2 Productivity growth, environmental policies and the Porter Hypothesis

The link between environmental policies and productivity growth is the focus of this chapter.[1] New regulations often impose additional costs on firms, thereby reducing their productivity. However, new regulations might also trigger productivity increases through a redesign of production processes or a reallocation of resources within firms. This hypothesis is known as the Porter Hypothesis and has been the subject of a number of empirical studies. However, the evidence is inconclusive so far, especially at the cross-country level as a comparable measure of environmental policy stringency was missing to date. This study uses the OECD EPS indicator, a cross-country indicator for environmental policy stringency, to provide new evidence on the Porter Hypothesis. Using an extended neo-Schumpeterian productivity model, it looks at productivity developments at the industry and firm level of 17 OECD countries over the period 1990 to 2009. The results suggest that better environmental protection is associated with a short-term increase in industry-level productivity growth in countries that are considered to be at the technology frontier. The firm-level analysis shows that only the most productive firms are able to reap productivity gains while the least productive ones face a productivity decline.

Background

Environmental policies affect firms' economic performance

Over the past decades, governments implemented a range of environmental policies with the objective of protecting the environment and human health. These policies can broadly be differentiated between policies based on price mechanisms (market-based instruments) or command-and-control policies which enforce environmental standards (non-market based instruments). These policies inevitably change production processes, resource allocation within and among firms, capital investment and innovation incentives, which all affect the economic performance of firms.

Productivity increases at the firm level are possible due to previously overlooked potential gains

Environmental policies pose a burden on firms through shifting the use of resources from 'productive uses' to pollution abatement, thereby potentially lowering the productivity of firms. However, the Porter Hypothesis (PH) suggests that environmental policies might instead raise the productivity of firms. As suggested by Porter and van der Linde (1995[1]; Porter, 1991[2]), firms might see an increase of productivity through within-firm resource reallocation, efficiency improvements, a re-design of production processes or innovation. Three versions of the so-called Porter Hypothesis have been put forward (Jaffe and Palmer, 1997[3]): the weak version suggests that environmental policies stimulate innovation, the strong version states that environmental policies lead to higher overall productivity of firms, and the narrow version claims that innovation and productivity gains are more likely under adequate policies, i.e. market-based policies. This study focuses on the strong and narrow version of the Porter Hypothesis.

An industry-level analysis allows to take reallocation across firms into account

At the industry level, effects of environmental policies on industry productivity might differ from effects at the firm level, because of potential factor reallocation across firms within an industry: some firms might exit the market because they are unable to cope with the new regulation, new firms might enter with disruptive technologies, and production might be shifted away from less productive toward more productive firms. If, additionally, environmental policies were to affect market barriers to entry or trade flows, competitive pressure in the market could decline, potentially leading to a decrease in productivity.

Empirical evidence is inconclusive so far

The empirical evidence on the Porter Hypothesis has been inconclusive so far. Studies mainly focus on the strong version (productivity effect) and weak version (innovation effect) and results vary across the level of analysis (country, industry, firm level) (see Cohen and Tubb, (2017[4])2017; Koźluk and Zipperer, (2014[5]); and Ambec et al. (2013[6]), for detailed overviews). The studies often lack a cross-country dimension because comparable measures of environmental policies were not readily available. At the industry level, the literature is still inconclusive about the significance and the direction of the effect. Early work indicated a negative effect but was often characterised by context-specific set-ups and suffered from identification problems (Gray, 1987[7]; Barbera and McConnell, 1990[8]; Dufour, Lanoie and Patry, 1998[9]). More recent work is often based on longer time series and rather finds positive or no effects (Hamamoto, 2006[10]; Yang, Tseng and Chen, 2012[11]; Lanoie, Patry and Lajeunesse, 2008[12]; Franco and Marin, 2017[13]; Rubashkina, Galeotti and Verdolini, 2015[14]; Alpay, Buccola and Kerkvliet, 2002[15]). At the firm level, recent studies tend to find a negative effect of environmental regulation on productivity (Becker, 2011[16]; Gray and Shadbegian, 2003[17]). However, all of the studies focus on specific industries in a single country setting or very specific regulations, and thus lack generality.

