8 The joint effects of energy prices and carbon taxes in the French manufacturing sector

This chapter focuses on the environmental and economic effects of energy prices and carbon taxes in the French manufacturing sector.[1] Like the previous chapter, it analyses the economic effects of environmental policies alongside environmental ones, focusing here on the effect of energy taxes. These taxes are a main policy instrument to reduce energy consumption and associated carbon emissions. France is one of several OECD countries that have introduced a carbon tax, which translated into higher energy prices. The study uses a unique micro-level dataset and an instrumental variable approach to evaluate the joint effects of changes in energy prices on the French manufacturing sector. The firm-level analysis shows that a 10% increase in energy prices results in a reduction of energy use by 6%, of carbon emissions by 9% and of employment on average by 2%. However, the effect on employment differs according to the size and energy-intensity of the firm. Small and medium-sized enterprises, which stay in business after the energy price increase do not decrease their workforce. The industry-level analysis shows that there is no change in the number of jobs at the sector-level, implying that jobs are not lost but reallocated. The reason for this absence of an effect at the sector level is two opposing factors: large and energy-intensive firms reduce employment in the short run, while smaller energy-efficient firms increase employment in response to output reallocation.

Background

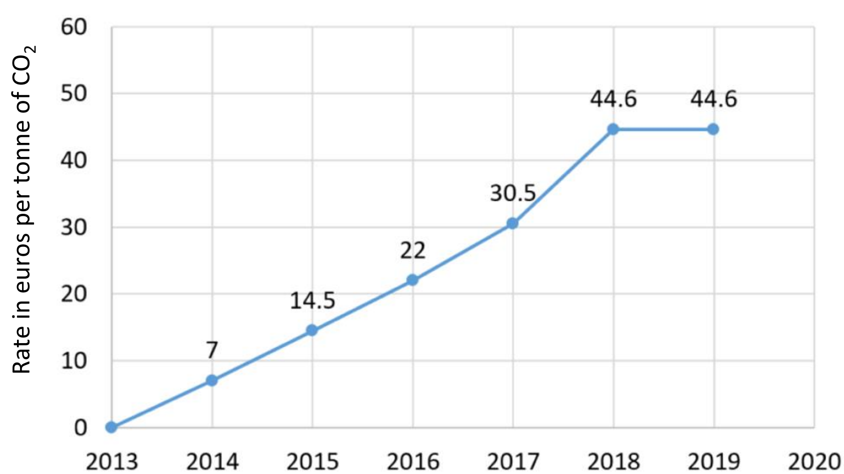
Energy taxes are a commonly used policy instrument to reduce energy use and thus carbon emissions

Among market-based environmental policy instruments, energy taxes are a common tool to incentivise reductions in energy use and thus ultimately in carbon emissions (Jacobsen, 2015[1]). While these market-based instruments are associated with lower abatement costs compared to regulatory instruments (Holland, 2012[2]) and do not interfere with consumption choices (Gayer and Viscusi, 2013[3]), they do impose real costs on consumers. Because energy taxation increases production costs, policy makers fear negative consequences for firms in terms of a reduction of output or employment from these policies.

The design of the French carbon tax

In 2013, France introduced a carbon tax. After a gradual phase-in, the carbon tax amounted to EUR 44.6 per tonne of carbon since 2019 (Figure 8.1.). Evaluating the environmental and economic impacts of this large-scale policy instrument is crucial to understand actual firm-level responses to this policy.

Figure 8.1. Evolution of French carbon tax over time (2013-19)



Note: The data are based on various French laws (article 266 quinquies B of the French customs law, the 2018 Finance Bill, and the 2019 Finance Bill).
Source: Dussaux (2020[4]).

Firms might react differently to changes in energy prices depending on their size

There are several reasons why firms' reactions to changes in energy prices are likely to differ according to the firm's size. First, large firms are more efficient than small firms not only because of economies of scale but also because they can incur the fixed cost required for energy efficiency investments. Therefore, smaller firms have more room for energy-efficiency gains than larger firms, which might not be able to reduce energy use without cutting output and thus lowering employment. Similarly, larger firms might have greater capacity to offshore or outsource part of their production in response to changes in energy prices, while small and medium-sized firms might be driven out of the market. This could imply that large firms are more affected by higher energy prices in terms of employment or output. Last but not least, small surviving firms might be able to capture the market share of other small firms that exit the market because of the energy cost increase. However, whether and by how much the effects may differ according to the size of firms remains an empirical question.

