4 Induced investment through environmental policies

Investment decisions of firms are the focus of this chapter.[1] Adapting to new environmental regulations ultimately requires investment by firms. These could be investment in abatement capital or more environmentally-friendly/less polluting machines. Firms could respond by downsizing their capital investment or increasing investment and thereby modernising their capital stock. They might also shift more of their capital investment into foreign countries, circumventing stricter environmental regulations at home. The empirical literature on the investment responses of firms to stricter environmental policies has been inconclusive so far. This study sheds more light into this relationship by estimating a reduced-form model of firms' capital demand. Using sector-specific energy prices as a proxy for environmental policies, this study analyses data on over 12 000 listed firms in 30 OECD countries over the period 1995 to 2011 and is able to differentiate investment effects across sectors as well as across domestic and foreign capital investment, contributing to the empirical evidence around the so-called Pollution Haven Hypothesis. The results show that higher energy prices are associated with a small but significant decrease in total investment, though in the most energy-intensive sectors, total investment increases. Differentiating between domestic and foreign investment shows that domestic investment of all sectors is negatively correlated with increasing energy prices, indicating that energy-intensive sectors offshore some of their investment to foreign countries.

Background

Environmental policies need to incentivise investment in carbon-saving production processes

Limiting global warming to below 2°C requires significant investment into new technologies and low-carbon production processes in the manufacturing industries. Around one fifth of total greenhouse gas emissions globally are directly emitted by the industrial sector (IPCC, 2014[1]). This makes it one of the key players to reduce emissions in order to achieve the goals formulated in the Paris Agreement signed at the UN Climate Change Conference in 2015. The path to limiting global warming to (less than) 2°C implies a reduction of emissions in the manufacturing sector by 19% to 38%, depending on industry classifications and methodology (McKinsey, 2013[2]; OECD, 2012[3]). These reductions can only be achieved with substantial investment into more efficient production processes – be it in terms of energy, CO_2 or material efficiency.[2]

Environmental policies may reduce investment through output reductions

In order to design policies that incentivise low-carbon investment, policy makers need to better understand the implications of environmental policies on investment undertaken by firms. While the objective of environmental policies is to contribute to better environmental outcomes, these policies will likely affect production costs of firms and thus investment. This effect could work through the acquisition of abatement capital such as end-of-pipe technologies or through a more complex re-design of production processes towards low-carbon production, e.g. requiring new machinery investment.

The net effect on investment is unclear a priori

Whether total investment increases or decreases in response to environmental policies is unclear a priori. The theoretical literature suggests that the total effect on investment depends on the size of the downsizing and the modernisation effect (Xepapadeas and de Zeeuw, 1998[4]). On the one hand, a tightening of environmental policies might increase input costs (e.g. of energy), which lead to increased production costs and decreased output via a downsizing effect – which will eventually also affect investment. On the other hand, increased input costs such as rising energy prices might have a modernisation effect, incentivising firms to switch from old energy-intensive to new, more energy-efficient machines. Whether the reduced investment from the downsizing effect outweighs the increased investment into new capital through the modernisation effect is, however, not clear a priori.

Investment effects depend on the substitutability of inputs

The direction of the effect of increased input costs through environmental policies on total investment also depends on the substitutability between the various production inputs. Particularly energy as a production input might become more expensive in response to tighter environmental policies. If energy and capital are complements as inputs, then higher energy prices will likely lead to a reduction of energy input use and thus require less capital. If energy input and capital input are substitutes, then higher energy prices might lead to a reduction in the use of energy as an input and to an increase of capital at the same time (Constantini and Paglialunga, 2014[5]). Determining this elasticity of substitution, however, difficult as it is, depends on the modelling assumptions of production functions.

The effects on domestic and foreign investment are potentially heterogeneous

It is important to disentangle the effect of higher energy prices on domestic versus foreign investment. According to the Pollution Haven Hypothesis, tighter environmental policy might lead firms to shift their production to less stringent countries, thereby keeping production costs low but potentially keeping emissions at the same level globally. This effect might increase the foreign direct investment of firms, leading to higher investment of firms. It might, however, also come at the expense of domestic investment which could be reduced, leading to lower investment. An increase in investment might thus not imply a positive environmental outcome as emissions might just have been shifted to another country.

