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Stefan Ambec, Mark A. Cohen, Stewart Elgie, and Paul Lanoie

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Twenty years ago, Harvard Business School economist and strategy professor Michael Porter stood conventional wisdom about the impact of environmental regulation on business on its head by declaring that well-designed regulation could actually enhance competitiveness. The traditional view of environmental regulation held by virtually all economists until that time was that requiring firms to reduce an externality like pollution necessarily restricted their options and thus by definition reduced their profits. After all, if profitable opportunities existed to reduce pollution, profit-maximizing firms would already be taking advantage of those opportunities. Over the past 20 years, much has been written about what has since become known simply as the Porter Hypothesis (PH). Yet even today, we find conflicting evidence and alternative theories that might explain the PH, and oftentimes a misunderstanding of what the PH does and does not say. This paper provides an overview of the key theoretical and empirical insights into the PH to date, draws policy implications from these insights, and sketches out major research themes going forward.

Keywords: Porter Hypothesis, environmental policy, innovation, performance

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1. Introduction

Twenty years ago, Harvard Business School economist and strategy professor Michael Porter stood conventional wisdom about the impact of environmental regulation on business on its head by declaring that well-designed regulation could actually enhance competitiveness. According to Porter (1991), "Strict environmental regulations do not inevitably hinder competitive advantage against rivals; indeed, they often enhance it." He went on to suggest various mechanisms by which environmental regulations might enhance competitiveness, such as reduction in the use of costly chemicals or lower waste disposal costs. The traditional view of environmental regulation held by virtually all economists until that time was that requiring firms to reduce an externality like pollution necessarily restricted their options and thus by definition reduced their profits. After all, if profitable opportunities existed to reduce pollution, profit-maximizing firms would already be taking advantage of those opportunities.

Over the past 20 years, much has been written about what has since become known simply as the Porter Hypothesis (PH). Yet even today, we find conflicting evidence, alternative theories that might explain the PH, and oftentimes a misunderstanding of what the PH does and does not say. However, a careful examination of both the theory and evidence yields some important policy implications for design of regulatory instruments, as well as a rich research agenda to further understand what works, what does not, and why.

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This paper provides an overview of the key theoretical and empirical insights into the PH to date and sketches out major research themes going forward. We start in Section 2 with a brief overview of the Porter Hypothesis, as well as the variations that have been expressed in the literature. Next, Section 3 examines the theoretical developments that have taken place over the past 20 years to explain why regulation might indeed improve competitiveness. Section 4 similarly reviews the empirical evidence to date. Section 5 enters the realm of policy recommendations, by examining the implications of our knowledge on the PH for designing regulatory mechanisms that promote innovation and competitiveness. Finally, we end with a section outlining what we see to be the main research gaps that have yet to be filled in this important policy area.

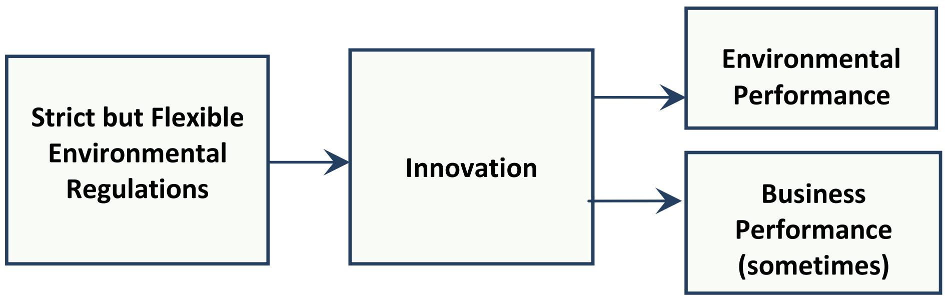
2. The Porter Hypothesis

The traditional view among economists and managers concerning environmental protection is that it comes at an additional cost imposed on firms, which may erode their global competitiveness. Environmental regulations (ER) such as technological standards, environmental taxes, or tradable emissions permits force firms to allocate some inputs (labor, capital) to pollution reduction, which is unproductive from a business perspective. Technological standards restrict the choice of technologies or inputs in the production process. Taxes and tradable permits charge firms for their emissions pollution, a by-product of the production process that was free before. These fees necessarily divert capital away from productive investments.