The empirical literature has so far ignored heterogeneous effects along energy-intensity and firm size

The study summarised here contributes to the literature investigating the direct effects of higher energy prices on energy use as well as to the literature evaluating joint outcomes of environmental policies more broadly. The previous literature investigating the relationship between energy prices and energy use has found non-negligible fuel and electricity price elasticities, especially in the long run (Houthakker, 1951[5]; Taylor, 1975[6]; Bohi and Zimmerman, 1984[7]; Al-Sahlawi, 1989[8]; Espey, 1996[9]; Brons et al., 2008[10]; Havranek, Irsova and Janda, 2012[11]; Labandeira, Labeaga and Lopez-Otero, 2017[12]).

This study adds to this literature by investigating the way in which firms actually reduce their energy consumption, i.e. through fuel switching, input substitution or investment in pollution abatement technologies. The literature investigating economic and environmental outcomes of changes in environmental policies (Greenstone, List and Syverson, 2012[13]; Walker, 2013[14]; Martin, de Preux and Wagner, 2014[15]; Wagner et al., 2018[16]; Flues and Lutz, 2015[17]; Gerster, 2015[18]; Petrick and Wagner, 2014[19]) finds a reduction in the use of energy inputs and thus in carbon emissions in response to tighter environmental policies, but is ambiguous regarding the effect on economic outcomes.

Firm and sector heterogeneity is often not investigated in detail and the economic outcomes considered vary across studies. The most relevant paper to the study at hand also investigates the impact of energy prices on employment and environmental performance in the French manufacturing sector for the years 1997 to 2010 (Marin and Vona, 2017[20]), but focuses only on surviving plants. Marin and Vona (2017[20]) find that a 10% increase in energy prices is related to a reduction of 6% in energy consumption, an 11% reduction in CO_2 emissions and a decrease in employment by 2.6% with a small impact on wages and productivity. The study by Marin and Vona (2017) is based on plant-level data and does not investigate firm-level responses such as real output, investment and patenting activity.

The combination of a firm-level and an industry-level analysis offers deeper insights into the mechanisms behind the effects

The study summarised in this chapter offers one of the first comprehensive, causal analyses of the effect of energy taxes by combining a firm-level with an industry-level analysis. Using a unique dataset of 8 000 French manufacturing firms from 2001 to 2016, an instrumental variable approach is used to provide a causal analysis. The study investigates multiple economic outcomes, namely output, employment, investment in terms of pollution abatement capital expenditure, and patent applications. In addition, firm-level heterogeneity is explored in terms of the energy-intensity and the size of firms. The industry-level analysis complements the firm-level analysis by taking into account reallocation effects between firms.

Empirical set-up

A causal analysis using an instrumental variable approach

The empirical analysis comprises two parts, a firm-level and an industry-level analysis. The firm-level analysis identifies firms' responses to exogenous changes in energy prices by relying on the use of the fixed-weight energy price index by Sato et al. (2019[21]) as an instrumental variable for average energy costs. Using fixed instead of average weights helps to avoid endogeneity issues associated with firms potentially being able to affect energy demand and energy prices simultaneously. Moreover, these energy prices are measured at the industry-level and can therefore be assumed to be exogenous at the firm-level.

This is not the case at the industry-level, making this analysis rely on stronger assumptions than the firm-level analysis. The strong advantage of the industry-level analysis is, however, that it is able to analyse between-firm adjustments, for example, through new firms entering the market as it is not restricted to surviving firms. The comprehensive employment data covers the whole population of French firms, thus allowing to calculate job destruction and job creation metrics, following Davis and Haltiwanger (1992[22]).

