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ENERGY PRICES, FIRMS HETEROGENEITY AND ECONOMIC PERFORMANCES

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Sustainability Environmental Economics and Dynamics Studies

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Staying Competitive: Productivity Effects of Environmental Taxes

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There is extensive evidence that well-designed taxes can be an efficient policy instrument to mitigate environmental degradation and climate change

From a static point of view, environmental taxes adopted unilaterally may undermine competitiveness if foreign competitors do not face equivalent cost increases. The cost competitiveness of domestic firms could be hampered by higher energy prices, especially in energy-intensive and trade-exposed (EITE) sectors.

On the other hand, several factors imply that impacts on competitiveness ought to be moderate. Energy represents a relatively small share of production costs in most industries, and even substantial taxes on energy would generally amount to a small proportion of sales or profits

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the literature reviewed in this study has found that adverse impacts on firms and their competitiveness, if any, are likely to be small and concentrated in a few energy-intensive and trade-exposed (EITE) sectors

While reassuring, the available evidence has largely focused on the European and North American cases.

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The present study contributes to filling this knowledge gap by providing novel evidence on the impacts of energy price fluctuations on firm performances in developing countries.

It summarizes the results from three background empirical studies using detailed firm-level data: **one cross-country analysis using World Bank Enterprise Survey (WBES) data on 11 upper-middle income countries** and two country-specific analyses using large panels of manufacturing plants in Indonesia and Mexico.

These countries are particularly suitable for such analyses given the long-standing policies of low fuel prices and the recent changes in fuel pricing, with the energy sector reform and carbon tax applied in Mexico since 2014, and the reduction in the fuel subsidy in Indonesia in 2015.

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From the one hand, rising energy prices may induce innovation and eventually increase competitiveness. From the other hand, higher prices are expected to reduce competitiveness whether firms are forced to pass this increase in cost through consumers.

FORUM

Industrial Ecology and Competitiveness

Strategic Implications for the Firm

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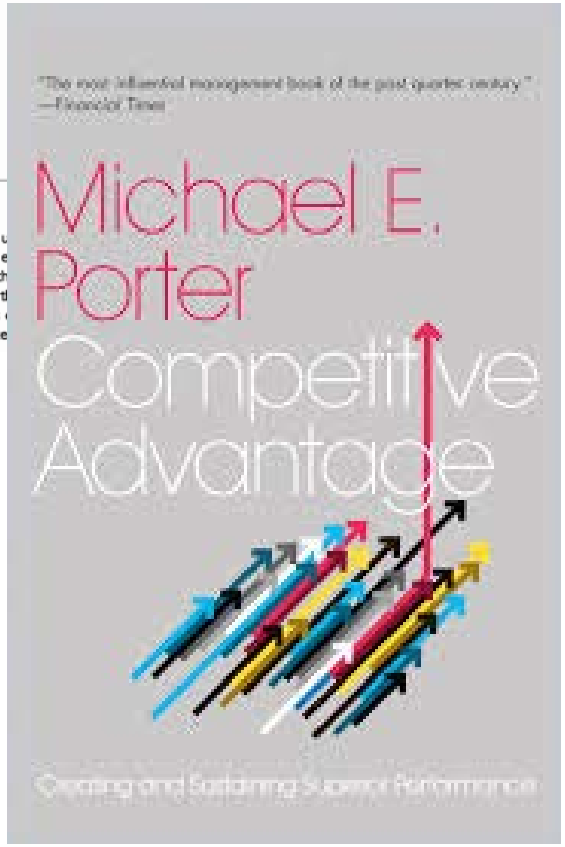
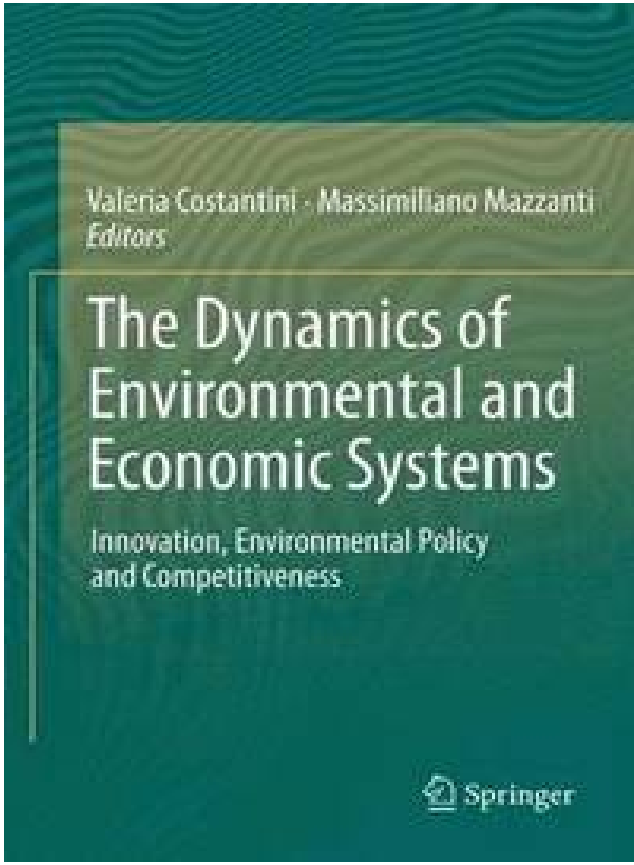
Keywords
closed loop
competitiveness
corporate environmental management
eco-efficiency
externalities
resource productivity

Summary

In the emerging field of industrial ecology one of the
settled questions is the degree to which design for the e
vironment, closing energy and materials loops, and oth
industrial ecology concepts apply at the firm level. In t
article we examine this issue with a particular focus
whether industrial ecology can guide company strate