This traditional paradigm was challenged by a number of analysts, notably Professor Michael Porter (Porter 1991) and his coauthor Claas van der Linde (Porter and van der Linde 1995). Based on case studies, the authors suggest that pollution is often a waste of resources and that a reduction in pollution may lead to an improvement in the productivity with which resources are used. More stringent but properly designed environmental regulations (in particular, market-based instrument such as taxes or cap-and-trade emissions allowances) can "trigger innovation [broadly defined] that may partially or more than fully offset the costs of complying with them" in some instances (Porter and van der Linde 1995, 98).

Figure 1 summarizes the main causal links involved in the PH. As Porter and van der Linde first described this relationship, if properly designed, environmental regulations can lead to "innovation offsets" that will not only improve environmental performance, but also partially—and sometimes more than fully—offset the additional cost of regulation.

Figure 1. Schematic Representation of the Porter Hypothesis



Porter and van der Linde go on to explain that there are at least five reasons that properly crafted regulations may lead to these outcomes:

- First, regulation signals companies about likely resource inefficiencies and potential technological improvements.
- Second, regulation focused on information gathering can achieve major benefits by raising corporate awareness.
- Third, regulation reduces the uncertainty that investments to address the environment will be valuable.
- Fourth, regulation creates pressure that motivates innovation and progress.
- Fifth, regulation levels the transitional playing field.

Finally, they note, “We readily admit that innovation cannot always completely offset the cost of compliance, especially in the short term before learning can reduce the cost of innovation-based solutions” (Porter and van der Linde 1995, 100).

The Porter Hypothesis has met with great success in political debate, especially in the United States, because it contradicts the idea that environmental protection is always detrimental to economic growth. The PH has been invoked to persuade the business community to accept environmental regulations, as it may benefit from them in addition to other stakeholders. In a nutshell, well-designed environmental regulations might lead to a Pareto improvement or “win–win” situation in some cases, by not only protecting the environment, but also enhancing profits and competitiveness through the improvement of the products or their production process or through enhancement of product quality.

The PH has been criticized for being incompatible with the assumption of profit-maximizing firms (see Palmer et al. 1995). Indeed, the hypothesis rests on the idea that firms often ignore profitable opportunities. In other words, why would regulation actually be needed for firms to adopt profit-increasing innovations? In fact, Porter directly questions the view that firms are profit-maximizing entities: "The possibility that regulation might act as a spur to innovation arises because the world does not fit the Panglossian belief that firms always make optimal choices." As discussed below, firms might not appear to be making optimal choices for many reasons, such as imperfect information or organizational or market failures.

Moreover, even if systematically profitable business opportunities are missed ("low-hanging fruits"), the next question is, how could environmental regulations change that reality? Are regulators in a better position than managers to find these profitable business opportunities? Porter argues that environmental regulation may help firms identify inefficient uses of costly resources. They may also produce and disseminate new information (e.g., best-practice technologies) and help overcome organizational inertia.

There is much confusion in the literature about what the Porter Hypothesis actually says. As we note above, it does *not* say that all regulation leads to innovation—only that well-designed regulations do. This is consistent with the growing trend toward performance-based and/or market-based environmental regulations. Second, it does *not* state that this innovation necessarily offsets the cost of regulation—that is, it does not claim that regulation is *always* a free lunch. Instead, it does make the claim that in many instances, these innovations will more than offset the cost of regulation—in other words, there may be a free lunch in many cases.

