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Can Environmental Regulations be Good for Business? An Assessment of the Porter Hypothesis

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ABSTRACT

The Porter hypothesis asserts that polluting firms can benefit from environmental policies, arguing that well-designed environmental regulations stimulate innovation. This is achieved by increasing either productivity or product value which leads to private benefits. As a consequence, environmental regulations would benefit both society and regulated firms. This point of view has found a receptive audience among policy makers and the popular press but has been severely criticized by economists. In this paper, we present some of the arguments in this debate and review the empirical evidence available so far in the economic literature.

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INTRODUCTION

Since the early seventies, the scope of Environmental Regulations (ERs) in most developed economies has considerably broadened resulting in increased pollution control expenditures. For example, in the US, pollution abatement investments increased by 137% over the 1979-1994 period. In the early nineties, total pollution abatement costs represented between 1.5% and 2.5% of the US GDP (see Berman and Bui, 2001). The same trend has been observed in Canada where environmental protection expenditures by business increased by 27% from 1995 to 2002 (Statistics Canada, 1995 and 2002). Given the growing concern for environmental quality and the threat of climate changes, significant increases in ERs and pollution control expenditures are very likely to continue in the near future. Furthermore, ERs is especially relevant in the energy sector for it includes several "pollution intensive" industries such as petroleum or power generation.

The traditional view among economists — ERs impose private costs on regulated industries — was recently challenged by Porter (1991) and Porter and van der Linden (1995). In fact, what is now referred as the Porter Hypothesis (PH) states that stringent, well-designed ERs lead not only to social benefits but may *very often* also result in private benefits for regulated companies. Much of the controversy in this debate has centered around the "*very often*" given the general consensus that there does indeed exist cases where ERs have improved polluting firms' profit. Critics of the PH argue that such success stories are not the norm and that overall, improving environmental quality is not a "free lunch". Obviously, the policy implications of this question are potentially huge.

In Section II, we review the main arguments in this debate and present some of the theoretical foundations of the PH. In section III, we assess the empirical evidence available thus far in the economic literature. Since the controversy centered on whether there is systematic positive or negative relationship between ERs and regulated firms' performance, we ignore case studies and focus on econometric analyses.

1. BACKGROUND

Traditionally, economists believe that ERs have a negative impact on polluting firms. Several reasons justify this hypothesis, the most obvious being that ERs almost always require firms to allocate some input (labor, capital) to pollution reduction, which is unproductive from a business perspective. For example, new scrubbers installed in a power plant increase its capital stock but not its productive capacity. In other words, ERs reduce firm productivity thereby increasing cost and lowering profit.[1]

For Porter and van der Linden (1995), the traditional view has a narrow static perspective on firms' reaction to ERs. Indeed, faced with the prospect of higher abatement costs, firms will invest in innovation activities to find new ways to meet new regulatory requirements.[2] The resulting new production process or new product specifications would reduce pollution and at the same time lower production costs or increase product market value.[3] These benefits will very often offset and even exceed the costs initially imposed by regulations. Clearly, the nature of the ERs here is critical. They should be stringent enough to trigger firms to overhaul their production process, but offer firms sufficient latitude regarding how to achieve the environmental targets.[4] Figure 1 summarizes the main causal links involved in the PH.

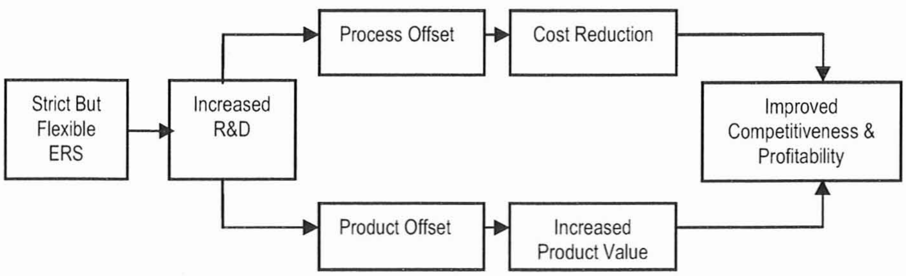

Figure 1. Schematic representation of the Porter Hypothesis

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[1] Other reasons justifying a negative relationship between ERs and productivity include: i) emission control technology may reduce the production process efficiency; ii) ERs may reduce investments if they increase energy prices, an input that is complementary to capital; iii) investments in abatement capital may crowd out productive investments; iv) stricter ERs for new plants may delay introduction of new and more productive capital.