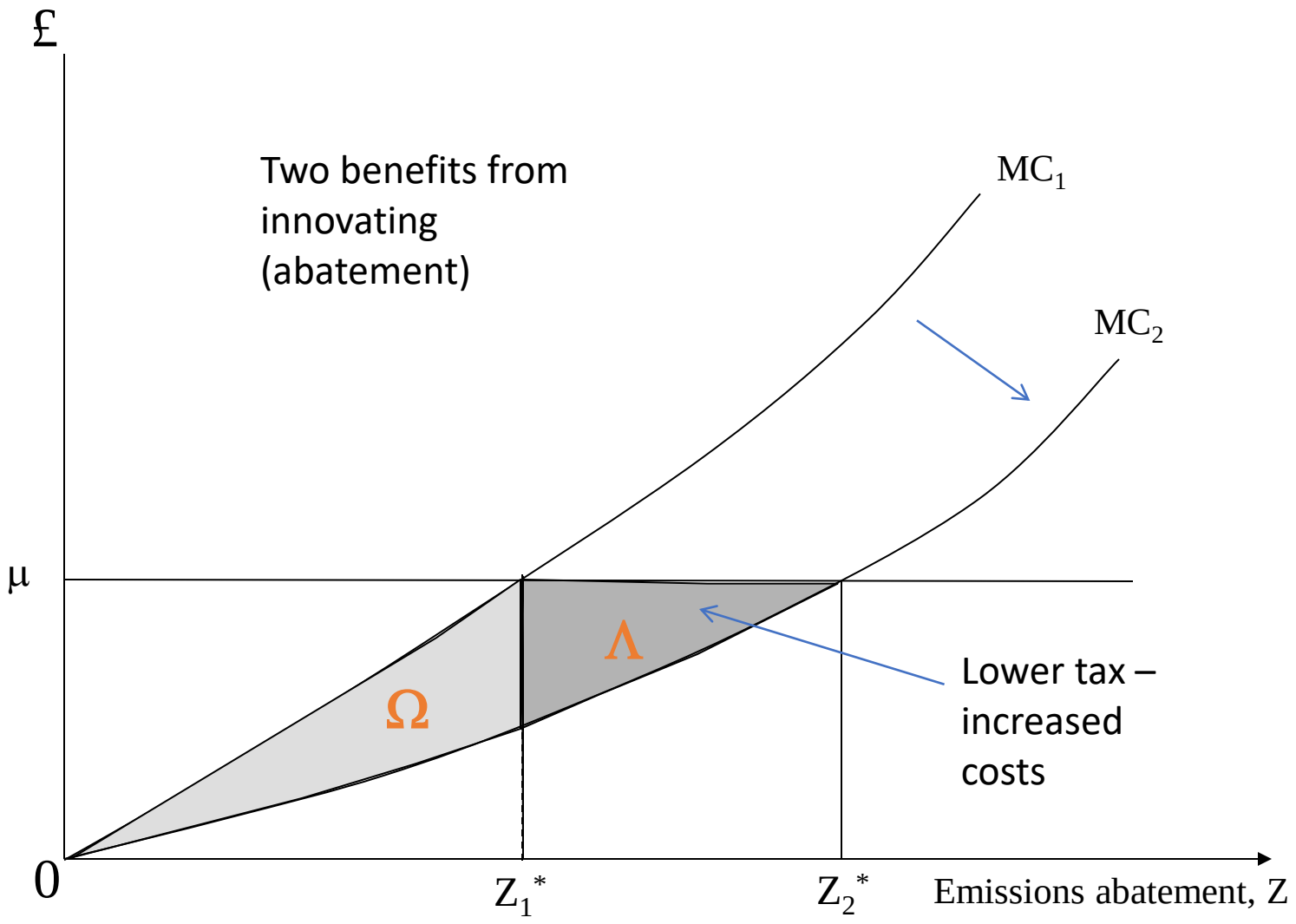




Porter hypothesis - strong

- **Stricter and well designed environmental policies can spur economic performances through innovation offsets**

Dynamic incentives under emissions tax controls: **tax savings**



Dynamic efficiency

- In a market-based scheme, **every unit of emissions reduction is rewarded by a tax saving**. The key issue here is what incentives firms face in developing pollution-saving technology or developing new, environmentally cleaner products.

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On the green and innovative side of trade competitiveness? The impact of environmental policies and innovation on EU exports

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ABSTRACT

This paper aims at exploring how the export competitiveness of the European Union has been affected by environmental regulation and innovation. Starting from the Porter idea that environmental policies may foster international competitiveness by inducing technological innovation. We test both the strong and narrowly strong versions of the Porter hypothesis, in order to understand if such a virtuous cycle is confined into the environmental goods sector (respecting the narrow criterion) or it spreads out through the whole economic system. For this purpose we adopt a theoretically based gravity model applied to the export dynamics of five aggregated manufacturing sectors classified by their technological or environmental content.

When testing the strong version, the overall effect of environmental policies does not seem to be harmful for export competitiveness of the manufacturing sector, whereas specific energy tax policies and innovation efforts positively influence export flows dynamics, revealing a Porter-like mechanism. When testing the narrowly strong version, environmental policies, but more incisively environmental innovation efforts, foster green exports. These results show that public policies and private innovation patterns both trigger higher efficiency in the production process through various complementarity mechanisms, thus turning the perception of environmental protection actions as a production cost into a net benefit.

Chapter 3
On the Economic Returns of Eco-Innovation: Where Do We Stand?

Claudia Ghisetti

3.1 Introduction

Of paramount importance for policymakers is to properly assess the economic consequences of sustainable production choices aimed at reducing environmental negative externalities. Such an assessment is relevant at different levels of aggregation, starting from the firm level analysis, to understand whether "going green" brings about certain economic gains or instead it is counterproductive, and moving to the meso (sectors) or macro (country) levels of analysis, to understand whether any aggregate effects are at stake and to which direction they point

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Firm Surveys relating Environmental Policies, Environmental Performance and Innovation

DESIGN CHALLENGES AND INSIGHTS FROM EMPIRICAL APPLICATION

Massimiliano Mazzanti, Davide Antonioli,
Claudia Ghisetti, Francesco Nicolli

LIT REVIEW

- Rammer, C., Gottschalk, S., Peneder, M., Wörter, M., Stucki, T., & Arvanitis, S. (2017). Does energy policy hurt international competitiveness of firms? A comparative study for Germany, Switzerland and Austria. *Energy Policy*, *109*, 154–180.
- Rentschler, J. and Kornejew, M. (2017). Energy price variation and competitiveness: Firm level evidence from Indonesia. Energy Economics, 67:242–254.

LIT REVIEW

- Marin, Giovanni & Vona, Francesco, 2017. "The Impact of Energy Prices on Employment and Environmental Performance: Evidence from French Manufacturing Establishments," Fondazione Eni Enrico Mattei (FEEM).

LIT REVIEW

- Sadath, A. C., & Acharya, R. H. (2015). Effects of energy price rise on investment: Firm level evidence from Indian manufacturing sector. Energy Economics, 49, 516–522
- Sato, M., Singer, G., Dussaux, D., Lovo, S., (2015). International and sectoral variation in energy prices 1995-2011: how does it relate to emissions policy stringency. Grantham Research Institute on Climate Change and the Environment.

Research questions

- ***Proposition 1***: positive changes in energy prices may affect firm's performances positively or negatively. The magnitude and direction of this effect varies across different measures of firms' performances.
- ***Proposition 2***: The effect of a positive change in energy prices depends on a different country and sector related factors such as firm's size, domestic ownership and business environment.

Data sources

- **World Bank Enterprise Survey**
- Detailed picture of a country's business environment
  - Firms characteristics such as number of employees, innovative activities, competitiveness, etc.,
  - Constraints to firms' performance and growth, e.g. infrastructure, crime, business-government relationships, etc.
- Repeated observations for the same firm over time.
- By tracking the same firm across different years enables us to carry out a robust multivariate analysis that exploit panel data structures.