The literature is inconclusive so far

The empirical evidence on investment effects of environmental policies is limited and inconclusive so far (see Dlugosch and Koźluk (2017[6]) for more detail). Country-specific analyses of the United States tend to associate tighter environmental policies with a downsizing effect and thus lower investment (Greenstone, 2002[7]; Nelson, Tietenburg and Donihue, 1993[8]) while a study on Japan found support for a stronger modernisation effect (Hamamoto, 2006[9]). The only cross-country study so far focuses on European economies and finds evidence for a stronger modernisation effect for machinery, buildings and total investment (Leiter, Parolini and Winner, 2011[10]). Differentiating between investment into productive capital and pollution abatement capital (e.g. filters and scrubbers), early empirical evidence from the United States hints at a crowding-out effect of investment in pollution abatement on productive investment (Garofalo and Malhotra, 1995[11]; Gray and Shadbegian, 1998[12]) whereas more recent empirical evidence from the United Kingdom finds that total investment is unaffected, while investment into environmentally friendly technologies increased (Kneller and Manerson, 2012[13]).

This study: the first large-scale panel analysis with heterogeneous effects across sectors

This study provides the first large-scale cross-country study on the investment effects of increased environmental protection efforts. Using sector-specific energy prices as a proxy for environmental policies, this study analyses data on 12 619 listed firms in 30 OECD countries over the period 1995 to 2011, estimating a reduced-form model of firms' capital demand. While the sample only contains listed firms, the behaviour of this set of firms helps explain a major part of aggregate fluctuations (Gabaix, 2011[14]). By using sector-specific energy prices and firm-level capital investment data, this study is able to differentiate investment effects across sectors, with a special focus on clean versus dirty sectors. Furthermore, by differentiating between domestic and foreign capital investment, this study is able to investigate whether firms offshore some of their production to other countries in response to increasing energy prices, contributing empirical evidence for or against the so-called Pollution Haven hypothesis.

Empirical set-up

Capital demand derived from a three-factor production function

The empirical analysis is based on a model of the firm's optimal capital demand. A three-factor production function, where the inputs are capital, labour and energy, is used as the basis to model the firm's capital demand. As the demand for capital depends on the inputs and their respective prices (Holly and Smith, 1989[15]), a change in input prices due to changes in the business environment thus implies changes in the capital stock. These changes depend on the substitutability between inputs. The changes in energy prices could thus translate directly into changes in the capital stock.

Empirical model

Firm-level investment is measured as the ratio of capital expenditure over the capital stock. The following equation is then estimated:

$$I_{isct} = +\beta_1 \Delta EPI_{sct-1} + \sum_j \gamma_j X_{isct}^j + \sum_t \theta_t d_t + \alpha_i + \varepsilon_{isct}$$

where I_{isct} is investment defined as $I_{isct} = \frac{CE_{isct}}{K_{isct}}$, with CE_{isct} being the capital expenditure and K_{isct} the capital stock. ΔEPI_{sct-1}measures the three-year moving average of energy price changes, X_{isct} is a vector of control variables, d are year dummies, α are firm fixed effects, and ε is the error term. The indices *i* indicate firms, *s* sectors, *c* countries and *t* time. Similar to the analysis of productivity effects in Chapter 2, a three-year moving average of the energy price is used here as it is assumed that investment takes time (decision making process, implementation etc.). The control variables X include the current level of firm sales scaled by total assets as a demand proxy, as well as country-specific variables like the output gap, real interest rates, an employment protection legislation indicator (EPL), an indicator for financial development and a regulatory impact indicator (see Dlugosch and Koźluk (2017[6]) for more detail). The EPL and the financial development variables are interacted with sector-level variables (lay-off rates and dependency on external finance, respectively) in order to allow for sector-level heterogeneity of these variables.