[2] Stricter ERs may also boost R&D activities by the eco-industry *i.e.* firms specializing in the production and delivery of abatement or cleaner technology. This industry is presently booming with worldwide earning expected to reach over $700 billion by 2010 (see David and Sinclair-Desgagné, 2005).

[3] Adopting strict ERs may also be a way for a country to become a leader in developing new, cleaner exportable technologies, as other countries adopt more stringent environmental norms.

[4] It is generally admitted that economic instruments (such as emission charges or tradable permits) provide more flexibility and thereby incentives to innovate than "command and control approaches" (e.g. technological standards). Note however that the threat of imposing technological standards might enhance innovation (Cadot and Sinclair-Desgagné, 1995). Furthermore, "best-available-technology" standards may actually introduce a contest between producers of abatement technology thereby favoring R&D activities (see David and Sinclair-Desgagné, 2005).

Two main criticisms of the PH (see Palmer, Oates and Portney, 1995) are as follows: first, this hypothesis rests on the idea that firms systematically ignore profitable opportunities. In other words, why would regulation actually be needed for firms to adopt profit-increasing innovations? In fact, Porter and van der Linden directly question the view that firms are profit-maximizing entities: "The possibility of regulation might act as a spur to innovation arises because the world does not fit the Panglossian belief that firms always make optimal choices."[5]

Second, even if there are systematically-profitable business opportunities that are missed ("low hanging fruit"), the next question is how could ERs change that reality? Are bureaucrats better informed about business conditions than managers? Porter and van der Linden argue that ERs may help firms identify inefficient use of costly resources. They may also produce and disseminate new information (e.g. best practice technologies) and help overcome organizational inertia.

A few research papers have set forth formal theoretical models underlining conditions under which profit increasing projects may systematically be missed and how ERs could potentially help. A first set of explanations departs from the neo-classic profit maximizing framework. Kennedy (1994) examines the R&D investment decision of a risk-averse manager.[6] Since the outcome of the R&D program is uncertain, the manager will not choose an investment level that minimizes expected costs. He will have a tendency to under-invest in R&D as he places more weight on bad outcomes than on good ones. In this context, ERs may bring the manager's decision closer to the optimal one by affecting the marginal value of an extra dollar spent on R&D.[7] Therefore, ERs would lead to a reduction in expected costs. A necessary condition to obtain this result is that ERs increase benefits associated with good R&D outcomes more than those resulting from bad outcomes thereby, offsetting the impact of risk aversion. It is difficult to precisely access the empirical relevance of this condition. However, Kennedy's model suggests that testing for a positive relationship between ERs and R&D activities may provide some indication on the validity of the PH. As we will see below, this approach has been adopted in a few empirical works.

The booming literature on behavioural economics also offers ways to justify the PH. For example, several researches have formalized

[5] Porter and van der Linden (1995), p.99.

[6] Rather than maximizing expected profits, the manager is assumed to maximize a utility function that is concave in the level of profit.

[7] In Kennedy, ERs require that a portion α of the input x be used for abatement activities. Since the marginal value of R&D activities depends on the level of input used for production $(1-\alpha)x$, ERs affect the manager's investment decision.