Contribution of this study – first large-scale panel study, combining industry and firm level analysis

This study offers two main contributions to the literature. First, it is the first study to provide cross-country evidence on the strong version of the Porter Hypothesis by using the environmental policy stringency indicator (EPS) recently developed by the OECD (see Box 1.3. in Chapter 1 for details on the EPS indicator; see also Botta and Koźluk (2014[18]). This panel study thus allows a more global view on the Porter Hypothesis than the earlier single-country studies. Second, it is the first analysis of the Porter Hypothesis combining firm- and industry-level results, offering additional insights on the channels at work behind the effects. While the industry-level analysis covers aggregate effects and reallocations among firms, it might suffer from aggregation bias as some firm-level effects might cancel each other out. The firm-level analysis allows for heterogeneous effects among firms but suffers from representativeness bias and has limitations in tracking entry and exit dynamics.

Empirical set-up

An augmented neo-Schumpeterian growth model to analyse productivity effects

A standard neo-Schumpeterian model of multifactor productivity growth is used and augmented with environmental regulation. Multifactor productivity growth is modelled to be driven by a technological catch-up effect, indicating the industries' (or firms') ability to adopt the newest technologies, and a technological pass-through effect, indicating the industries' (or firms') ability to innovate (Acemoglu, Aghion and Zilibotti, 2006[19]; Aghion and Howitt, 2006[20]; Nicoletti and Scarpetta, 2003[21]). Multifactor productivity growth is then modelled to also depend on the country's environmental regulation. Following Bourlès et al. (2013[22]), this regulation is allowed to influence multifactor productivity growth in a heterogeneous way, differing with the industry's/firm's distance to the technological frontier. More technologically advanced industries and firms are assumed to be better capable of adopting new regulations as they are likely to have more (financial) resources to invest into research and development, better access to new technologies, financial markets or managerial capacity.

Heterogeneous industry effects through different exposure to country-level environmental regulation

The effect of environmental policy stringency on multifactor productivity is allowed to vary across industries, depending on their exposure to the regulation. The environmental policy variable (EPS) is measured at the country level. However, depending on the environmental dependence of an industry, the sector might be differently affected by the regulation. Therefore, the EPS variable is interacted with the pre-sample industry's pollution intensity to account for these heterogeneous effects. This approach is common in the literature analysing country-level policies and industry/firm developments and was first proposed by Rajan and Zingales (1998[23]) in the context of work on financial markets.

Empirical model

The empirical model incorporates lagged changes in environmental regulation. Instead of looking at the level of environmental policy stringency, the study focuses on regulatory changes as this is assumed to be a stronger driver for investment decisions by firms, potentially leading to productivity effects. As the effects of environmental policy changes might take time, a moving average of the past three years of changes in EPS is used to account for lagged effects in the adaptation process of firms. The following model is estimated:

$$\Delta \ln MFP_{cit} = \propto_1 + \alpha_2 \frac{1}{3}\sum_{j=1}^{3}\left(ED_{i\,1987}\Delta EPS_{ct-j}\right) + \alpha_3 gap_{cit-1}\frac{1}{3}\sum_{j=1}^{3}(ED_{i\,1987}\Delta EPS_{ct-j})$$

$$+\propto_4 gap_{cit-1} + \propto_5 \Delta \ln \widehat{MFP}_{it} + x_{cit}\gamma + \eta_t + \delta_{ci} + \epsilon_{cit}$$