Identification of the effect

The effect of increasing energy prices is identified through the within-firm time-series variation of investment. The firm fixed effects control for firm-specific time-invariant characteristics that might influence investment decisions and might be correlated with energy prices (such as management performance or human capital endowment effects, which might be associated with higher investment and lower energy prices). The time dummies control for global shocks, e.g. supply shocks or energy price shocks, which are correlated with both investment and energy price variation and affect all firms similarly. Once these global drivers of energy prices are controlled through the time dummies, the remaining variation in energy prices mostly reflects differences in domestic energy taxes or emission limits imposed on the energy sector (Sato et al., 2019[16]). It should be noted that firms are often able to negotiate firm-specific energy contracts, so that actual energy prices faced by firms might differ from sector-level energy prices used in the analysis. However, firm-specific energy prices would be endogenous in the estimation (because they are partly chosen by firms based on negotiations with utilities). The use of sector-specific energy prices helps to avoid this endogeneity.

Data

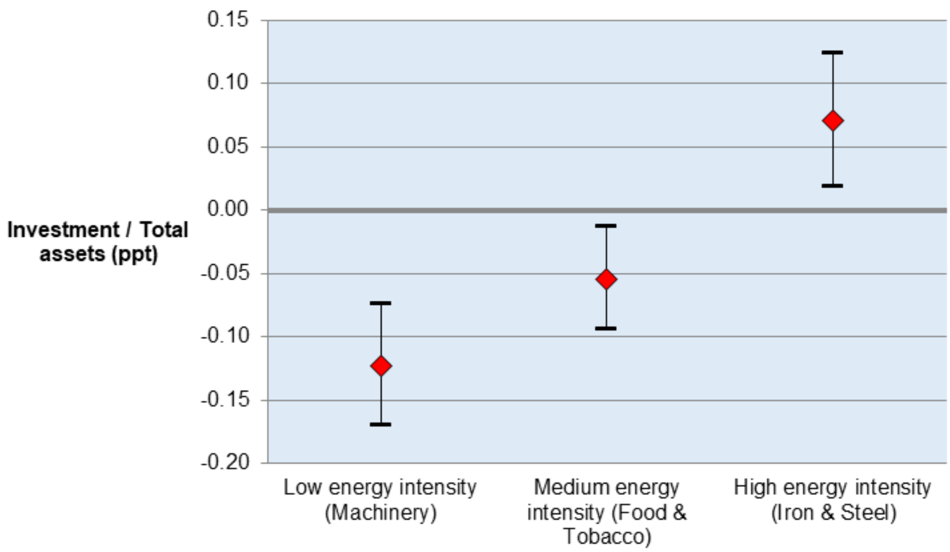
The dataset covers 30 OECD economies, 10 manufacturing sectors, spans the time period from 1995 to 2011 and consists of a total of (70 497 observations from 12 619 listed firms). The firm-level data are retrieved from Thomson Reuters Worldscope database, which compiles mandatory information from balance sheets and income statements on variables such as investment and sales. While the data are audited and thus very reliable, the dataset covers only listed firms, limiting the validity of the results to such firms. The investment figures in the dataset include investment in foreign subsidiaries, thus reflecting total investment. However, a sub-sample of the dataset also includes data on domestic investment, allowing to investigate whether effects of energy prices differ across domestic and foreign investment, shedding some light on the Pollution Haven Hypothesis (see Chapter 6 for an in-depth analysis of the Pollution Haven Hypothesis). The investment data from Worldscope are more volatile than economy-wide business investment data from the OECD STAN database, but are similar in level (and broad trends over time). Sector-specific data on energy prices are taken from Sato et al. (2019[16]). The prices are deflated and include taxes paid by industry but exclude VAT and other recoverable taxes and levies.

Results

Total investment goes down, but the effect is heterogeneous

The baseline results show support for a downsizing effect on investment. The results shown in Table 4.1 (column 1) show a statistically significant negative correlation between rising energy prices and total investment, and the control variables show the expected signs. These baseline results are, however, mainly driven by sectors that are not very energy intensive. Adding an interaction term between the sectors' energy-intensity and the change in energy prices allows investigation if there is a heterogeneous reaction of sectors. The results in Table 4.1 (column 2) show a statistically significant positive coefficient of the interaction term: the more energy-intensive the sectors are, the smaller the decrease in investment in response to higher energy prices. Figure 4.1 shows that very energy-intensive sectors even show an increase in investment in response to rising energy prices, possibly suggesting that these firms invest in more energy-efficient or abatement technologies.