procrastination behaviours by assuming that individuals have present-biased preferences: "When considering trade-offs between two future moments, present-biased preferences give stronger relative weight to the earlier moment as it gets closer".[8] In this context, good investment opportunities ("low hanging fruits") may be missed by a present-biased manager that has the tendency to procrastinate costs. A simple example can illustrate this point. Suppose that a manager has the opportunity to invest c in one period to obtain V in benefits in the next period. Traditionally, economists have assumed that investment will occur whenever $c<\delta V$ with $\delta<1$ representing the manager's discount rate. A present-biased manager is also assumed to trade-off between any two consecutive *future* periods using δ. However, when it comes to trading off between "now" or "later", he is assumed to use a different discount factor $\beta\delta$ with $\beta<1$. These "beta-delta" preferences, as they are referred in the literature, implies that when looking into the future, the manager plans to undertake every investment project such that $c<\delta V$. Yet, in reality, he only undertakes those that respect $c < \beta\delta V$. In other words, he has a tendency to continuously procrastinate projects that are such that $\beta\delta V<c<\delta V$. ERs may therefore help the manager to overcome his self-control problem.[9] Note however that if the manager is "sophisticate" (*i.e.* award of his self-control problem), he may also try to control his tendency to procrastinate by implementing incentive devices that commits his "tomorrow-self" to invest. An example of such a device could be an ISO 14001 certification which commits the firm to continuously improve its environmental performance.[10]

In the traditional profit maximizing paradigm, the PH can be explained by intra-firm inefficiencies due to asymmetric information. Ambec and Barla (2002) develop a principal-agent model with renegotiation to formalize the idea that ERs may overcome organizational inertia.[11] In their model, a manager (agent) has private information about the outcome of an R&D investment. A successful R&D program means a more productive and less polluting technology becomes available. In order to favor revelation by the agent, the shareholder (*i.e.* the principal) must offer a compensation structure with a bonus, known as "informational rent", when success is reported. To lower this rent, the principal would like to lower the agent welfare when failure is reported. Without renegotiation, this could be achieved by lowering the firm's level of production when the agent announces failure since his

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[8] O'Donoghue and Rabin, 1999, page 103. See also Akerlof, 1991 or Laibson, 1997.

[9] Obviously, the project should also improve the firm's environmental performance.

[10] See also Gabel and Sinclair-Desgagné (1998), Goldstein (2002) and Ambec and Barla (2005) for further discussions on why "behavioural" managers might miss profitable business opportunities without ERs.

[11] See also Campbell (2003) for a model where environmental regulations improve the principal's position.

remuneration is a function of output. The problem is that this distortion is not credible: the agent realizes that the principal will renegotiate *ex post* (imposing the distortion also reduces the principal *ex post* profit). By imposing limitations on production (e.g. quotas, standards) or supplementary production cost (taxes on emissions), ERs renders the production distortion credible, thereby minimizing the rent and increasing the principal *ex ante* profit. The level of R&D investment is also increased and thus cleaner technology is also more likely to be adopted.

A third set of theoretical explanations relies on inter-firm imperfect competition. In a strategic trade model, Simpson and Bradford (1996) show that a government may provide a strategic advantage to its domestic industry by imposing a strict ER. The ER acts as a commitment device for the industry to invest aggressively in R&D activities that reduce marginal costs. Once again, very specific conditions (in terms of parameters and rival behavior) are necessary to obtain the Porter result. Greaker (2003) also showed that strict ERs may improve a domestic firm's competitiveness in international markets if it transforms some of its variable costs into sunk expenditures. Interestingly, he shows that the existence of economies of scale in abatement may lead to such an outcome.

Also using an inter-firm argument but with technological spillovers, Mohr (2001) shows that coordination failure may prevent introduction of cleaner and more productive technologies. In his model, new technology productivity increases with the industry's accumulated experience. Therefore, this new technology may not be introduced because nobody wants to bear the initial learning cost. An ER forcing adoption may thus result in long-term private gains for the industry.

Xepapadeas and Zeeuw (1999) also analyze the impacts of ERs on the dynamics of capital accumulation. Specifically, they examine the effects of emission tax on the composition of capital using a vintage capital model. They show that under some conditions, an emission tax leads to retirement of older vintage capital, thereby increasing average productivity. However, despite this productivity gain, the tax negatively impacts firms' profit. Furthermore, Feichtinger *et al.* (2005) shows the opposite may also occur: an emission tax may increase the capital's average age.