where *c* indexes countries, *t* indexes years and *i* indexes industries (in the industry-level regressions) or firms (in the firm-level regressions). $\Delta \ln MFP_{cit}$ is the multifactor productivity growth for each combination of country *c* and industry/firm *i* at time *t*. ΔEPS_{ct-j} is the change in the country's environmental policy stringency, multiplied with a pre-sample measure for the industry's pollution intensity, $ED_{i\,1987}$ (see Albrizio, Koźluk and Zipperer (2017[24]) for more details). The technology gap allows for catch-up effects and is defined as the distance to the productivity frontier, $gap_{cit-1} = \ln(\frac{\widehat{\mathrm{MFP}_{\mathrm{I}}}}{MFP_{ci}})$. At the industry level, the global technology frontier is defined as the highest productivity growth rate among countries by industry and year (corrected for outliers). At the firm level, the global technology frontier is defined as the average productivity growth of the top-5% firms across countries, by industry and year. $\Delta \ln \widehat{MFP}_{it}$ is the technological pass-through, measured as the growth rate of the leader productivity. The vector x_{cit} contains country and industry-/firm-specific control variables, including the output gap, a dummy for the financial crisis, a common time trend, employment protection legislation, product market regulation, and lagged R&D expenditure over value-added. Further, a time trend η_t is included and country-industry fixed effects δ_{ci} (or alternatively country and industry fixed effects, δ_c and δ_i. Additionally, the firm level analysis controls for the total asset turnover and the firms' size as lagged log number of employees.

Data

The industry level dataset covers 17 OECD countries and 10 manufacturing sectors over the time period 1990-2009. Productivity is calculated with a Cobb-Douglas production function, based on data from the OECD Structural Analysis database (STAN) and the Database Productivity by industry (PDBi).[2] The firm level dataset covers 11 OECD countries and 22 manufacturing sectors over the time period 2000-09. The calculation of productivity data follows Wooldridge (2009[25]), using data from the OECD-ORBIS database developed by Gal (2013[26]) based on data from the Bureau Van Dijk ORBIS dataset. Data on the environmental dependence of industries, measured as pollution-intensity, are taken from the World Bank's IPPS Pollution Intensity and Abatement Cost dataset, and used for the US manufacturing sector in 1987.

Results

Support for the strong version of the Porter Hypothesis at the industry level

At the industry level, tighter environmental policies are found to be associated with a positive short-term effect on productivity growth, in countries that are close to the technological frontier (Table 2.1. , columns 1 and 2). This positive effect diminishes with the distance to the frontier and eventually becomes insignificant. Importantly, however, no industry experiences a decline in productivity growth as environmental policies become tighter. The technological catch-up term, i.e. the coefficient of the gap_{cit-1}variable, is also positive and significant, as is the MFP growth rate of the leader, indicating technological pass-through to lagging industries. In order to evaluate the magnitude of the effect of changes in EPS on industry productivity growth, marginal effects are calculated, taking into account the interaction between EPS and the technological gap of the industry to the productivity frontier. Figure 2.1 (left-hand panel) shows the marginal effects calculated for high-polluting industries for a change in EPS of 0.12 points (which corresponds to the mean in-sample change of the EPS).

Table 2.1. Porter Hypothesis - main estimation results

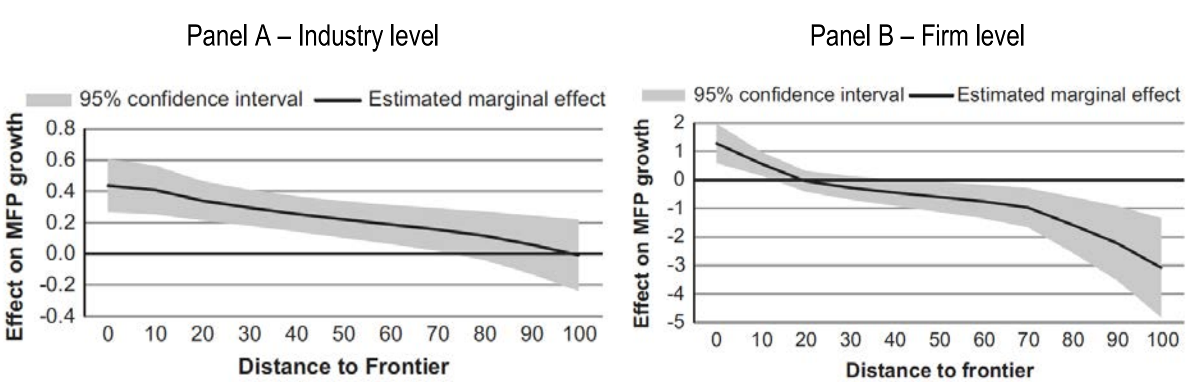
Dependent variable: MFP growth	Industry-level		Firm-level	
	1	2	3	4
EPS tightening°	0.12***	0.12***	0.34***	0.34***
	(0.02)	(0.03)	(0.08)	(0.09)
Gap * EPS tightening°	-0.15***	-0.16**	-0.15***	-0.18***
	(0.05)	(0.07)	(0.05)	(0.05)
Leader MFP growth	0.12***	0.14***	0.13***	0.16***
	(0.03)	(0.03)	(0.02)	(0.02)
Gap (t-1)	0.088***	0.16***	0.21***	0.28***
	(0.01)	(0.03)	(0.03)	(0.01)
Fixed effects				
Country*Industry	No	Yes	No	Yes
Country	Yes	No	Yes	No
Industry	Yes	No	Yes	No
N	1954	1954	1062460	1062460
Adjusted R^2	0.184	0.117	0.104	0.132