Figure 4.1. Effect of higher energy prices on the investment ratio



Note: The figure shows the effect on the investment ratio associated with energy price inflation equivalent to the 75th percentile of energy price growth within the sample. This is equivalent to the difference in energy price inflation between Poland and Germany over the sample period. The authors first order countries by their average energy price inflation over time and sectors. The baseline growth in energy prices is taken as the median growth in energy prices across countries, which is equivalent to the growth in energy prices in Poland in their sample. This baseline growth in energy prices is compared with a high energy prices growth, specifically the 75% percentile, which is equivalent to growth in German energy prices over the sample. The figure can be interpreted as showing the expected annual change in the average investment ratio of Polish firms, if energy prices over the sample were to rise as fast as in Germany. Low energy-intensity refers to the machinery sector, medium energy-intensity to the food and tobacco sector and high energy-intensity to the iron and steel sector. The centre point estimate is plotted together with the 95% confidence intervals. The results are based on Table 4.1 column 2.
Source: Dlugosch and Koźluk (2017[6]).

Policy-driven price increases seem to trigger investment effect

The effects of increased energy prices on investment are likely driven by tighter environmental policies in the up-stream sector. Energy prices might not be an optimal proxy for all environmental policies as they mainly reflect environmental policies in up-stream, energy-producing sectors. The OECD's Environmental Policy Stringency Index (EPS) is thus used to decompose the energy price inflation into a policy component, which covers price increases triggered by policy changes, and a residual component, which includes all other effects triggering price increases. This decomposition is done in two steps. First, the authors regress energy price inflation on EPS growth. In a second step they re-estimate their empirical model including both the policy-driven and the residual components of changes in energy prices as explanatory variables. The results show support for the hypothesis that the investment effect is indeed driven by changes in environmental up-stream policies (Table 4.1. , column 3).

Dirty sectors are more sensitive to price changes, particularly in times of high energy price levels

The effect on investment of changes in energy prices differs with the level of the energy prices (Table 4.1. , column 4). Adding an interaction term indicating whether the energy price in a certain year lies above the sector median energy prices or not, shows that the investment effect differs for low and high levels of energy prices. For low levels of energy prices, a change in energy prices is negatively correlated with investment for energy-efficient sectors, while they do not seem to react in times when energy prices are high. Energy-intensive sectors, on the other hand, only seem to react to rising energy prices, when the energy price level is already high.

Table 4.1. Investment effects - main estimation results

Dependent variable: Investment/total assets	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline	Sector-level heterogeneity	Policy component	Level effects	Total investment where domestic available	Domestic investment
Energy Intensity * EPI Inflation (MA) $_{(t-1)}$		0.0872***			0.0648***	0.1252***
		(0.0141)			(0.0171)	(0.0402)
EPI (Inflation) (MA) $_{(t-1)}$	-0.0107*	-0.0132**			-0.0057	-0.0795***
	(0.0057)	(0.0057)			(0.0073)	(0.0216)
Energy Int. * EPI (Inflation) - Policy Part			0.0896***			
			(0.0146)			
EPI Inflation - Policy Part			-0.0108*			
			(0.0061)			
Energy Int. * EPI Inflation - Residual Part			0.0885***			
			(0.0142)			
EPI Inflation - Residual Part			-0.0114*			
			(0.0061)			
Low price level:				0.0931***		
Energy intensity * EPI Inflation (MA) $_{(t-1)}$				(0.0208)		
High price level:				0.0759***		
Energy intensity * EPI inflation (MA) $_{(t-1)}$				(0.0193)		
Low price level: EPI inflation (MA) $_{(t-1)}$				-0.0372***		
				(0.0067)		
High price level: EPI inflation (MA) $_{(t-1)}$				0.0160**		
				(0.0071)		
Observations	68,334	68,334	68,180	68,334	35,633	35,633
Adj. R2	0.412	0.413	0.4806	0.413	0.447	0.0574

Notes: All models include firm- and time fixed effects, sales over total capital, lagged out gap and lagged real interest rates, an interaction of lay-off rates and employment protection and a financial dependency control as further controls. Estimated coefficients of control variables are not shown. EPI inflation (MA) denotes the three-year moving average of changes in the energy price indicator. Energy-intensity is the share of electricity, water and gas inputs in total inputs to the production of each industry. Low and high levels are defined as being above or below the pooled median. The energy-intensity has been demeaned before application. Low energy-intensive sectors thus have a negative sign. Firm clustered standard errors in parentheses. *, **, *** denote significance at the 10, 5, and 1% level respectively.

