per cent confidence interval.

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Estimated coefficient on the quality of management interacted with fuel subsidy/output and 90 per cent confidence intervals, excluding one sector at a time
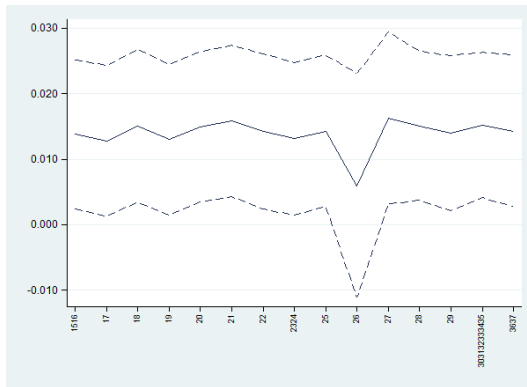
Source: BEEPS V, MENA ES, IMF Energy Subsidies Template and authors' calculations.
Note: Dashed lines represent the 90 per cent confidence interval.

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Differences in fuel intensity by data availability Back

Has data on	No Mean	Std. error	Yes Mean	Std. error	p-value
Management (z-score)	3.129	0.857	3.901	0.306	0.396
Capital, log	4.234	0.678	3.732	0.317	0.503
% with a completed university degree	1.597	0.568	3.874	0.296	0.000
Age	4.114	0.796	3.869	0.296	0.773
25+% foreign ownership	5.840	2.789	3.865	0.296	0.481
25+% state ownership	6.561	3.013	3.864	0.296	0.373
Exporter status	1.254	0.313	3.883	0.297	0.000
Electricity as an obstacle	1.299	0.561	3.876	0.296	0.000
All control variables	4.013	0.607	3.806	0.331	0.765

Source: BEEPS V, MENA ES and authors' calculations.
Note: Means using survey-weighted observations (using Stata's svy prefix). Linearised Taylor standard errors clustered on strata.

- Difference in the average fuel intensity of firms with non-missing data for all control variables and firms for which at least one of the control variables has missing values is not statistically significant.