Data sources

- **Energy Prices (International Energy Agency - IEA)**
  - Includes energy prices of OECD countries related to different products, such as crude oil, natural gas, electricity, etc.
- **Sato et al. (2015)**
  - Provides country-sector energy price indices, which are available for 48 countries and 12 sectors over the period 1995-2011

- Ideally, one would want EP to vary also across sectors, which is feasible with data made available by Sato et al., 2015.
- Nevertheless, the country coverage using this approach would be limited to 8 countries, while using national prices as in specification 1, we can extend our sample to more countries. The sectoral level data are used in a robustness exercises on a smaller dataset.

World Bank Enterprise Survey (1)

Variable name	Description	WB Survey information exploited	Measurement
tot emp	Total number of employees within firm	WB Question #l1: Permanent, full-time employees end of last fiscal year (Number) WB Question #l6: Full-time seasonal/temporary workers employed last fiscal year (Number)	l1 + l6
sales/emp	Amount of sales over total employment	WB Question #d2: what were this establishment's total annual sales? WB Question #l1: Permanent, full-time employees end of last fiscal year (Number) WB Question #l6: Full-time seasonal/temporary workers employed last fiscal year (Number)	d2 /(l1+l6)

World Bank Enterprise Survey (2)

Variable name	Description	WB Survey information exploited	Measurement
VA/emp	Value added over total number of employees	WB Question #n2e: Total annual cost of raw materials and intermediate goods used in production (Number) WB Question #d2: what were this establishment's total annual sales? (Number) WB Question #l1: Permanent, full-time employees end of last fiscal year (Number) WB Question #l6: Full-time seasonal/temporary workers employed last fiscal year (Number)	(d2-n2e)/(l1+l6)
Return on sales	Percentage of revenues converted in profits	WB Question #n5a: how much did this establishment spend on purchases of machinery, vehicles, and equipment (new or used)? (Number) WB Question #n5b: how much did this establishment spend on purchases of land and buildings? (Number) WB Question #n2a: Total annual cost of labor (including wages, salaries, bonuses, social security payments) (Number) WB Question #n2e: Total annual cost of raw materials and intermediate goods used in production WB Question #d2: what were this establishment's total annual sales? (Number)	(d2-n2e-n5a-n5b-n2a)/d2

World Bank Enterprise Survey (3)

Variable name	Description	WB Survey information exploited	Measurement
Export share	Percentage of exports	WB Question #d3b: what percent of this establishment's sales were indirect exports (sold domestically to third party that exports products)? (Share) WB Question #d3c: what percent of this establishment's sales were direct exports? (Share)	d3b + b3c

Energy prices and intensity (1)

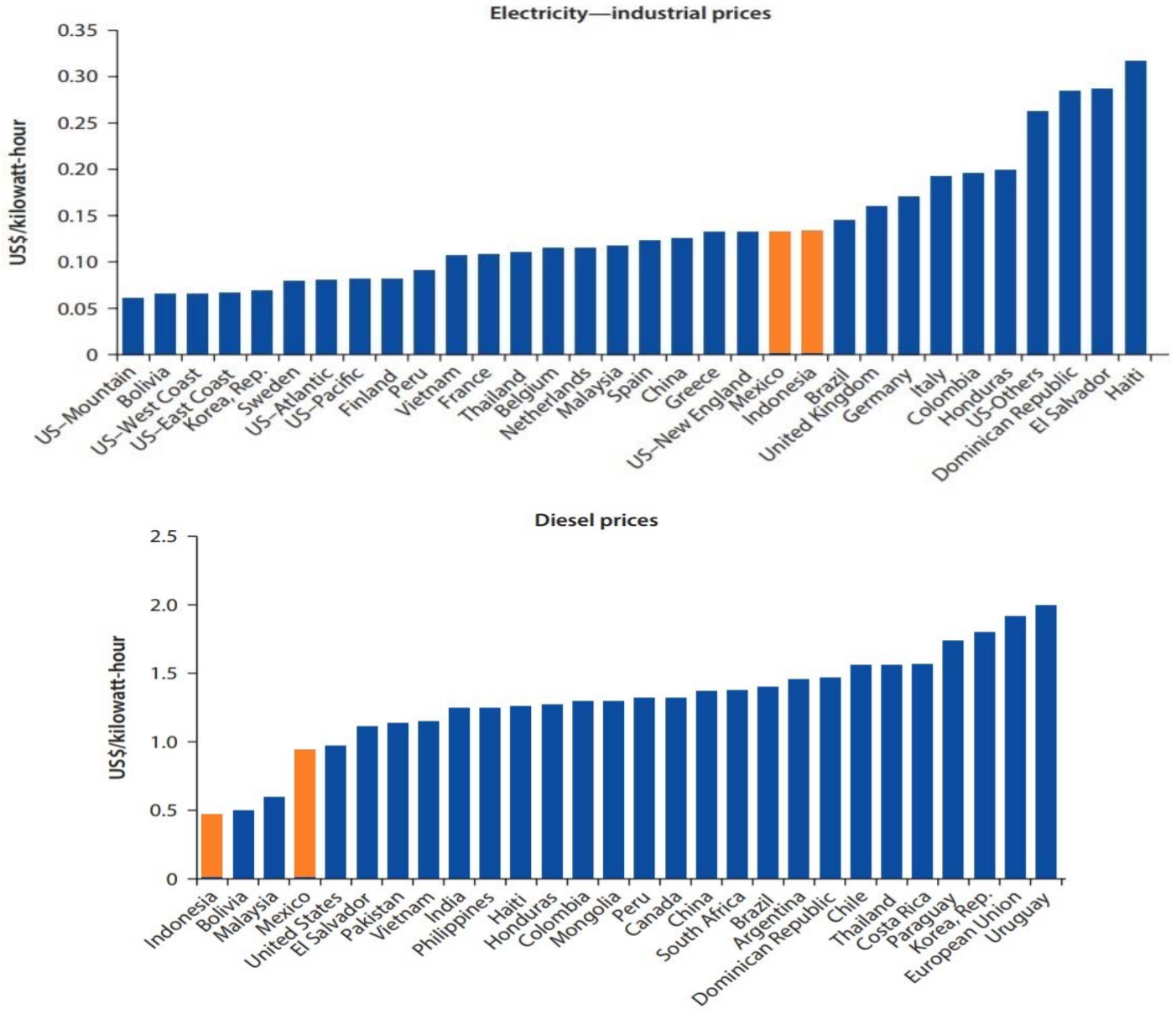
- The IEA provides energy prices for different products which has been used to calculate the energy mix.
- This mix of energy input has been used to weight the energy prices of specific products, i.e. crude oil, steam and coking coal, electricity, natural gas, liquefied petroleum gas and light and low/high sulphur fuel oil.
- We measure the relevance of each energy source within the specific country allowing our energy price indicator to capture to what extent the country relies on each energy product.