Empirical model

The following model is estimated at the firm-level for several outcome variables, using a fixed-effects, two-stage least squares estimator:

$$y_{it} = \beta_0 + \beta_1 Cost_{it-1} + \beta_2 X_{it-1} + \mu_i + \gamma_t + \varepsilon_{it}$$

where y_{it} is an outcome variable of firm *i* at time *t* (i.e. energy use, number of workers, real output, etc.). $Cost$ is the log of average energy cost measured by the ratio between energy expenditure (electricity and other energy carriers) and the purchased quantity in tonnes of oil equivalent. X is a vector of firm-level control variables, including a dummy equal to 1 when the firm is subject to the European Union Emissions Trading System and the average age of the firm's plant. These control variables are lagged by one year in order to account for the time lag firms need to adjust to new energy prices. μ_i are firm fixed effects, γ_t are year dummies and ε_{it} is the remaining error term. In order to test for heterogeneous effects across firm size, two interaction terms are added to the model, differentiating the effect by firm size and energy intensity. The average energy cost is interacted with (i) a dummy variable equal to 1, if the firm has less than 250 employees in the first year it is observed, and (ii) a continuous variable indicating the energy use per employee of the firm in the first year it is observed.

The empirical model at the industry level differs slightly from the firm-level model, with the following equation being estimated:

$$y_{kt} = \alpha_0 + \beta FEPI_{kt-1} + \lambda_t + \gamma_k + \varepsilon_{kt}$$

where y_{kt} is a job flow metric in industry *k* at time *t* (i.e. job creation rate, job destruction rate, net change in jobs), $FEPI_{kt-1}$ is the lagged fixed-weight energy price index (used as an instrument for average energy cost in the firm-level analysis), λ_t are time fixed effects, γ_k are sector fixed effects, and ε_{kt} is the remaining error term.

Data

The dataset used in this study covers 8 000 firms in the French manufacturing sector over the period 2001 to 2016. The dataset combines several databases which are managed by the French Statistical Office (INSEE): Data on energy consumption and expenditure comes from the EACEI (Enquête Annuelle sur les Consommations d'Énergie dans l'Industrie) survey, financial data from FARE (Fichier approché des résultats d'Esane) and FICUS (Fichier de comptabilité unifié dans SUSE), patent data from the PATSTAT database maintained by the European Patent Office, and pollution abatement investment data from the Antipol survey. The emission data are calculated based on the energy consumption from the EACEI survey and CO_2 emission factors from the French Environment and Energy Management Agency (ADEME). As these data are available at the plant level but the data on economic outcomes are available at the firm level, the emission data are aggregated at the firm level, ensuring that only observations are used where all plants belonging to a firm are available in the data. The dataset used for the analysis on investment, built from the Antipol survey, is smaller than the firm-level dataset for the other economic outcomes.

Results

The French carbon tax led to CO_2 reductions at the firm level

The results of the study show an average reduction of energy and fossil fuel use, as well as a reduction in CO_2 emissions and workers in response to higher energy prices (Table 8.1). A 10% increase in energy costs leads to a decrease of 5.9% in energy use and a reduction of fossil fuel use of 6.5%. The reduction in CO_2 emissions is estimated to be 9.2% and the number of workers declines by 2.2%.

In addition, no statistically significant effect is found for real output and investment. Investigating the channels through which firms react to changing energy prices shows that the energy-intensity is reduced by 5.2% in response to an increase of energy prices by 10%. There is also some statistical evidence that labour, material and capital decrease significantly less than energy use when energy prices rise, suggesting that firms reduce their energy-intensity by substituting energy by other inputs (for detailed results see Dussaux (2020[4])). The reduction in the CO_2 intensity is found to come from substituting fossil fuel use by electricity use.

It is important to note that these reductions estimated at the firm level correspond to a situation where only the energy price of the firm varies. In reality, when the price of a fuel increases in responses to an energy tax, all firms experience a change in their relative energy cost. Energy-intensive firms experience larger energy cost increases than energy-efficient firms. This relative change can lead to market share reallocations between firms. Therefore, it is not possible to extrapolate the effect of a change in the energy price at the aggregate manufacturing level simply by multiplying the estimated effect by the number of firms in a given sector. Consequently, the study also includes an analysis at the industry level that incorporates between-firm reallocations.