Divestment effect of domestic investment is present for clean and dirty sectors

Re-estimating the equation for a sample of firms where total investment can be broken down into its domestic and foreign components confirms the heterogeneous effects on total investment in energy-intensive sectors. However, looking only at domestic investment, the differentiated effect among clean and dirty sectors vanishes and a negative effect of rising energy prices is found on domestic investment throughout all sectors (Chapter 1, Figure 1.8.). This suggests that firms in the overall sample tend to invest more abroad, which compensates for the decrease in domestic investment (see Chapter 6 for a more detailed analysis of the Pollution Haven Hypothesis).

Robustness checks

The results are robust to several additional checks. First, restricting the sample to the period before the financial crisis does not change the results, neither does an exclusion of US firms (as US firms represent one quarter of the sample). The results are also robust to adding country-year and sector-year fixed effects. The results also hold when estimating a dynamic (instead of a static) panel specification using a one-step system GMM estimator.

Conclusion

Energy-intensive sectors seem to offshore investment

This study finds that increasing energy prices are associated with lower total investment by firms listed on the stock market. However, this relationship differs among sectors with low and high energy-intensity. Low energy-intensive sectors show lower investment during times of increasing energy prices. Energy-intensive sectors show higher total investment when energy prices increase. These investment effects can be largely attributed to a tightening of up-stream environmental policies. One possible explanation for these results is the offshoring of investment by energy-intensive sectors. While results on domestic investment show a negative correlation with higher energy prices across all sectors, total investment in energy-intensive sectors seems to increase at the same time, hinting at more pronounced investment activities abroad.

Small firms not covered here might provide innovative technological solutions

It is important to keep the context of this study in mind when interpreting the results. The underlying sample consists only of listed (usually bigger and more established) firms. However, innovative technological solutions in response to tighter environmental policies might come from new entrants and SMEs, which are often not listed on the stock market and thus not covered in this analysis. Moreover, depreciation of capital is not considered in this study but could also be affected by more stringent environmental policies.

Additional policies might help to mitigate the estimated effect on investment

This study underlines the importance of considering general framework policies in addition to environmental policies. The results of this study show that environmental policies as such do not seem to foster investment among existing firms and might even reduce investment. However, by raising input (especially energy) costs, it is probable that these policies trigger investment in energy-saving capital on the one hand but reduce investment in other domains on the other hand, thus reducing total investment. While this study does not identify specific effects on energy-saving investments, policy makers should keep the crowding-out effect on investment in mind when considering environmental policies. Complementary policies, which reduce the cost of capital or improve general financing conditions without putting pressure on financial stability, can be helpful to mitigate such divestments.

Notes

[1] This chapter is a summary of the paper "Energy prices, environmental policies and investment – Evidence from listed firms" by D. Dlugosch and T. Koźluk, published as OECD Economics Department Working Paper No. 1378.

[2] More efficient production processes can reduce the environmental impact through at least three channels. First, processes can reduce the overall energy demand of firms, improving the energy efficiency. The carbon intensity of the energy savings determines the emission reductions. Second, firms can change energy sources for example by switching from carbon intensive coal to less carbon intensive natural gas or renewable sources of energy. This reduces the amount of carbon emissions per unit of output. Third, firms can reduce their non-energy related material inputs, for example the amount of raw materials used in production. Since the extraction, transportation and use of raw materials is often carbon intensive, improving the material efficiency can reduce carbon emissions and lower the overall environmental footprint of production.

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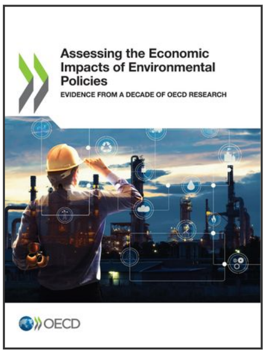

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