From this overview of theoretical contributions, we can draw the following conclusions.[12] Justifying the PH requires either giving up the traditional profit-maximizing hypothesis or using a framework with specific conditions. Indeed, in the traditional paradigm, the Porter outcome seems to only occur when the externality associated with pollution is combined with

[12] See Ambec and Barla (2005) for a more complete description of other theoretical arguments that could be made to justify the PH.

another source of distortion (asymmetric information, market power, technological spillovers). In such a context, ERs should not only reduce pollution but also affect the other distortions in a way that improves regulated firms' profit. For example, ERs increase market power or reduce firms' agency costs. In other words, the PH requires fairly specific conditions whose prevalence should be empirically evaluated. Moreover, the type of ERs susceptible to generate the Porter outcome will depend upon the nature of the interacting distortions. For example, it is not obvious that flexible regulations are the best way to overcome organizational inertia. Next, we turn to the empirical evidence available so far.

2. EMPIRICAL EVIDENCE

While theoretical analyses underline conditions favoring the PH, its ultimate validity should be empirically evaluated.[13] Table 1 provides a basic summary of the empirical studies we considered for this review. Rather than being exhaustive, we have tried to provide an overview of the various empirical strategies that help access the PH. Most of the selected researches have been published in peer-reviewed journals. Moreover, we have privileged studies relating to the energy sector.

2.1 Impact of ERs on Innovation

The first strategy for accessing the Porter argument is to test whether strict ERs do indeed stimulate innovation. In fact, this is a necessary if not sufficient condition for the PH. Looking at a panel of US manufacturing industries for the 1973-1991 period, Jaffe and Palmer (1997) estimated a reduced-form equation to test the relationship between total R&D expenditure and pollution abatement cost (a proxy for environmental severity). Beside the abatement cost, the authors controlled the industry value added (a measure of size), a proxy for government-funded R&D within the industry and fixed effects associated with industries and years. They found that total R&D expenditure increased by 0.15% with pollution abatement cost increases of 1% (a proxy for environmental severity). Interestingly, their results suggest a somewhat larger impact for the petroleum refining and extraction industry. They did not find any statistically significant link between the number of successful patent applications by U.S. corporations (a proxy for success of R&D activities) and ERs.[14] However, Brunnermeier and Cohen (2003) report a positive but small relationship between ERs and the number of

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[13] For an earlier review see Jaffe *et al.* (1995).

[14] In this equation, they replace the government funding proxy for a variable representing the number of successful applications in a given year by foreign corporations.

environmentally-related successful patent applications.[15] Research results thus far suggest a weak positive link between ERs and innovation, but the evidence is still inconclusive given the scarcity of studies conducted on this topic. Moreover, one limitation of this approach is that even if strict ERs do not stimulate R&D activities in the regulated industry it may very well do so in the abatement equipment industry.

2.2 ERs and Productivity

Another necessary condition for profit to increase as a result of process offset is that ERs lead to productivity gains. The relationship between these two variables has long been explored by the economic literature. Two broad methodological approaches can be distinguished. Some studies derive productivity changes from the estimation of the technology that include ERs proxies as explanatory variables (for example Gollop and Robert, 1983, Alpay, Buccola and Kerkvliet, 2002). Others proceed in two steps: first, a productivity index is computed then, it is regressed on ERs proxies and other control variables (for example Dufour, Lanoie and Patry, 1998, Gray and Shadbegian, 2003). The list in Table 1 is a fairly representative sample of the results found in the literature: most studies report a negative relationship between ERs and productivity (or productivity growth). The impact may be quite important for some pollution-intensive industries. For example, Gollop and Robert (1983) found that SO_2 regulations slowed productivity growth of US electric utilities by as much as 43% in the seventies. Two studies provide some support of PH. Berman and Bui (2001) reports that refineries located in the Los Angeles area, where stringent air pollution control regulations came into effect in the late eighties, enjoyed significantly-higher productivity than other US refineries, suggesting that pollution control investments also enhanced productivity.[16] Alpay, Buccola and Kerkvliet (2002) provide somewhat similar results for the Mexican food processing industry faced with increasing environmental regulations in the nineties. Their empirical results show these increasing pressures were associated with productivity growth. They estimate that a 10% increase in pollution regulation pressure resulted in an average 2.8% increase in productivity growth. However, despite this positive impact, they show that ERs negatively affect profits. Moreover, they