Table 8.1. The effect of energy prices on environmental and economic performance - main estimation results

	Environmental performance				Economic performance		
Dependent variable:	Energy use	Electricity use	Fossil fuel use	CO_2 emissions	Workers	Real output	Investment
Energy cost (ln)	-0.592***	-0.144	-0.649***	-0.920***	-0.223***	-0.077	-0.365
	(0.111)	(0.107)	(0.170)	(0.143)	(0.065)	(0.074)	(0.258)
Firm age in years	-0.030***	-0.038***	-0.014	-0.023***	-0.032***	-0.033***	0.004
	(0.007)	(0.007)	(0.009)	(0.007)	(0.004)	(0.004)	(0.012)
ETS dummy	0.019	-0.038	0.081	0.063	0.061**	0.075***	0.032
	(0.037)	(0.036)	(0.061)	(0.043)	(0.026)	(0.029)	(0.074)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry x Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	45 903	45 893	40 788	45 903	45 903	45 903	36 327
Number of firms	8 002	7 999	7 048	8 002	8 002	8002	7 168
KP LM statistic	388	388	334	388	388	388	304

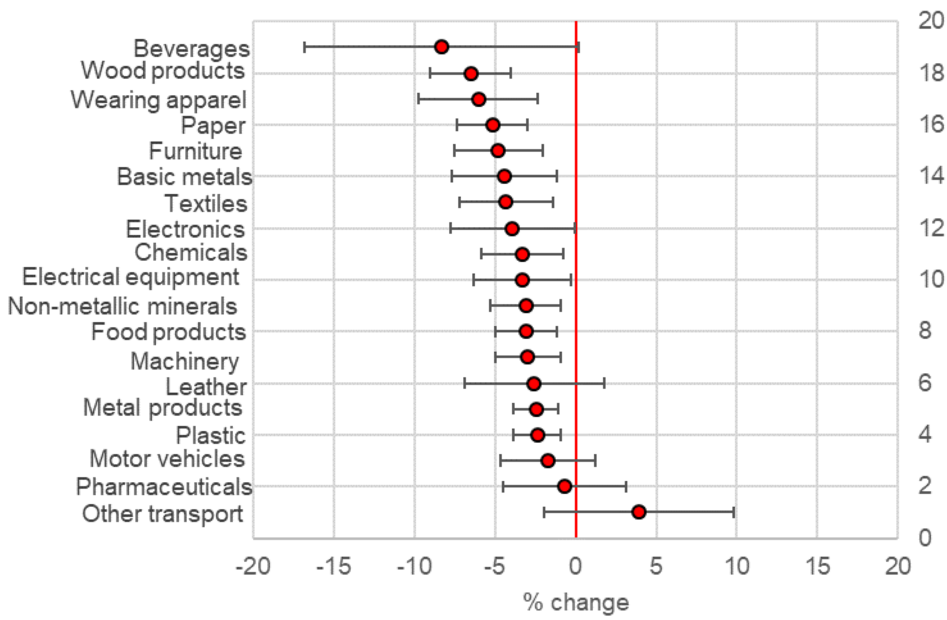
Notes: Robust standard errors clustered at the firm level in parentheses. ***, ** and * represent $p<0.01$, $p<0.05$, $p<0.1$ respectively. All outcome variables are logged. All columns are estimated with the TSLS estimator. Energy cost equals the log of the ratio between energy expenditure and energy use. The instrumental variable for average energy cost is the Fixed weight Energy Price Index (FEPI). The Kleibergen-Paap LM (KP LM) statistic is a version of the first-stage F-statistic that is robust to heteroscedasticity.

Effects differ according to firm size, their energy-intensity and the sector they operate in