Energy prices and intensity (2)

- Energy prices at sectoral level:
  - Fixed-Weight energy Price Level: captures the within-sector variation in energy price patterns for specific country-sectors (Sato et al., 2015)

  →Real price of fuel in a given country weighted by the share of input quantity of fuel for specific sector-country combinations over total input quantity.
  - We fix the weight over time (anchored to 1995 levels)
  - In order to assess firms' exposure to energy prices, the energy intensity index is measured as fuel and electricity costs over revenues.

Figure 1. Energy Prices Across Countries (2012)



Source: Beylis and Cunha (2017)

- the country coverage of energy prices for less developed and emerging countries limits our analysis to only 11 countries for which both firm panel data and energy price indices are available.

WB Enterprise Surveys: sample

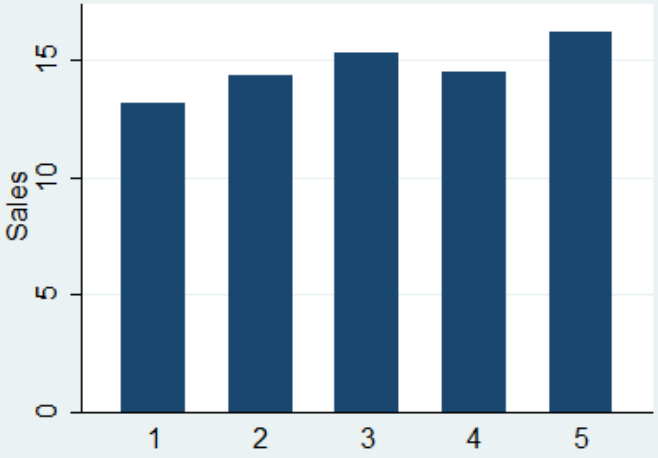
Country	WB survey year (panel data)			
Brazil	2003	2009		
Czech Republic	2002	2005	2009	2013
Hungary	2002	2005	2009	2013
Kazakhstan	2002	2005	2009	
Mexico	2006	2010		
Poland	2002	2005	2009	2013
Romania	2002	2005	2009	
Russia	2002	2005	2009	
Slovakia	2002	2005	2009	2013
Slovenia	2002	2005	2009	2013
Turkey	2005	2008	2013	

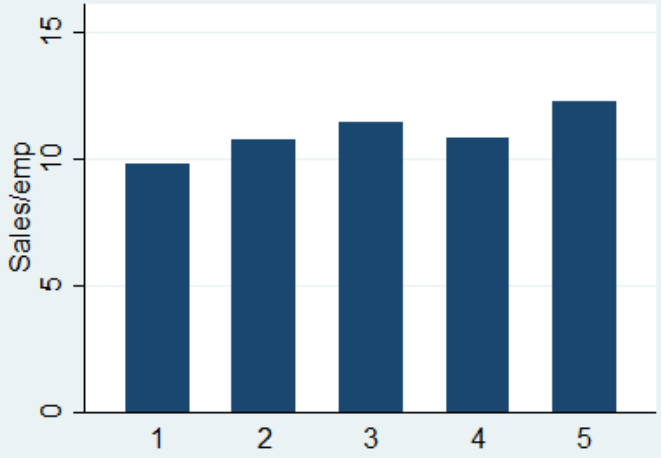
- The resulting data set includes 11 countries for which we have observation in at least two years. We note here that in these counties for which we have only two years, we have a balanced panel of firms, while in the other countries, like Russia or Romania, for which more years are available, some firms have three or four observations while some others have only two.

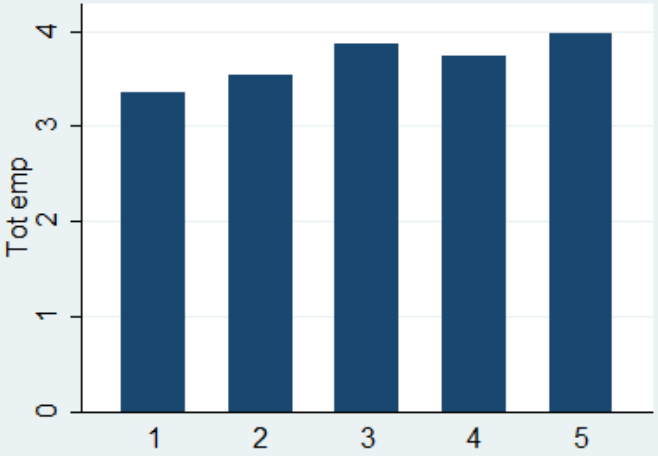
Descriptive statistics

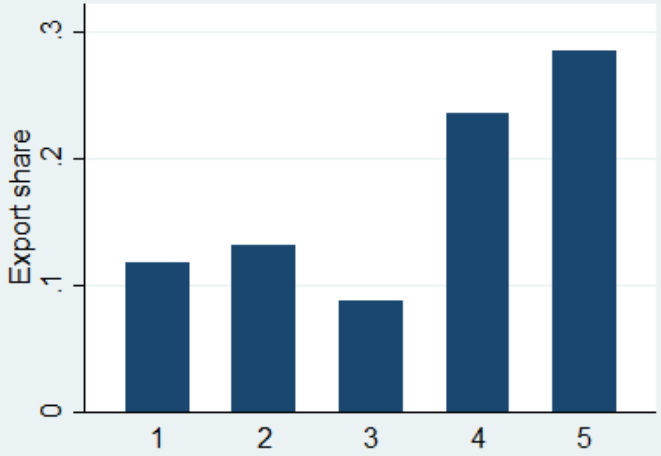
Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent variables: Main analysis					
Tot emp	4,107	3.700743	1.516276	0	10.82118
Sales/emp	3,408	11.04017	1.905796	-2.302585	21.27534
VA/emp	1,962	10.53882	1.776611	3.289201	20.19118
ROS	3,040	.4422371	.3356461	-.9802957	.9999984
Export share	4,001	.1611167	.29234	-.16	1
Dependent variables: Robustness checks (Appendix A)					
Share of production workers	3,250	.6889317	.2345699	0	1
Share of skilled workers	3,987	.4084086	.2980777	-.08	1
Sales	3,420	14.76619	2.505895	2.772589	24.9413
TFP	738	3.029082	1.127158	-4.835469	9.668178
R&D	830	.3180723	.4660085	0	1
Loan	5,067	.6295638	.4829692	0	1
Fixed Assets	4,591	.1791178	.2820747	0	1
Outages	6,071	.6977434	.4592737	0	1
Outage_days	5,582	3.391777	10.60923	0	240

Firms' performance indicators over quintiles of the Energy Price index









Empirical strategy

- We estimate the following equation:

$$y_{it} = \alpha_i + \beta \log(EP_{ct}) + \gamma \log(EP_{ct}) \times EI_i + \\ + \delta_c Trend_t + X_i' \eta_t + \varepsilon_{it}$$

- The interpretation of the interaction term should be as follows: if γ is negative, then a rise in energy prices has a stronger (negative) effect on performance for more energy intensive firms.