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[15] They use a methodological approach similar to Jaffe and Palmer (1997). Their control variables are however somewhat different (see table 1). Using simple descriptive statistics, Landjouw and Mody (1996) and Popp (2004) also find some evidences of a positive link between patent application and environmental severity using international data.

[16] There is no obvious factor explaining this positive result. The ERs were not particularly flexible imposing emission reductions and investments in pollution control equipment.

do not find a similar pattern for the U.S. food industry. Overall, the bulk of evidence is for a negative impact of ERs on productivity. Note however that all these researches use "traditional" productivity measures *i.e.* measures that do not directly include pollution in the production process. It can easily be shown that these measures bias down productivity gains by firms or industries that improve their environmental performance (see Kolstad, 1999). While a growing literature proposes productivity indexes that include pollution as an input or an undesirable output (see for example Fare, Grosskopf, Lovell and Pasurka, 1989), these researches do not directly address the question of how ERs affect productivity.

2.3 Evidence on product offset

We did not find any studies specifically examining how ERs *per se* may have resulted in increased product value ("product offset"). However, the literature contains an increasing number of attempts to evaluate the premium consumers may be willing to pay for more environmentally-friendly products. We review some of these works in Table 1.[17] These researches indicate that products with green attributes (e.g. eco-labeled) enjoy some market advantage either through higher prices or increased market share. While these researches do not directly test the PH, they provide at least some indications on how consumers' choices may be affected by environmental concerns. Further studies are however necessary to test if consumers are also willing to pay more for products that become less polluting following the implementation of new ERs and if these premiums do translate into higher industry profits.

2.4 Impact of ERs on Investment and Capital

Theoretically, ERs may affect regulated firms costs and profits by changing their investment decisions. A few empirical contributions have addressed this question. Contrary to the modernization effect underlined by the theoretical analysis of Xepapadeas and Zeeuw (1999), Nelson *et al.* (1993) finds that ERs increase the average capital age in US electric utilities. However, this result is likely to be driven by the fact that stricter regulations are imposed on new power plants thereby slowing down investment in new facilities. For the US pulp and paper industry, Gray and Shabegian (1998) find that State ERs significantly affect technological choices and somewhat reduce investment levels. Moreover, a 1% abatement investment increase

[17] These studies develop econometrical models to measure consumers' response to environmental attributes of consumption goods. Their methodology varies depending notably upon whether actual or hypothetical choice data are analyzed.

would crowd out productive investment by 1.88%. Therefore, these results more strongly support the traditional hypothesis.

2.5 ERs and Firms' Financial Performance

Some studies have examined the impact of environmental regulation on firms' financial performance thereby directly testing for the Porter outcome. For example, Brannlund *et al.* (1995) shows that ERs reduce the short-term profit of the Swedish pulp and paper industry, while King and Lennox (2001) found evidence of a positive relationship between ER proxies and Tobin's Q using data from the US manufacturing sector. However, this latter result is only statistically significant in one of the four specifications reported in their paper. For US electric utilities, Filbeck and Gorman (2004) finds that ERs negatively impact financial returns. More research work on this link is required but, at this stage, no clear positive relationship between ERs and profitability seems to emerge.

It is also useful to mention a growing empirical literature examining the relationships between firms' environmental and financial performance. This research usually show that bad (good) unexpected news about a firm's environmental performance result in significant negative (positive) abnormal returns. If, as expected, environmental performance is positively affected by ERs, this would imply a positive impact of ERs on return. However, this conclusion may be misleading for several reasons. First, higher environmental performance may be a signal for investors of good management thereby creating an "artificial" correlation between returns and environmental results. Second, it may also signal lower than expected abatement costs. In contrast, poor environmental results are bad news for investors as they anticipate increased future liability costs and intensifying regulator scrutiny.