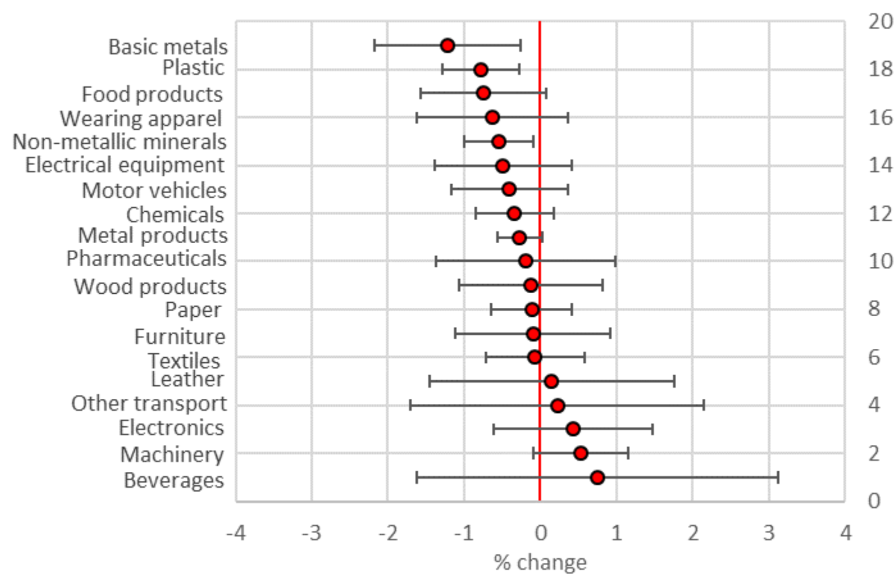
Analysing potential heterogeneous effects shows that firm responses to increasing energy prices differ significantly according to their initial size and energy-intensity (see Dussaux (2020[4]), for detailed estimation results). Energy-intensive firms react more negatively to higher energy costs in terms of both environmental and economic performance likely because the same energy cost increase penalises these firms more. Small, medium-sized and large firms react differently in terms of both environmental and economic performance. The larger the firm, the more it improves its environmental performance in response to higher energy cost. In terms of economic outcomes, large firms reduce their output by 2.6%, while medium-sized firms do not change their output. Surprisingly, small firms increase their output by 1.4%. The responses in terms of employment also differ greatly. A 10% increase in energy cost does not affect employment of small firms, but reduces it by 2.6% for medium-sized firms and by 5.5% for large firms. Allowing for heterogeneous effects at the sector level shows that firms do not reduce their CO_2 emissions or the number of employees in every sector (Figure 8.2). There are large differences between industries. 79% of the sectors experience a statistically significant reduction in CO_2, 26% reduce employment, 53% reduce CO_2 emissions but not employment, and no sector reduces employment, but not CO_2 emissions in response to higher energy prices. The largest reduction in CO_2 emissions is found for the beverages, wood products and wearing apparel sectors (Figure 8.2, Panel A). For employment, the largest changes are found in the basic metal, plastic and food products sectors (Figure 8.2, Panel B).

Figure 8.2. Changes in CO_2 emissions and workers for a 10% increase in energy cost by sector

Panel A – Change in CO_2 emissions



Panel B – Change in the number of workers



Source: Dussaux (2020).

The industry-level analysis suggests reallocation of workers instead of job losses

The industry-level analysis shows no statistically significant effects of rising energy prices on job destruction, job creation or net employment (see Dussaux (2020[4]), for estimation results). The difference compared to the results from the firm-level analysis is explained by the different sample of firms covered: The firm-level analysis only covers surviving firms while the industry-level accounts for new firms as well as firms exiting the market. An additional analysis of the study finds evidence for the hypothesis that an output reallocation between firms induced by changes in the energy price leads to a reallocation of workers between firms, especially from large energy-intensive firms to energy-efficient SMEs. The negative effect on surviving firms found at the micro level is thus offset by worker reallocation towards energy-efficient firms. This implies that while there is no average effect at the industry level in terms of employment, workers are reallocated within industries and thereby might face adjustment costs.

Robustness checks

The results are robust to many robustness checks, including using different lags of the main explanatory variables and investigating contemporaneous as well as dynamic effects of energy price variation.

Conclusion

The French carbon tax reduced emissions but also triggered a reallocation of workers

The results of the study show that climate policies, which increase energy costs, are effective in terms of carbon emission reductions but also have some small economic effects in terms of employment reallocation. Regarding the environmental effects, the firm-level analysis shows that a 10% increase in energy prices results in a decline in energy use by 6% and a reduction in carbon emissions by 9%. For the economic effects, the study finds that employment can decline for mid-sized and large firms. However, small enterprises, who stay in the market after energy prices rise, do not reduce their employment. The accompanying industry-level analysis shows that at the industry level, the total number of jobs is unaffected. This is due to two opposing effects: On the one hand, employment declines in large and energy-intensive firms and on the other hand, employment rises in energy-efficient firms (including new firms entering the market) as output is reallocated. The overall contribution of changes in energy prices to changes in employment is, however, small: changes in energy prices only triggered the reallocation of 0.25% of total manufacturing employment over the period 2005-16. In comparison, over this period, energy prices rose by 80% and manufacturing employment declined by 26%. In other words, 99% of employment reallocations within the manufacturing sector is due to factors other than changes in the energy price. These effects are, however, heterogeneous across sectors with the beverages, basic metals and wood products sectors having the largest worker reallocation caused by changes in energy prices.