Previous authors have disaggregated the PH into its component parts in order to test the theory and evidence. First (as shown in the first two boxes of Figure 1), properly designed environmental regulation may spur innovation.[1] This has often been called the "weak" version of the PH (see Jaffe and Palmer 1997), because it does not tell us whether that innovation is good or bad for firms. Of course, the notion that regulation might spur technological innovation is not a new idea in economics and would not itself have brought about such controversy. The second part of the PH (the lower right-hand side of Figure 1) is that this innovation often more than offsets any additional regulatory costs—in other words, environmental regulation often leads to

[1] Actually, the notion that regulation could spur technological innovation follows from the notion of induced innovation, which goes back to Hicks (1932).

an increase in firm competitiveness. This is often called the “strong” version of the PH. (Note, however, that the PH never goes so far as to suggest that environmental regulation will *always* lead to either innovation or increased competitiveness, but the authors say that it is probable.) Finally, in what has been called the “narrow” version of the PH, it is noted that flexible regulatory policies give firms greater incentives to innovate and thus are better than prescriptive forms of regulation. Indeed, Porter challenges regulators to examine the likely impacts of their actions and choose regulatory mechanisms that will foster innovation and competitiveness, particularly economic instruments. Thus, the PH is as much a normative prescription for regulatory policy as it is a positive assessment of current policy.

3. New Developments in the Theory

This controversy gave rise to an abundant economics literature on the theoretical bases underlying the Porter Hypothesis over the last 20 years. A sample of this literature is summarized in Appendix. We can distinguish between two approaches. A first set of papers departs from the assumption of profit-maximizing firms in light of the emerging organizational and behavioral economics literature. The rationality of the firm is driven by its manager, who has motivations and objectives other than profit maximization. He or she might be risk-averse (Kennedy 1994), resistant to any costly change (Aghion et al. 1997; Ambec and Barla 2007), or rationally bounded (Gabel and Sinclair-Desgagné 1998). He or she therefore misses good investment opportunities (from the point of view of the firm’s profit) because they are too risky, too costly (for the manager but not for the firm), or out of the manager’s habits and routines. In Ambec and Barla (2006), the manager has present-biased preferences that make her or him procrastinate on profitable but costly investment opportunities (“low-hanging fruits”). Because the cost of innovating is for “now” while the benefit is “later,” a present-biased manager will tend to postpone any investments in innovation. By making those investments more profitable or requiring them, environmental regulations help the manager overcome this self-control problem, which enhances firm profits.[2]

A second set of papers reconciles the PH with profit maximization by assuming a “market failure.” Under imperfect interfirm competition, Simpson and Bradford (1996) show that a government may provide a strategic advantage to its domestic industry by imposing a more

[2] See also Chowdhury (2010) and Kriechel and Ziesemer (2009) on timing issues.

stringent environmental regulation. Also, with imperfect competition but differentiated products, André et al. (2009) show that a minimum standard for environmental product quality might benefit all firms by solving a coordination problem—allowing them to reach a Pareto-improving equilibrium. Mohr (2002) and Mohr and Saha (2008) provide a similar coordination failure argument with technological spillovers. When the return on a firm's R&D investment is partly captured by its competitors, firms underinvest in cleaner and more productive technologies. An environmental regulation forcing adoption may thus switch the industry from an equilibrium with low investment in R&D to a Pareto-improving equilibrium with higher investments in R&D.[3] Greaker (2003) also relies on technological spillovers as a market failure to provide a theoretical foundation to the PH, but with an upstream market for innovation. In the same vein, Xepapadeas and Zeeuw (1999) analyze the impact of environmental regulations on the dynamic of capital. They show that an emissions tax may lead to retirement of older vintage capital, thereby increasing average productivity. [4] However, despite this productivity gain, the impact on profit is negative in their study. In a related paper, Popp (2005) argues that uncertain returns to R&D can reconcile the notion that in specific cases, researchers observe complete offsets of environmental regulation, while economywide studies typically find a net cost to environmental regulation. Because the returns to R&D are highly skewed, some innovations will result in significant cost savings even if the average innovation does not.