2.6 Evidence on the "Pollution Haven Hypothesis"

Lastly, the literature on the impact of ERs on firm location decision and cross-countries trade patterns may also be useful in accessing the PH. In fact, usually tested in the literature is the "pollution haven hypothesis," which states that strict ERs are likely to hurt the competitiveness of domestic polluting firms, thereby reducing their market share or even driving them to move to countries with less stringent regulations. Obviously, if the PH holds, one should observe no trade diversion effect and even a trade stimulating effect of ERs. Rather than reviewing this literature in detail, we can directly refer to Brunnermeier and Levinson (2004) for an up-to-date overview of this literature. Their main conclusion is the following: "The early literature based on cross-sectional analysis typically tended to find that environmental regulations did not significantly affect firms' location decisions. However, several recent studies using panel data to control for unobserved heterogeneity, or instruments to control for endogeneity, do find statistically-significant pollution haven effects of reasonable magnitude". Once again the evidence does not support the PH.

CONCLUSIONS

From this review the following conclusions can be drawn:

- There is only scanty, weak evidence to date showing that ERs stimulate innovation activity. More research is necessary to provide conclusive results regarding that relationship.
- Most evidence points towards ERs as having a negative impact on productivity growth. For pollution-intensive industries, this impact could be significant.
- There is mounting evidence that a price premium exists for more environmentally-friendly products. It remains to be established if forcing green products in the market through regulations also results in increased product value.
- The scarce evidence available suggests that ERs may have a significant negative impact on investments and increase the average age of capital.
- There is mixed evidence on the relationship between financial and environmental performance. Several studies find that investors react positively to unexpected good environmental performance. However, it is not clear whether this result actually supports the PH. Studies directly examining the impact of ERs on firms' financial performance have generated contradictory results.
- Recent studies suggest that ERs may have an impact on businesses' localization that is contrary to the PH prediction.

Overall, it appears that to date, more evidence has been reported against, than in favor of, PH. However, it would be unreasonable, at this stage, to simply reject this hypothesis. Indeed, the existing empirical research efforts are tainted with several weaknesses. First, most studies examine the impact of traditional command and control regulations, while theoretical research findings suggest that innovation activities (thus offsets) are more likely to result from incentive-based regulations. As recourse to economic instruments is expanding, future research may be able to properly address the PH. Second, more progress is required towards accessing regulation stringency.

Indeed, the proxies now used in the literature are usually crude and possibly misleading. For example, high pollution-control expenditures may not only result from ER severity, but also from poor management practices. A negative relationship between a firm's financial performance and its abatement expenditures may therefore simply reflect that inefficient firms have both higher pollution-control costs and weak financial results. A third, problem is related to the indicators used to access a firm's performance. For example, studies examining the impact of ERs on productivity usually use productivity indicators that underestimate the productivity growth rate of firms that reduce emissions. Indeed, these "traditional" measures take into account the negative effect on productivity of reducing pollution (increased use of pollution control inputs) but completely ignore the reduction of "bad outputs" that may be valuable for the firm.[18] Fourth, while the PH is in essence a dynamic hypothesis, most empirical research use empirical specification with a very simple dynamic structure or none at all. In a working paper, Lanoie *et al.* (2001) shows that allowing richer dynamic effects may drastically change the relationship between pollution control expenditure and productivity growth in the Quebec manufacturing sector. Lastly, future empirical research should take into account recent theoretical contributions showing that the Porter results require interactions of several distortions. This could help to more accurately pinpoint where to look for Porter effects.

Table 1. Empirical studies relevant for accessing the Porter Hypothesis.

Study	*Data*	*Methodology*	*Main Results*
I. Impact of ERs on Innovation			
Jaffe and Palmer (1997)	▪ Panel of U.S. manufacturing industries – 1973-1991.	▪ Reduced form model. ▪ Innovation proxy: R&D investments and number of successful patent applications. ▪ ERs proxy: Pollution control capital costs. ▪ Control variables: industry value added, a proxy for government-funded R&D within the industry, time and industry fixed effects.	▪ R&D significantly increases with ERs. Elasticity: +0.15. ▪ No significant impact of ERs on number of patents.