An industry-level analysis of carbon emissions is not possible due to data constraints

The results of the analysis regarding reductions in carbon emissions are only based on the firm-level analysis, implying that the effect is only driven by surviving firms. Due to data limitations, an industry-level analysis of effects of increased energy cost on carbon emissions, similar to the analysis conducted for employment, is not possible. However, a net negative effect at the industry-level in terms of carbon emissions can be expected as the effect on surviving firms in the firm-level analysis is negative and because output reallocation is directed towards more energy-efficient firms in the sectors.

Tighter climate policies reduce carbon emissions, but should be accompanied by complementary labour market policies

Two important policy-relevant conclusions can be drawn from the analysis. First, tighter environmental policies, in the form of higher energy prices, can lead to employment reallocations between firms and industries. While some sectors are affected more than others, complementary labour market policies could help to absorb redistributive implications and reduce the costs for laid-off workers. Second, carbon taxes reduce carbon emissions significantly. As shown in Chapter 1, the carbon tax applied on the French manufacturing sector since 2014, which gradually increased the cost per tonne of CO_2 emission to EUR 45 in 2019 (corresponding to a 5.4% increase in energy prices), decreased carbon emissions by 5% (3.6 Mt of CO_2) with no statistically significant impact on aggregate employment. These two factors imply that there is scope for tighter unilateral environmental policies in order to achieve global climate goals and suggest that accompanying labour market policies could potentially reduce the economic impacts of these policies.

Notes

[1] The chapter is a summary of "The joint effects of energy prices and carbon taxes on environmental and economic performance: Evidence from the French manufacturing sector" (2020[4]) by D. Dussaux, published as OECD Environment Working Paper No. 154.

References

Al-Sahlawi, M. (1989), "The demand for natural gas: a survey of price and income elasticities", *The Energy Journal*, Vol. 10/1, pp. 77-90, https://www.jstor.org/stable/41322309. [8]

Bohi, D. and M. Zimmerman (1984), "An update on econometric studies of energy demand behavior", *Annual Review of Energy*, Vol. 9/1, pp. 105-154, https://doi.org/10.1146/annurev.eg.09.110184.000541. [7]

Brons, M. et al. (2008), "A meta-analysis of the price elasticity of gasoline demand. A SUR approach", *Energy Economics*, Vol. 30/5, pp. 2105-2122, https://doi.org/10.1016/j.eneco.2007.08.004. [10]

Davis, S. and J. Haltiwanger (1992), "Gross job creation, gross job destruction, and employment reallocation", *The Quarterly Journal of Economics*, Vol. 107/3, pp. 819-863, https://www.jstor.org/stable/2118365. [22]

Dussaux, D. (2020), "The joint effects of energy prices and carbon taxes on environmental and economic performance: Evidence from the French manufacturing sector", *OECD Environment Working Papers*, No. 154, OECD Publishing, Paris, https://dx.doi.org/10.1787/b84b1b7d-en. [4]

Espey, M. (1996), "Explaining the variation in elasticity estimates for gasoline demand in the United States: a meta-analysis", *The Energy Journal*, Vol. 17/3, pp. 49-60, https://www.jstor.org/stable/41322693. [9]

Flues, F. and B. Lutz (2015), "Competitiveness Impacts of the German Electricity Tax", *OECD Environment Working Papers*, No. 88, OECD Publishing, Paris, https://dx.doi.org/10.1787/5js0752mkzmv-en. [17]

Gayer, T. and W. Viscusi (2013), "Overriding consumer preferences with energy regulations", *Journal of Regulatory Economics*, Vol. 43/3, pp. 248-264, https://link.springer.com/article/10.1007/s11149-013-9210-2. [3]