Baseline results – country level energy prices

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	0.213	1.410***	2.114***	0.268**	0.0669
	(0.234)	(0.450)	(0.728)	(0.123)	(0.0688)
log(ener price) x energy exp share	-0.560	-7.709**	-26.62***	-0.487	-0.0325
	(1.077)	(3.102)	(5.642)	(0.567)	(0.469)
N	4101	3405	1962	3037	3995
Effect at 10 percentile of EI	0.211	1.381	1.982	0.266	0.0668
Effect at 25 percentile of EI	0.208	1.333	1.834	0.263	0.0665
Effect at 50 percentile of EI	0.199	1.215	1.475	0.255	0.0660
Effect at 75 percentile of EI	0.184	1.015	0.831	0.243	0.0652
Effect at 90 percentile of EI	0.157	0.648	-0.301	0.220	0.0636

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

- **The positive effect of energy prices on performance is weaker in more energy-intensive firms, but remains positive even for the most energy-intensive firms.**

- **There is no evidence that these results may be explained by a substitution between energy and labor inputs, higher output prices or R&D investments.**

- Additional analysis also suggests that the share of production workers increases with energy prices, and that energy price changes seem to have no effect on firms' R&D investments. This result may be consistent with the fact that firms in developing countries tend to be far from the technological frontier and hence may adopt, rather than invent, energy-saving technologies in response to energy price increases.

- The marginal effect of energy prices, accounting for different energy intensity levels, is calculated in the last lines of each table. To give an example, in column 3, VA/emp becomes negative after the 75 percentiles of the EI distribution, while in column 2 and 4, the effect of energy prices only decreases in size. This result is in line with the overall idea that firms' characteristics may influence the effect of energy prices on firm performances.

- **The results are robust to various checks, including instrumenting energy intensity and using country-sector instead of national energy prices**

Instrumental variable approach

- It might be the case that firm-level energy intensity is correlated at the same time with unobserved firm's features and firm's performance

- we run instrumental variable regressions where we consider the interaction between firm-level energy intensity and energy prices as endogenous
  - instrumenting the interaction term, which relies on firm's based information and is subject to endogeneity concerns.

- Instrumental variable: country-sector average energy intensity interacted with energy prices
  - Correlated with firm-level energy intensity
  - Uncorrelated with firm-specific performance

Results accounting for endogeneity – country level energy prices

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	0.160	2.102***	0.983	0.488***	0.109
	(0.341)	(0.681)	(1.042)	(0.183)	(0.0947)
log(ener price) x energy exp share	0.481	-20.01**	-8.184	-4.003*	-0.862
	(4.045)	(8.712)	(12.80)	(2.196)	(1.444)
F test of excluded IV	43.29	40.53	19.79	65.37	42.33
N	4101	3405	1962	3037	3995
Effect at 10 percentile of EI	0.162	2.026	0.942	0.470	0.106
Effect at 25 percentile of EI	0.165	1.902	0.897	0.445	0.101
Effect at 50 percentile of EI	0.172	1.595	0.787	0.384	0.0876
Effect at 75 percentile of EI	0.185	1.077	0.589	0.286	0.0641
Effect at 90 percentile of EI	0.208	0.125	0.241	0.0966	0.0230

IV-Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Results accounting for endogeneity – country-sector level energy prices

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	-0.131	1.708***	3.425	0.307**	0.113
	(0.355)	(0.591)	(3.903)	(0.147)	(0.0782)
log(ener price) x energy exp share	0.351	-25.93**	-31.22	-4.226	-0.891
	(6.782)	(11.21)	(62.82)	(2.933)	(1.842)
F test of excluded IV	16.15	15.48	1.737	14.65	16.15
N	1016	869	166	774	1012
Effect at 10 percentile of EI	-0.129	1.513	2.944	0.275	0.107
Effect at 25 percentile of EI	-0.125	1.277	2.512	0.238	0.0983
Effect at 50 percentile of EI	-0.119	0.800	2.047	0.161	0.0816
Effect at 75 percentile of EI	-0.109	0.0843	1.308	0.0407	0.0576
Effect at 90 percentile of EI	-0.0967	-0.855	0.660	-0.109	0.0255

IV-Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Additional dependent variables - FE

	(1)	(2)	(3)	(4)	(5)	(6)
	R&D dummy	log(TFP)	log(sales)	log(export)	Share of production workers	Share of skilled workers
log(ener price)	1.008	0.297	1.556***	1.068	0.240**	-0.0450
	(0.640)	(0.915)	(0.485)	(0.791)	(0.112)	(0.0979)
log(ener price) x energy exp share	-0.492	-7.553	-8.043**	-7.819	-0.0705	0.378
	(2.124)	(4.895)	(3.295)	(6.549)	(0.285)	(0.532)
N	828	738	3417	1109	3249	3981
Effect at 10 percentile of EI	1.004	0.242	1.526	1.046	0.240	-0.0437
Effect at 25 percentile of EI	0.999	0.184	1.475	1.011	0.239	-0.0412
Effect at 50 percentile of EI	0.991	0.0410	1.352	0.921	0.238	-0.0354
Effect at 75 percentile of EI	0.977	-0.175	1.144	0.723	0.236	-0.0251
Effect at 90 percentile of EI	0.959	-0.549	0.761	0.397	0.233	-0.00684

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Additional dependent variables – FE-IV

	(1)	(2)	(3)	(4)	(5)	(6)
	R&D dummy	log(TFP)	log(sales)	log(export)	Share of production workers	Share of skilled workers
log(ener price)	0.978	0.284	2.118***	2.010	0.334**	0.000605
	(0.687)	(2.361)	(0.713)	(1.328)	(0.153)	(0.141)
log(ener price) x energy exp share	-0.00281	-7.288	-18.03**	-30.21	-1.754	-0.519
	(4.337)	(44.72)	(8.770)	(24.94)	(2.259)	(2.048)
F test of excluded IV	32.61	3.697	40.87	8.591	22.72	43.20
N	828	738	3417	1109	3249	3981
Effect at 10 percentile of EI	0.978	0.231	2.050	1.925	0.326	-0.00117
Effect at 25 percentile of EI	0.978	0.175	1.937	1.787	0.315	-0.00457
Effect at 50 percentile of EI	0.978	0.0372	1.662	1.441	0.287	-0.0126
Effect at 75 percentile of EI	0.978	-0.171	1.194	0.677	0.238	-0.0267
Effect at 90 percentile of EI	0.978	-0.532	0.336	-0.585	0.150	-0.0519

IV-Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Differential effects

- **The analysis does not find much heterogeneity in the effects of energy prices on performance across firm size, business constraints and workforce composition.** The analysis suggests that the declining effect of energy prices on labor productivity as energy intensity increases is mainly driven by domestic firms.
- **The effects of energy price changes are particularly large for the poorer half of countries in the sample.**

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Our results highlight that the prevailing effect depend mainly from firms' energy intensity, i.e. their exposure to an energy price rise. Other firms' characteristics, like size and type of ownership, seems to matter less.