A related approach relies on an "organization failure" to reconcile the PH with a profit-maximizing firm. It formalizes Porter's idea that environmental regulation may overcome organizational inertia. In Ambec and Barla (2002), informational asymmetries on technologies inside the firm might support the PH. Managers have private information about the real costs of new technologies that enhances both productivity and environmental performance. They use information opportunistically by exaggerating these costs, thereby extracting some rent from the firm. By imposing environmental regulation, the government lowers the rent managers extract to the benefit of the firm. The regulation is profitable for the firm when the rent saved offsets the cost of complying with the regulation. It helps the head of the firm to foster technological innovation at lower organizational costs.

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[3] For a counterargument, see Gans (2010), who shows that more stringent climate change policies will not necessarily lead to more innovation. Indeed, it is demonstrated that a tighter emissions cap will reduce the scale of fossil fuel usage, and this effect will diminish incentives to improve fossil fuel efficiencies.

[4] Notice that Feichtinger et al. (2005) show that the opposite may occur: an emissions tax may increase the capital's average age.

4. The Empirical Evidence

Many researchers have attempted to test the Porter Hypothesis empirically. Three approaches emerge from this empirical literature. The first intends to analyze the "weak" version of the PH—the link between the intensity of environmental regulation and innovation (that is to say, the first link in the chain described in Figure 1). Operationally, innovation is generally assessed through R&D expenses (input) or through the number of registered patents (the product of R&D activity). However, as Porter and van der Linde (1995, 98) make clear, innovation is not just technological change and can take various forms, including "a product's or service's design, the segments it serves, how it is produced, how it is marketed and how it is supported."

A summary of many of these studies is contained in the Appendix (adapted and updated from Ambec and Barla 2006; Ambec and Lanoie 2008). As an illustration of this first set of papers, Jaffe and Palmer (1997) estimate the relationship between total R&D expenditures (or the number of successful patent applications) and pollution abatement costs (a proxy for the stringency of environmental regulation). They find a positive link with R&D expenditures (an increase of 0.15% in R&D expenditures for a pollution abatement cost increase of 1%), but no statistically significant link with the number of patents. However, restricting themselves to environmentally related successful patents, Lanjouw and Mody (1996), Brunnermeier and Cohen (2003), Popp (2003, 2006), Arimura et al. (2007), Johnstone et al. (2010b), and Lanoie et al. (2010) find a positive relationship with environmental regulation. Furthermore, Johnstone et al. (2010a) examine not only the impact of the stringency of environmental policies, but also the impact of their stability and flexibility (as measured by the World Economic Forum Survey). Evidence is found that both stability and flexibility have distinct effects on innovation beyond that of policy stringency.

For the firm's technological choices, two older studies emphasize a negative relationship between environmental regulations and investment in capital. Nelson et al. (1993) find that air pollution regulations significantly increased the age of capital in the U.S. electric utilities in the seventies. As discussed later, however, this finding might not be surprising given the fact that U.S. regulations imposed more stringent requirements on new sources—likely an example of regulations that are not well designed to encourage innovation. According to Gray and Shadbegian (1998), more stringent air and water regulations have a significant impact on paper mills' technological choice in the United States. However, their results suggest that such regulations tend to divert investment from productivity to abatement, consistent with the standard paradigm.

Altogether, these works deduce that there is a positive link, although varying in strength, between environmental regulation and innovation.

The second empirical approach assesses the impact of environmental regulation on the business performance of the firm (the link between the first and last steps in the chain described in Figure 1). The "strong" version of the Porter Hypothesis is tested, however, without looking at the cause of this variation in performance (whether it is linked to innovation or to another cause). The firm's business performance is often measured by its productivity.

This second approach has a long tradition in the economics literature (see Jaffe et al. 1995 for a review). The second half of the Appendix lists many of these studies. Most papers reviewed in Jaffe et al. (1995) highlight a negative impact of environmental regulation on productivity. For instance, Gollop and Roberts (1983) estimate that SO_2 regulations slowed down productivity growth in the United States in the 1970s by 43%. However, several more recent papers find more positive results. For example, Berman and Bui (2001) report that refineries located in the Los Angeles area enjoyed a significantly higher productivity than other U.S. refineries despite a more stringent air pollution regulation in this area. Similarly, Alpay et al. (2002) estimate the productivity of the Mexican food-processing industry to be increasing with the pressure of environmental regulation. They therefore suggest that a more stringent regulation is not always detrimental to productivity.