Note: All columns include the control variables discussed above, i.e. the output gap, employment protection legislation, product market regulation, R&D intensity, a crisis dummy and a year trend. The firm-level analysis (column 3 and 4) additionally includes the return on investment, firm size and asset turnover as control variables. Robust standard errors in parentheses and they are clustered at country-industry level; *** denotes statistical significance at the 1% level, ** significance at 5% level, * significance at 10% level. ° denotes the moving average of the EPS change over three-years-lags.

High-productivity firms win, low-productivity firms lose out

At the firm level, the results show a positive coefficient of the environmental policy stringency variable (Table 2.1. , columns 3 and 4). However, when calculating the marginal effect for the distribution of firms, only one fifth of the firms are able to reap productivity gains as Figure 2.1 (right-hand panel) shows. The least productive firms face a statistically significant productivity decline.

Figure 2.1. Marginal effects of increasing environmental policy stringency for high-polluting industries



Note: The annual productivity effect of a 0.12 point increase in the environmental policy stringency indicator (equal to the in-sample mean of changes in EPS) is shown for highly polluting industries. Grey bands show 95% confidence interval. The figure shows short-term effects based on the estimation results reported in Table 2.1.

Difference in industry and firm level results are likely driven by exit dynamics

While the positive effect in technologically-advanced industries might be due to a better ability to improve production technologies or a better access to financial markets, it might also result from an aggregation bias. Low-productivity firms might be driven out of the market because they are not able to adapt to the new regulation or firms might outsource emission-intensive production processes. To investigate whether less technologically advanced firms are driven out of the market or reduce their activity, the analysis uses data on the age of firms to proxy the in-sample survival of firms (for a sub-sample of firms for which this data is available). Results show that firm survival is indeed negatively correlated with the distance to the technological frontier, pointing towards a higher exit rate of the least productive firms. This indicates that the difference in industry and firm level results is indeed due to entry and exit dynamics. The most productive firms in the distribution might be more likely to be part of a multinational firm or to trade internationally, and thus have more resources and capacity to adapt to changes in environmental regulations.

The effects are independent of the level of environmental regulation but depend on policy design

The comparative stringency of environmental regulation does not have an influence on the productivity effects observed. By interacting the "change in EPS"-variable with a dummy variable indicating whether the absolute level of EPS is above or below the sample average, the analysis investigates whether a tightening of regulation has a more detrimental effect in countries with high environmental protection compared to countries taking a laxer approach. The results show no significant difference in the effect of high- versus low-regulation countries. A further analysis at the firm level differentiates the design of environmental policies into market-based and non-market based components. In line with the narrow version of the Porter Hypothesis, the results show that market-based policies are more productivity-friendly, in line with economic theory suggesting the greater cost-efficiency of price-based mechanisms.