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Overall, the empirical analysis confirms the hypothesis that higher energy prices relate to better economic performances, an outcome that does not reject the strong version of the Porter hypothesis.

Employment and export, on the contrary, are not influenced by rising levels of energy prices. Interestingly, and in line with our second research hypothesis, the magnitude of this effect is lower in more energy intensive sectors.

Limits

- The role of induced innovations is not fully taken into account
- Two equations models that study both production and innovation functions are for further research

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the results of these new analyses strongly support a re-evaluation of the conventional wisdom that environmental taxes may harm competitiveness by increasing energy costs. If anything, the results suggest that energy price increases can have net beneficial impact on firms' productivity, growth and in certain cases also profitability.

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Environmental taxes (or reduction of environmentally harmful subsidies) have broad economic benefits by reducing environmental externalities. The evidence on middle-income countries presented in this study suggest that they can also foster firm-level efficiency gains by encouraging more efficient energy use and investment in more modern equipment

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SEEDS

Only consider providing support if there is clear evidence that some sectors will not be able to adapt to the tax before losing competitiveness. A rigorous country-specific empirical assessment should provide evidence about the industries and firms that could be positively or negatively affected.

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SEEDS

- **Design taxes in a way that increases political acceptability.** Even without mitigation measures, the experience shows that good tax design can increase the chances that an environmental tax be broadly accepted, including by industries. This includes setting explicit objectives for the tax and a clear place in the government's strategy; inclusive stakeholder consultations; a gradual, predictable and credible implementation, allowing firms to adapt their investment plans; a clear communication on expected benefits (including to build public support and coalition from industries standing to benefit disproportionately) compared to potentially more costly alternatives; etc.

Journal of Productivity Analysis
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Reconciling the Porter hypothesis with the traditional paradigm about environmental regulation: a nonparametric approach

Jean Pierre Huiban[1] · Camilla Mastromarco[2] · Antonio Musolesi[3] · Michel Simioni[4,5]

Abstract

This paper estimates the impact of pollution abatement investments on the production technology of firms by pursuing two new directions. First, we take advantage of recent econometric developments in productivity, efficiency analysis and nonparametric kernel regression by adopting a conditional nonparametric frontier analysis. Second, we focus not only on the average effect but also search for potential nonlinearities. We provide new results suggesting that pollution abatement capital affects with a bell-shaped fashion technological catch-up (inefficiency distribution) and does not affect technological change (shifts in the frontier). These results have relevant implications both for modeling and for the purposes of advice on environmentally friendly policy.

Keywords Pollution abatement investments · Technology · Conditional nonparametric frontier analysis · Full and partial order frontiers · Location-scale nonparametric regression · Infinite order cross-validated local polynomial regression · Separability condition.

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Antonio Musolesi* and Massimiliano Mazzanti

Nonlinearity, heterogeneity and unobserved effects in the carbon dioxide emissions-economic development relation for advanced countries

Abstract: We study long run carbon dioxide emissions-economic development relationships for advanced countries grouped in policy relevant groups: North America and Oceania, South Europe, North Europe. By relying on recent advances on Generalized Additive Mixed Models (GAMMs) and adopting interaction models, we handle simultaneously three main econometric issues, named here as *functional form bias*, *heterogeneity bias* and *omitted time related factors bias*, which have been proved to be relevant but have been addressed separately in previous papers. The model incorporates nonlinear effects, eventually heterogeneous across countries, for both income and time. We also handle serial correlation by using autoregressive moving average (ARMA) processes. We find that country-specific time related factors weight more than income in driving the northern EU Environmental Kuznets. Overall, the countries differ more on their carbon-time relation than on the carbon-income relation which is in almost all cases monotonic positive. Once serial correlation and (heterogeneous) time effects have been accounted for, only three Scandinavian countries – Denmark, Finland and Sweden – present some threshold effect on the CO_2-development relation.

Keywords: environmental Kuznets curve; generalized additive mixed models; interaction models; semiparametric models.

JEL classification: C14, C23, Q53.

Need of reconcile different objectives: overall (macro) evidence, country evidence, etc..

Models that treat heterogeneity, semiparamatric flexible models, etc..

New Research centre CERCIS

Centre for Economic Research on Circularity, Innovations and SMEs

Funded by MIUR Dipartimenti di Eccellenza 2018-22

Two surveys on innovations and analyses
on the drivers and effects of eco innovations will be carried out

Domestically-owned firms

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	1.054***	0.386	2.575	0.340	0.184*
	(0.383)	(0.796)	(1.584)	(0.208)	(0.0980)
log(ener price) x Dom ownership	-1.048***	1.240	-0.748	-0.0875	-0.148
	(0.370)	(0.769)	(1.631)	(0.201)	(0.0952)
log(ener price) x energy exp share	-1.576	7.684	-10.48	1.362	-1.186*
	(2.615)	(5.186)	(14.35)	(1.296)	(0.671)
log(ener price) x energy exp share x	1.230	-18.82***	-17.04	-2.377	1.469*
Dom ownership	(2.891)	(5.727)	(14.84)	(1.466)	(0.757)
N	4101	3405	1962	3037	3995
Effect at 10 percentile of EI for foreign firms	1.052	0.400	2.557	0.344	0.183
Effect at 25 percentile of EI for foreign firms	1.041	0.453	2.466	0.353	0.174
Effect at 50 percentile of EI for foreign firms	1.015	0.597	2.280	0.378	0.154
Effect at 75 percentile of EI for foreign firms	0.965	0.820	2.004	0.417	0.117
Effect at 90 percentile of EI for foreign firms	0.896	1.158	1.599	0.477	0.0649