[18] For a firm, reducing emissions will be valuable if these "undesirable outputs" have negative shadow prices.

Study	*Data*	*Methodology*	*Main Results*
II. Impact of ERs on Productivity			
Gollop and Robert (1983)	▪ 56 U.S. electric utilities, 1973-1979.	▪ Productivity measure: derived from the estimation of a cost function that includes the ERs proxy. ▪ ERs: the intensity of SO_2 regulations based on actual emissions, state standard and the utility estimated unconstrained emission levels.	▪ ERs reduce productivity growth by 43%.
Smith and Sims (1983)	▪ 4 Canadian beer breweries, 1971-1980.	▪ Productivity measure: derived from the estimation of a cost function. ▪ Two breweries were submitted to an effluent surcharge and two breweries were not.	▪ Average productivity growth regulated breweries -0.08% compared to +1.6% for the unregulated plants.
Gray (1987)	▪ 450 U.S. manufacturing industries, 1958-1978.	▪ Change in average annual total factor productivity growth between 1959-69 period and the 1973-78 period regresses on pollution control operating costs. ▪ Control variables: occupational safety and health inspections rate, average industry share of energy and capital, change in growth rate of production workers hours and change in productivity growth rate in the sixties.	▪ 30% of the decline in productivity growth in the seventies due to ERs.

Study	*Data*	*Methodology*	*Main Results*
Dufour, Lanoie and Patry (1998)	▪19 Quebec manufacturing industries, 1985-1988.	▪ Total factor productivity growth regressed on changes in the ratio of the value of investment in pollution-control equipment to total cost. ▪ Control variables: occupational safety and health inspection rate, time and industry dummies, share of energy costs in total cost.	▪ ERs have a significantly negative impact on productivity growth rate.
Berman and Bui (2001)	▪ US petroleum refining industry, 1987-1995.	▪ Comparison of total factor productivity of California South Coast refineries (submitted to stricter air pollution regulations) with other US refineries. ▪ ERs severity is measured by the number of environmental regulations each refinery is submitted.	▪ Stricter regulations imply higher abatement costs. However, these investments appear to increase productivity.
Alpay, Buccola and Kerkvliet (2002)	▪ Mexican and U.S. processed food sectors (1962-1994)	▪ Productivity measure obtained through the estimation of a profit function that includes pollution abatement expenditures (US) and inspection frequency (Mexico) as proxies for ERs.	▪ US: negligible effect of ERs on both profit and productivity. ▪ Mexico: ERs have a negative impact on profits but a positive impact on productivity.
Gray and Shadbegian (2003)	▪ 116 U.S. paper mills, 1979-1990.	▪ Regression of total factor productivity on pollution abatement operating costs, technology and vintage dummies and interaction terms between the dummies and the abatement variable. ▪ Estimation of a production function that includes beside input prices, pollution abatement costs and other control variables.	▪ Significant reduction in productivity associated with abatement efforts particularly in integrated paper mills.