The results are robust and potential endogeneity concerns are limited

The results of the industry- and firm-level regressions are robust to several checks, including a different definition of the environmental dependence variable, excluding fossil-fuel dependent countries[3] (as the EPS indicator is largely based on upstream regulations), and a re-estimation with a different environmental policy proxy based on a survey of the World Economic Forum which focuses on the enforcement of environmental policies. Endogeneity concerns might arise because of reverse causality or simultaneity, e.g. when poorly performing firms successfully lobby the government not to implement more stringent policies. The nature of the EPS indicator (being based largely on out-of-sample, upstream sectors) makes potential lobbying effects unlikely, while using the lagged variables mitigates simultaneity issues. Testing in a regression framework whether past changes in productivity growth are able to predict changes in the environmental policy variable shows no significant support (see Albrizio, Koźluk and Zipperer (2017[24]) for more details).

Conclusion

Summary of results

The analysis shows some support for the strong version of the Porter Hypothesis. At the industry level, the most technologically advanced country-industry pairs see a positive short-term effect of a tightening of environmental policy on their productivity. This effect declines with the distance to the technological frontier, eventually becoming insignificant for the least productive country-industry pairs. At the firm level, results show that one fifth of the firms – the most productive ones – are able to reap productivity gains. Half of the firms – the least productive ones – see a decline in their productivity following tighter environmental policy. This significant negative effect at the firm level is compatible with the industry-level results because the firm-level analysis focuses on surviving firms while the industry-level analysis also accounts for entry and exit. Environmental policies may force the least-productive firms to exit the market and trigger a reallocation of factors towards more productive or new firms. The analysis also finds heterogeneous effects depending on the design of environmental policy, in line with the narrow version of the Porter Hypothesis. Market-based environmental policies are found to be more productivity-friendly than non-market-based ones.

Limitations: Evidence is limited to OECD countries; the channels at work are not analysed

While this analysis provides one of the first large-scale studies of the Porter Hypothesis, it is still limited to OECD countries only. Extending the stringency measure would allow to include developing countries and emerging economies into the analysis. While the EPS indicator provides the most comprehensive indicator of environmental policies related to air and climate, it is not without limitations; for example, it does not account for enforcement (Chapter 1). This study is also only able to provide insights into overall effects on productivity, without being able to detect the actual channels at work behind these effects. Whether productivity increases through changes in investment patterns, entry and exit, international trade, relocation, or employment is not covered in this study (see Chapters 3 to 9 for in-depth studies of these channels).

A stronger focus on market-based policies is needed

Market-based environmental policy instruments are found to be more friendly to productivity growth than non-market instruments. Explicit price signals provide firms with higher flexibility in the abatement process, by allowing them to choose either the most suitable technology solution or the timing of the adjustment. These findings can be seen as tentative support for the idea that market-based instruments are more cost-effective than command-and-control policies, including through their effects on productivity.

Notes

[1] This chapter is a summary of the paper Albrizio, Koźluk and Zipperer (2017[24]), "Environmental policies and productivity growth: Evidence across industries and firms", Journal of Environmental Economics and Management, 81, 209-226, which originated from the OECD Working Paper "Empirical Evidence on the Effects of Environmental Policy Stringency on Productivity Growth" by Albrizio, Koźluk and Zipperer (2014[27]), OECD Economics Department Working Papers, No. 1179. Preceding work also includes the OECD Working Paper "Environmental Policies and Productivity Growth: A Critical Review of Empirical Findings" by Koźluk and Zipperer (2014[5]), OECD Economics Department Working Papers, No. 1096.

[2] The OECD's Productivity by industry (PDBi) database has been discontinued. Annual sectoral statistics on productivity growth are now available within the "Productivity and ULC by Main Economic Activity" database (https://stats.oecd.org/Index.aspx?DataSetCode=PDBI_I4).

[3] Specifically this excludes countries that have a fossil fuel electricity generation capacity share below 30%, which excludes Norway, France, Sweden and Canada in their analysis.

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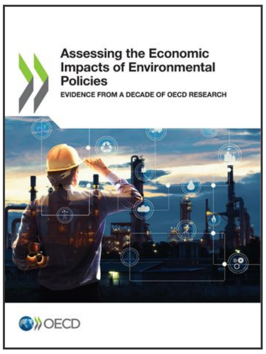

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