Gerster, A. (2015), "Do electricity prices matter: Plant-level evidence from German manufacturing", Vol. Available at SSRN, https://ssrn.com/abstract=2603211. [18]

Greenstone, M., J. List and C. Syverson (2012), "The effects of environmental regulation on the competitiveness of US manufacturing", *NBER Working Paper*, Vol. 18392, http://dx.doi.org/doi: 10.3386/w18392. [13]

Havranek, T., Z. Irsova and K. Janda (2012), "Demand for gasoline is more price-inelastic than commonly thought", *Energy Economics*, Vol. 34/1, pp. 201-207, https://doi.org/10.1016/j.eneco.2011.09.003. [11]

Holland, S. (2012), "Emissions taxes versus intensity standards: Second-best environmental policies with incomplete regulation", *Journal of Environmental Economics and Management*, Vol. 63/3, pp. 375-387, https://doi.org/10.1016/j.jeem.2011.12.002. [2]

Houthakker, H. (1951), "Some calculations on electricity consumption in Great Britain", *Journal of the Royal Statistical Society*, Vol. 114/3, pp. 359-371, https://www.jstor.org/stable/2980781. [5]

Jacobsen, G. (2015), "Do energy prices influence investment in energy efficiency? Evidence from energy star appliances", *Jouranl of Environmental Economics and Management*, Vol. 72, pp. 94-106, https://doi.org/10.1016/j.jeem.2015.09.004. [1]

Labandeira, X., J. Labeaga and X. Lopez-Otero (2017), "A meta-analysis on the price elasticity of energy demand", *Energy Policy*, Vol. 102, pp. 549-568, https://doi.org/10.1016/j.enpol.2017.01.002. [12]

Marin, G. and F. Vona (2017), "The impact of energy prices on employment and environmental performance: Evidence from French manufacturing establishments", *Working Paper 053.2017, Fondazione Eni Enrico Mattei*, https://www.ofce.sciences-po.fr/pdf/dtravail/WP2017-26.pdf. [20]

Martin, R., L. de Preux and U. Wagner (2014), "The impact of a carbon tax on manufacturing: Evidence from microdata", *Journal of Public Economics*, Vol. 117, pp. 1-14, https://doi.org/10.1016/j.jpubeco.2014.04.016. [15]

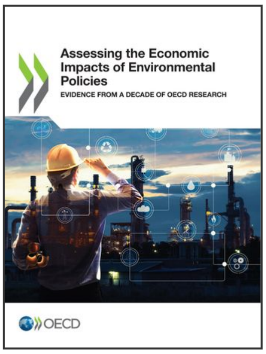
Petrick, S. and U. Wagner (2014), "The impact of carbon trading on industry: Evidence from German manufacturing (RMS)", *Kiel Working Paper*, Vol. No. 1912, https://www.econstor.eu/handle/10419/94357. [19]

Sato, M. et al. (2019), "International and sectoral variation in industry energy prices 1995-2015", *Energy Economics*, Vol. 78, pp. 235-258. [21]

Taylor, L. (1975), "The demand for electricity: a survey", *The Bell Journal of Economics*, Vol. 6/1, pp. 74-110, https://www.jstor.org/stable/pdf/3003216.pdf. [6]

Wagner, U. et al. (2018), *Emissions Trading, Firm Behavior, and the Environment: Evidence from French Manufacturing Firms*, http://conference.iza.org/conference_files/EnvEmpl2014/martin_r7617.pdf. [16]

Walker, W. (2013), "The transitional costs of sectoral reallocation: evidence from the Clean Air Act and the workforce", *The Quarterly Journal of Economics*, Vol. 1787, https://doi.org/10.1093/qje/qjt022. [14]



From:

Assessing the Economic Impacts of Environmental Policies

Evidence from a Decade of OECD Research

Access the complete publication at:
https://doi.org/10.1787/bf2fb156-en

Please cite this chapter as:

OECD (2021), “The joint effects of energy prices and carbon taxes in the French manufacturing sector”, in *Assessing the Economic Impacts of Environmental Policies: Evidence from a Decade of OECD Research*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/21167777-en