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Medium-big firms

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	0.0152	1.364***	0.484	0.295**	0.0522
	(0.273)	(0.524)	(0.969)	(0.145)	(0.0706)
log(ener price) x Medium-big firm	0.368	0.0978	2.278**	-0.0551	0.0346
	(0.275)	(0.493)	(0.953)	(0.145)	(0.0726)
log(ener price) x energy exp share	-0.125	-5.030	-16.39*	-1.195	-0.673
	(1.216)	(3.935)	(8.714)	(0.963)	(0.543)
log(ener price) x energy exp share x	-0.731	-4.316	-15.27	1.127	0.895
Medium-big firm	(2.007)	(5.925)	(10.00)	(1.203)	(0.789)
N	4101	3405	1962	3037	3995
Effect at 10 percentile of EI for small firms	0.0146	1.338	0.331	0.289	0.0489
Effect at 25 percentile of EI for small firms	0.0135	1.294	0.186	0.277	0.0429
Effect at 50 percentile of EI for small firms	0.0113	1.209	-0.0695	0.258	0.0313
Effect at 75 percentile of EI for small firms	0.00782	1.077	-0.511	0.227	0.0119
Effect at 90 percentile of EI for small firms	0.00146	0.839	-1.177	0.171	-0.0215

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Big firms

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	0.0199	1.320***	1.683**	0.243*	0.0317
	(0.238)	(0.475)	(0.810)	(0.131)	(0.0707)
log(ener price) x Big firm	0.819**	0.403	0.962	0.0758	0.152
	(0.385)	(0.599)	(1.006)	(0.181)	(0.103)
log(ener price) x energy exp share	-0.692	-6.844**	-26.25***	-0.868	0.229
	(1.156)	(3.236)	(6.913)	(0.676)	(0.566)
log(ener price) x energy exp share x	1.112	-5.078	-0.992	2.242*	-1.269
Big firm	(2.787)	(8.707)	(10.74)	(1.300)	(0.788)
N	4101	3405	1962	3037	3995
Effect at 10 percentile of EI for small firms	0.0165	1.284	1.439	0.238	0.0328
Effect at 25 percentile of EI for small firms	0.0106	1.225	1.207	0.230	0.0349
Effect at 50 percentile of EI for small firms	-0.00144	1.109	0.797	0.216	0.0388
Effect at 75 percentile of EI for small firms	-0.0210	0.929	0.0905	0.194	0.0455
Effect at 90 percentile of EI for small firms	-0.0563	0.605	-0.977	0.153	0.0568

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Quality of the business environment: time spent dealing with regulation

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	0.223	0.993**	1.807**	0.164	0.0381
	(0.254)	(0.494)	(0.799)	(0.136)	(0.0737)
log(ener price) x Little time for regulation	-0.0187	0.715	0.474	0.160	0.0473
	(0.204)	(0.437)	(0.708)	(0.112)	(0.0592)
log(ener price) x energy exp share	-0.357	-7.515**	-24.20***	0.429	0.0121
	(2.008)	(3.678)	(7.315)	(0.708)	(0.387)
log(ener price) x energy exp share x	-0.356	-0.513	-3.801	-1.641	-0.0857
Little time for regulation	(2.263)	(5.903)	(10.68)	(1.066)	(0.842)
N	4101	3405	1962	3037	3995
Effect at 10 percentile of EI for small firms	0.222	0.967	1.699	0.166	0.0381
Effect at 25 percentile of EI for small firms	0.220	0.923	1.570	0.168	0.0382
Effect at 50 percentile of EI for small firms	0.215	0.816	1.285	0.174	0.0384
Effect at 75 percentile of EI for small firms	0.205	0.618	0.760	0.184	0.0387
Effect at 90 percentile of EI for small firms	0.189	0.289	-0.149	0.203	0.0393

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Quality of the business environment: tax inspections

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	0.347	1.349***	2.198***	0.321**	0.0790
	(0.261)	(0.503)	(0.734)	(0.136)	(0.0732)
log(ener price) x No visit tax official	-0.286	0.119	-0.627	-0.102	-0.0367
	(0.201)	(0.426)	(0.672)	(0.108)	(0.0579)
log(ener price) x energy exp share	-1.322	-10.92**	-33.79***	-0.354	-0.425
	(1.688)	(5.006)	(5.579)	(0.709)	(0.353)
log(ener price) x energy exp share x	1.558	6.891	19.12**	-0.445	1.029
No visit tax official	(2.047)	(5.879)	(8.329)	(1.152)	(0.989)
N	4101	3405	1962	3037	3995
Effect at 10 percentile of EI for small firms	0.342	1.300	2.016	0.319	0.0773
Effect at 25 percentile of EI for small firms	0.334	1.235	1.837	0.317	0.0747
Effect at 50 percentile of EI for small firms	0.312	1.057	1.297	0.311	0.0677
Effect at 75 percentile of EI for small firms	0.276	0.754	0.422	0.301	0.0559
Effect at 90 percentile of EI for small firms	0.213	0.222	-1.143	0.284	0.0359

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Firms with R&D

	(1) log(tot emp)	(2) log(sales/emp)	(3) log(VA/emp)	(4) Return on sales	(5) Export share
log(ener price)	0.543	1.028	1.592*	0.427**	0.0667
	(0.501)	(0.977)	(0.880)	(0.198)	(0.127)
log(ener price) x No R&D	-0.417	0.452	-0.448	0.151	0.0202
	(0.277)	(0.516)	(1.015)	(0.155)	(0.0970)
log(ener price) x energy exp share	-1.801	-3.199	-6.345	1.023	0.0760
	(2.632)	(7.198)	(5.950)	(1.380)	(1.124)
log(ener price) x energy exp share x	2.306	2.074	-6.681	-3.182*	0.134
No R&D	(2.828)	(7.733)	(8.413)	(1.765)	(1.499)
N	2277	1861	802	1593	2167
Effect at 10 percentile of EI for small firms	0.538	1.016	1.584	0.432	0.0670
Effect at 25 percentile of EI for small firms	0.524	0.994	1.537	0.439	0.0676
Effect at 50 percentile of EI for small firms	0.493	0.939	1.428	0.456	0.0689
Effect at 75 percentile of EI for small firms	0.446	0.854	1.255	0.482	0.0709
Effect at 90 percentile of EI for small firms	0.375	0.726	1.001	0.524	0.0739

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Workers' skills

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	0.217	1.401	1.564	0.582***	0.0191
	(0.464)	(0.882)	(0.976)	(0.199)	(0.124)
log(ener price) x Low skill	0.0178	-0.236	-0.0516	-0.0361	0.0817
	(0.239)	(0.461)	(1.028)	(0.153)	(0.0768)
log(ener price) x energy exp share	0.425	-0.613	-11.61	-1.335	1.580
	(1.839)	(4.338)	(7.733)	(1.487)	(1.017)
log(ener price) x energy exp share x	-0.536	-1.354	0.445	-0.320	-2.759**
Low skill	(2.139)	(5.611)	(9.408)	(1.849)	(1.149)
N	2273	1857	802	1589	2163
Effect at 10 percentile of EI for small firms	0.219	1.397	1.512	0.573	0.0275
Effect at 25 percentile of EI for small firms	0.222	1.392	1.436	0.561	0.0410
Effect at 50 percentile of EI for small firms	0.232	1.379	1.144	0.533	0.0765
Effect at 75 percentile of EI for small firms	0.244	1.361	0.825	0.493	0.122
Effect at 90 percentile of EI for small firms	0.263	1.332	0.403	0.423	0.192