Lanoie et al. (2010) combine both approaches, assessing for the first time the whole Porter causality chain. The data come from a unique OECD survey carried out with more than 4,000 companies located in seven industrialized countries. The method consists of assessing three equations by proceeding in two stages with adequate instruments ("two-stage least squares"). Following Figure 1, the three dependent variables are environmental innovation, environmental performance, and business performance. The results first show a positive and significant link between the perceived severity of environmental regulations and environmental innovation; this is consistent with the weak version of the PH. Furthermore, the "predicted" environmental innovation from the first regression has a positive and significant impact on business performance. This provides evidence of the causal link suggested by the strong form of the PH—that regulation spurs innovation, which further enhances business performance. However, Lanoie and colleagues also note that environmental regulation has a direct negative effect on business performance. On balance, they find that the net effect is negative—that is, the positive effect of innovation on business performance does not outweigh the negative effect of the regulation itself. In brief, regulation appears to be costly—but less so than if one were to consider only the direct costs of regulation itself.

One important caveat to this negative finding is that most previous studies have not adequately taken into account the dynamic dimensions of the Porter Hypothesis. Porter argues that more stringent environmental policies will lead to innovations to reduce inefficiencies, and this, in turn, will eventually reduce costs. This process may take some time. In previous studies on the determinants of productivity, researchers have often regressed productivity at time 0 on proxies of environmental regulation stringency at time 0 as well, which does not allow time for the innovation process to occur. By introducing lags of three or four years between changes in the severity of environmental regulations and their impact on productivity, Lanoie et al. (2008) have found that stricter regulations led to modest long-term gains in productivity in a sample of 17 Quebec manufacturing sectors—first reducing productivity in year one, having a slightly positive effect in year two, and then resulting in more positive outcomes in years three and four—more than offsetting the first year's loss. Furthermore, they show that this effect is more important in industries highly exposed to outside competition. Further research should focus on these more dynamic impacts.

A third approach to evaluating the PH is to examine competition among nations—which returns to the original hypothesis of Porter that environmental regulation will enhance a country's competitiveness. Much of the empirical literature turns the issue on its head, examining the "pollution haven" hypothesis—that stringent environmental regulation will induce firms to leave the country for less strict (and hence, less expensive) regulatory regimes. The PH would suggest just the opposite. Of course, firms might move polluting facilities abroad for other reasons, such as access to markets or differences in the cost of labor, land, transportation, and other inputs (not just pollution).

Much of the earlier literature on the pollution haven hypothesis found a positive impact—industries with more stringent regulations (generally proxied by higher pollution abatement costs) had less net trade flows—consistent with the PH. However, as Copeland and Taylor (2004) and Brunnermeier and Levinson (2004) explain in their literature reviews, both endogeneity and unobserved variables that are correlated with regulation may explain these results. Indeed, they cite more recent literature accounting for these issues and conclude that while much work still needs to be done, the weight of the evidence supports the pollution haven hypothesis. Nevertheless, the magnitude of this effect does not appear to be "strong enough to be the primary determinant of the direction of trade or investment flows" (Copeland and Taylor 2004, 48). Perhaps more important from the perspective of the PH, few of these studies have been able to distinguish among the types of regulatory mechanisms employed; instead, they often use pollution control costs or emissions levels (see, e.g., Quiroga et al. 2009) as proxies of regulatory stringency. Although these might be reasonable measures of stringency, we do not know whether countries with more stringent policies are using “good” or “bad” forms of environmental regulation.