Study	*Data*	*Methodology*	*Main Results*
III. Price premiums for environmentally-friendly products			
Roe *et al.* (2001)	▪ Survey (joint analysis) 835 respondents. ▪ Cross-section of 21 green electricity products and attributes (2000)	▪ Econometric analysis of price premium for green label electricity as dependant upon demographic characteristics and product attributes.	▪ Small premium for tangible improvements in air emissions even without altering fuel mix. ▪ Significantly larger premium if reliance upon renewable fuels increases. ▪ Significant impact of eco-label.
Teils, Roe and Hicks (2002)	▪ 66 months of post-label time series obtained from scanner data in 3000 US supermarkets	▪ Impact of dolphin-safe labels on consumer purchases of tuna. Estimation of a demand system (almost ideal demand system) for canned protein market expanded to include information effects (label).	▪ Small positive impact of the label on market share.
Bjorner et al. (2004)	▪ Panel data for 1,596 Danish households from 1997 to 2001.	▪ Impact of Scandinavian environmental label (Nordic Swan) on consumer choices for toilet paper, paper towels and detergent brands. Estimation of a mixed logit model of brand selection.	▪ Statistically-significant price premium for labeled toilet paper: 13% to 18%. ▪ Premium for detergent: 17 to 29%. Small premium for paper towels (less statistically-significant results).
IV. Impact of ERs on Investments			
Nelson et al. (1993)	▪ 44 U.S. electric utilities over the 1969-1983 period.	▪ Three-equation model: i) age of capital; ii) emissions; and iii) regulatory expenditures. ▪ Model includes two ER proxies: air pollution cost and total pollution control costs per KW capacity.	▪ ERs significantly increase age of capital (elasticity: +0.15). ▪ Age of capital has no statistically-significant impact on emissions. ▪ Regulation has impacted emission levels.

Study	*Data*	*Methodology*	*Main Results*
Gray and Shadbegian (1998)	▪ Panel of 116 U.S. paper mills (1972-1990).	▪ Multinomial logit for technological choice (Kraft, sulfite, mechanical, etc.), and investment level equation. ▪ ER proxies: i) pro environmental votes by State congressional delegation; and ii) index of air and water regulation severity.	▪ Technological choice significantly affected by ERs. ▪ Negative impact of ERs on investment level (marginally significant). ▪ Productive investment is significantly reduced by abatement investments (-188%).

V. Impact of ERs on Firms' Financial Performance

Study	*Data*	*Methodology*	*Main Results*
Brannlund *et al.* (1995)	▪ 41 Swedish pulp and paper mills – 1989-1990.	▪ Estimation of regulated and unregulated profit using a non-parametric model of the technology.	▪ Average reduction in profits due to regulation -between 4% and 17%. However, between 66% and 88% of mills are unaffected by regulation.
Khanna *et al.* (1998)	▪ 91 U.S. Chemical firms over 1989-1994 period	▪ Event study: test for abnormal returns following annual disclosure of toxic release inventory. ▪ Panel regression model to identify determinants of abnormal returns. Particularly on-site/off-site releases and firm ranking within industry. ▪ Test impact of negative abnormal returns on future on-site/off-site and total releases.	▪ Negative abnormal returns during one-day period following disclosure. ▪ Abnormal losses are higher for firms that do not reduce emissions or whose performance worsens compared to other firms. ▪ Abnormal losses push firms to increase wastes transferred off-site.
Dasgupta and Laplante (2001)	▪ 126 events involving 48 publicly-traded firms in Argentina, Chile, the Philippines and Mexico	▪ Event study: test for abnormal returns following positive (investment in pollution control, awards) or negative (complaints, spills) environmental news.	▪ 20 out of 39 positive events lead to positive abnormal returns (+20% in firm value over a 11 days window) ▪ 33 of 85 negative events lead to negative abnormal returns.

Study	*Data*	*Methodology*	*Main Results*
King and Lenox (2001)	▪ Panel of 652 U.S. manufacturing firms (1987-1996). Firms must be included in the EPA's Toxic Release Inventory.	▪ Tobin's Q regressed on control variables, firms' environmental performance and proxy for ERs. ▪ ERs: number of environmental permits required and average pollution per capita in polluting industries in State of firm's operations.	▪ Positive impact of ERs on financial performance but only significant in one specification. ▪ Positive link between financial and environmental performance.
Filbeck and Gorman (2004)	▪ 24 U.S. electrical utilities 1996-1998.	▪ Impact of environmental regulation compliance index on financial returns	▪ Negative relationship between returns and environmental regulation compliance.
Gupta and Goldar (2005)	▪ 17 Indian pulp and paper plants, 15 auto firms and 18 chlor alkali firms (1999-2001).	▪ Event study: test for abnormal returns following public release of a Green Rating by an NGO. ▪ Green rating based on best practice.	▪ Negative relationship between abnormal returns and environmental rating.

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