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Line of credit or loan from a financial institution

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	-0.262	1.478***	2.407***	0.190	0.00798
	(0.297)	(0.570)	(0.849)	(0.156)	(0.0922)
log(ener price) x Loan	0.915***	0.0483	-0.537	-0.0142	0.0771
	(0.226)	(0.468)	(0.748)	(0.124)	(0.0670)
log(ener price) x energy exp share	1.784	-5.172	-26.78***	-0.784	0.492
	(1.089)	(3.473)	(8.609)	(1.057)	(0.827)
log(ener price) x energy exp share x	-4.671**	-10.00	0.0683	0.225	-0.796
Loan	(2.236)	(6.458)	(10.89)	(1.374)	(0.889)
N	3551	2927	1962	2653	3449

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Has experienced at least one outage in electricity supply

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	-0.0248	1.313**	2.656***	0.232	-0.0225
	(0.264)	(0.558)	(0.887)	(0.149)	(0.0752)
log(ener price) x Outage	0.360*	0.121	-0.616	0.0409	0.142**
by banks	(0.212)	(0.467)	(0.842)	(0.119)	(0.0583)
log(ener price) x energy exp share	1.749	-3.514	-37.56***	0.584	0.696
	(1.251)	(4.064)	(8.441)	(0.625)	(0.811)
log(ener price) x energy exp share x	-3.583*	-6.667	13.01	-1.644	-1.240
Outage	(1.892)	(5.742)	(10.37)	(1.024)	(0.910)
N	4101	3405	1962	3037	3995

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Days of outage in electricity supply

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	0.219	1.281***	1.818**	0.282**	0.0805
	(0.244)	(0.482)	(0.745)	(0.127)	(0.0714)
log(ener price) x Days of outage	-0.00441	0.0116	0.0237	0.00284	0.00274
by banks	(0.0108)	(0.0203)	(0.0372)	(0.00490)	(0.00399)
log(ener price) x energy exp share	-0.206	-7.198*	-26.73***	-0.447	-0.125
	(1.013)	(3.785)	(5.322)	(0.700)	(0.611)
log(ener price) x energy exp share x	0.0166	-0.231	-0.000900	-0.118	0.0338
Days of outage	(0.0576)	(0.189)	(1.501)	(0.123)	(0.118)
N	3805	3158	1884	2830	3699

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

High income countries (WB definition)

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	0.290	0.758	1.194	0.115	0.0383
	(0.260)	(0.482)	(0.733)	(0.132)	(0.0752)
log(ener price) x energy exp share	0.00585	1.312	-8.137**	0.258	0.216
	(2.104)	(2.385)	(3.811)	(0.735)	(0.391)
N	1294	1119	262	996	1296
Effect at 10 percentile of EI	0.290	0.763	1.128	0.117	0.0389
Effect at 25 percentile of EI	0.290	0.772	1.050	0.118	0.0404
Effect at 50 percentile of EI	0.290	0.793	0.909	0.123	0.0440
Effect at 75 percentile of EI	0.290	0.827	0.618	0.129	0.0497
Effect at 90 percentile of EI	0.290	0.890	0.240	0.142	0.0592

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Upper-middle income countries (WB definition)

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	-0.348	1.920**	16.11***	1.114***	0.278*
	(0.662)	(0.960)	(4.904)	(0.391)	(0.150)
log(ener price) x energy exp share	-0.678	-14.51***	-30.49***	-1.070	-0.327
	(1.107)	(5.389)	(7.178)	(0.845)	(0.843)
N	2807	2286	1700	2041	2699
Effect at 10 percentile of EI	-0.351	1.862	15.97	1.108	0.277
Effect at 25 percentile of EI	-0.355	1.775	15.80	1.102	0.275
Effect at 50 percentile of EI	-0.365	1.570	15.41	1.087	0.270
Effect at 75 percentile of EI	-0.383	1.194	14.74	1.060	0.261
Effect at 90 percentile of EI	-0.419	0.500	13.50	1.014	0.244

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

OECD countries

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	0.336	0.911*	1.344*	0.177	0.0196
	(0.249)	(0.480)	(0.695)	(0.132)	(0.0765)
log(ener price) x energy exp share	-0.783	-1.246	-11.13***	-0.690	0.359
	(1.377)	(2.237)	(3.766)	(0.740)	(0.584)
N	2618	2125	1048	1840	2510
Effect at 10 percentile of EI	0.335	0.908	1.308	0.175	0.0202
Effect at 25 percentile of EI	0.330	0.901	1.233	0.171	0.0226
Effect at 50 percentile of EI	0.317	0.879	1.033	0.159	0.0287
Effect at 75 percentile of EI	0.296	0.847	0.706	0.141	0.0384
Effect at 90 percentile of EI	0.256	0.785	0.180	0.106	0.0565

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

Non-OECD countries

	(1)	(2)	(3)	(4)	(5)
	log(tot emp)	log(sales/emp)	log(VA/emp)	Return on sales	Export share
log(ener price)	-0.421	2.692***	16.89***	1.019***	0.321**
	(0.670)	(1.022)	(4.936)	(0.393)	(0.142)
log(ener price) x energy exp share	0.319	-25.18**	-46.25***	0.0910	-0.912**
	(1.480)	(10.71)	(5.772)	(0.856)	(0.439)
N	1483	1280	914	1197	1485
Effect at 10 percentile of EI	-0.419	2.524	16.60	1.019	0.315
Effect at 25 percentile of EI	-0.417	2.392	16.38	1.020	0.310
Effect at 50 percentile of EI	-0.413	2.061	15.89	1.021	0.298
Effect at 75 percentile of EI	-0.404	1.403	14.96	1.023	0.272
Effect at 90 percentile of EI	-0.391	0.346	13.51	1.027	0.234

Fixed effect estimator. Robust standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. Additional controls: country-specific linear trends, year-specific size class dummies, year-specific dummy for foreign owned firms

- Moving to the dependent variables that are employed to provide robust results (Appendix A), the share of production workers (*Share production workers*) and the share of skilled workers (*Share skilled workers*) are calculated using, respectively, the number of blue-collars and the number of skilled production workers divided by firm's total employees. A second group of dependent variables includes establishment's total annual sales (*sales*) and total exports (*export*).
- In order to assess whether energy prices have an effect on firms' innovative activities, the variable *R&D dummy* is equal to one if R&D activities are performed in-house or contracted with other firms. Moreover, information on the number of outages (*outage*) and their duration (*outage_days*) is included in the dataset. Finally, we also the access to loan or credit (*loan*) and the proportion of total purchase of fixed assets that was financed from private banks (*Fixed Assets*).