5. Design of Policies to Enhance Competitiveness

It is clear from both the original Porter writings and empirical evidence to date that both innovation and competitiveness outcomes depend significantly on the context. The PH itself was premised on flexible, market-based regulation—not rigid command-and-control regulation. Beyond environmental regulations, other government policies can interact with the link between environmental regulation and innovation or competitiveness. In this section, we briefly explore the implications of policy design for the PH.

Environmental Policies

As mentioned by Porter, the type of regulatory instrument is an important premise of the PH. As Porter and van der Linde (1995, 110) argue:

> If environmental standards are to foster the innovation offsets that arise from new technologies and approaches to production, they should adhere to three principles. First, they must create the maximum opportunity for innovation, leaving the approach to innovation to industry and not the standard-setting agency. Second, regulations should foster continuous improvement, rather than locking in any particular technology. Third, the regulatory process should leave as little room as possible for uncertainty at every stage.

Market-based and flexible instruments such as emissions taxes or tradable allowances, or performance standards, are more favorable to innovation than technological standards, because they leave more freedom to firms on the technological solution to minimize compliance costs. Some authors, like Jaffe and Palmer (1997), refer to that as the narrow version of the PH. In this vein, Burtraw (2000) provides evidence that the switch in environmental regulations for SO_2 emissions in the United States from a technological standard with emissions caps to an allowance trading program in 1990 considerably reduced compliance cost (40% to 140% lower than projection)—although the net effect was still a net cost. However, the switch to an emissions cap enhanced innovation and fostered organizational change and competition on the upstream input market. The program left enough flexibility for the firm to select the best strategy for reducing emissions, including a switch to coal with lower sulfur content. The industry also experienced innovation in fuel blending and in the scrubber market.[5] In addition, the switch from a technological standard to tradable emissions allowances led to a transfer of responsibility from engineers or chemists, typically in charge of environmental issues, to top executives such as financial vice presidents, who are trained to treat SO_2 emissions allowances as financial assets.

Along the same lines, Hoglund Isaksson (2005) looks at the impact of a charge on nitrogen oxides (NO_x) emissions introduced in Sweden in 1992. She examines the impact on abatement cost functions of 114 combustion plants during the period 1990–1996. Her findings suggest that extensive emissions reductions have taken place at zero or very low cost, and that effects of learning and technological development in abatement have been present during the analyzed period.

Lanoie et al. (2010), described above, also provides indirect evidence on this issue, showing that performance standards are leading to more innovation than do more prescriptive technological standards. Driesen (2005, 303) reviews the literature and argues that "pollution taxes have a greater potential to promote innovation than either emissions trading (at least when permits are given away, rather than sold) or traditional regulation. For him, both emissions trading and performance standards produce incentives only to attain the standards government sets, rather than to go further. While trading does provide incentives for low cost sources to produce some 'extra' credits, it does so only to the extent that high cost sources need credits to meet their limits. Once the high cost sources have purchased enough credits to attain their limits, no further incentive to go beyond compliance exists. Pollution taxes, however, provide a continuous incentive for polluters to deploy innovations costing less than the marginal tax rate."

Furthermore, if market-based instruments generate revenues (e.g. from taxes or permit auctioning), then the efficient recycling of those revenues can improve competitiveness outcomes. For example, Andersen et al. (2007) analyzes environmental tax revenues in seven EU countries that are recycled into other tax cuts (labor or income) and finds that the result is a neutral or slightly positive net impact on GDP.

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[5] The former command-and-control regulation did not provide incentives to increase SO_2 removal by scrubbers from more than the 90% (for high-sulfur coal) or 70% (for low-sulfur coal) standard. With the new program, the incentives are such that upgrading of existing scrubbers through improvements is likely to occur.

Finally, Lankoski (2010, 6) reviews the empirical evidence to date and concludes, in line with Porter and van der Linde, that regulatory “policy should strive to be win-win compatible. This speaks in favour of policies that provide incentives to innovation, are stable and predictable, make use of suitable transition periods, focus on end results rather than means, and economic policy instruments” (see also the discussion in Wagner 2006).

Industrial and Patent Policies

Industrial and patent policies might complement environmental regulation to protect the environment at lowest cost to firms. In particular, well-defined property rights on innovations might help reduce R&D spillovers to the benefit of all innovating firms while slowing diffusion. Mandatory licenses might also foster technological adoption—but at the risk of reducing the incentive to invest in R&D. Subsidies and tax credits for R&D spending might make technological change as a strategy for environmental compliance more attractive. Popp (2006) provides evidence that the timing of the introduction of more stringent environmental regulations has an impact on the number of patents issued on pollution abatement technology. More precisely, the introduction of stringent sulfur dioxide (SO_2) and nitrogen dioxide (NO_x) standards in the United States, Germany, and Japan leads to a huge increase of patents issued on related abatement technologies in each of the three countries. Interestingly, transfer of technologies occurs across countries, though indirectly: earlier patents issued in other countries are cited on the new patent applications. In the same vein, Dechezlepêtre et al. (2010) study international transfer of technologies related to climate change mitigation policies, such as wind and solar power. They find that the strictness of intellectual property rights in a country seems to favor the diffusion of green power technologies.[6]

Training

Improved productivity or competitiveness under the PH relies heavily on the possibility of low-hanging fruit—although new technological innovations themselves are also important. Busy managers, especially in small and medium enterprises (SMEs), may not always have the time and the technical expertise to identify these profitable opportunities. Training may help them. Rochon-Fabien and Lanoie (2010) investigate the benefits of an original Canadian training program, the Enviroclub initiative. This initiative was developed to assist SMEs in improving

[6] Maskus (2010) provides a discussion on intellectual property rights on environmental and climate technologies.

their profitability and competitiveness through enhanced environmental performance. An Enviroclub consists of a group of 10–15 SMEs, each of which carries out one profitable pollution prevention project. To support this practical experience, business participants attend 4 days of workshops on various themes related to environmental performance. They also receive the services of a consultant for 90 hours. This consultant analyzes the operations of the firm and, after a thorough diagnosis, recommends different measures to prevent pollution and enhance business performance. The participating firm is committed to adopt at least one of the recommendations of the consultant. Rochon-Fabien and Lanoie (2010) examine the first 187 projects emerging from this program and conclude that all of them were profitable for the participating firms, i.e. reducing costs and pollution at the same time. Lyon and van Hoof (2009) provide similar results for Mexico.

Organizational or Governance Conditions

As noted, Porter argues that organizational inertia can be one reason why firms are missing profitable opportunities to both reduce pollution and increase profits. In the same vein, environmental regulations might help firms overcome their organizational inertia by forcing them to review the organization of production and their business model. This is more likely in firms with deficient governance structures, including asymmetric information with firms among divisions, lack of commitment by the hierarchy, costly communication, or contractual incompleteness. Such organizational or governance failures either constrain the ability of managers to pursue their objectives or distort incentives within the firm. The results from Burtraw (2000) showing how SO_2 allowances were handled by financial officers instead of environmental managers is a good example, as financial officers presumably had more of an incentive to reduce pollution (which would either increase the value of allowance they could sell or reduce the need to buy allowances). Inspired by three case studies, Arjalies and Ponssard (2010) analyze the managerial dimension of the Porter Hypothesis in firms that face different forms of environmental regulations and pressures regarding climate change. They conclude that the ability to support the Porter Hypothesis depends on the stage of development of the firm.

Recent trends to increase corporate transparency and reporting (e.g., the Carbon Disclosure Project and Global Reporting Initiative), provide training on sustainability issues, hire corporate responsibility officers who often report directly to the Board of Directors, and tappoint members of the Board of Directors with sustainability experience all point to actions that might reduce organizational inertia further.

6. The Future Research Agenda

After 20 years, the PH continues to stimulate academic research and policy debates. Although we have learned a lot, findings are often very context specific. With changes in globalization, industry structure, and social expectations, the research agenda over the next 20 years is already full. We have categorized the future research agenda into four major themes, as follows.

Data and Methodological Issues

Much of the existing literature necessarily uses proxies for the key variables of interest. For example, in studies of innovation, environmental regulations are often proxied by environmental compliance costs. Yet the PH does not posit that higher abatement costs will lead to innovation. Indeed, higher compliance costs might simply be attributable to older plants, for example, not more stringent regulatory standards. Instead, the PH suggests that more stringent environmental standards lead to investment in R&D (or changes in processes, organizations, and so on), which in turn leads to innovation. The challenge for researchers is to find appropriate data to fully understand and test these mechanisms.

Another reason we might be observing conflicting results is that firm, industry, or environmental characteristics affect the extent to which innovation offsets and productivity or competitiveness enhancements occur. What is it about manufacturing industries in Canada between 1985 and 1994 (Lanoie et al. 2008) or the U.S. petroleum industry between 1987 and 1995 (Berman and Bui 2001) that caused them to have an increase in productivity when faced with stricter environmental standards, while just the opposite was found in pollution-intensive industries from U.S. paper mills between 1979 and 1990 (Gray and Shadbegian 2003)?

These types of challenges abound in the literature on the PH. Lankoski (2010) provides a nice summary of these issues and notes that authors have identified 50 or more methodological or measurement problems that make it difficult to compare and draw conclusions. Not only is future research to refine and improve upon these issues, but perhaps a serious meta-analysis would help uncover some of the underlying effects and shed more light on these issues.

Nonregulatory Policies

As noted above, some evidence exists that training programs may provide knowledge to environmental managers about more productive (and perhaps even profitable) approaches to environmental protection. Related to direct training on better compliance approaches are the growing number of voluntary programs such as the 33/50 and Energy Star programs in the

United States as well as elsewhere. While these programs are generally designed to provide companies with knowledge and/or incentives to go beyond compliance—either to reduce costs or to increase demand for their products—they may have significant ancillary benefits of increasing compliance with existing regulations.

In addition, there is growing evidence that mandatory disclosure programs have resulted in improvements in environmental performance—even when not mandated. For example, while Hamilton (1995) finds that on average, firms have lost market value on the day that the first Toxic Release Inventory ("TRI") numbers were made public, Konar and Cohen (1997) find that firms with the largest stock price declines have subsequently reduced their emissions most. More importantly, Konar and Cohen (2001) find that subsequent reductions in TRI have increased the intangible asset value of firms. These and other similar findings raise the interesting question of whether indirect forms of regulation such as mandatory disclosure yield positive or negative impacts on balance.

Beyond the government, there are other actors whose policies might interact with the regulation-innovation-competitiveness links. As mentioned above, the trend toward increased transparency, whether through voluntary corporate reporting, quasimandatory requirements from stock exchanges or other agencies, or third-party reporting such as the Carbon Disclosure Project or www.scorecard.org, might reduce organizational inertia. This would appear a fruitful area for future research.

Longitudinal Studies

As noted, one reason we might continue to see mixed results on the regulation-competitiveness effect is the inability of previous studies to adequately capture the lag structure of innovation. While Brunnermeier and Cohen (2003) find a positive relationship between lagged compliance costs and innovation and Lanoie et al. (2008) find a positive relationship between lagged regulatory stringency and productivity, most authors have relied upon contemporaneous comparisons. Innovations might take several years to develop, and capital expenditures are often delayed for a few years through normal budgetary cycles and building lags. Thus, future studies that carefully examine the dynamic structure of the PH would be welcome.

Lankoski (2010) suggests that this difference in treating lag structures was one reason why earlier studies were more likely to reject the PH, while more recent studies appear more favorable. However, another potential reason why more recent studies are more likely to find positive results is simply that the world is changing over time. We have more experience with market-based regulation of the form advocated by Porter. Also, there is a heightened social consciousness around sustainability, in the form of both green products and corporate social responsibility. Thus, the "value" of improving environmental performance may have increased over time. Capturing these effects in a longitudinal study might be difficult but could provide some interesting insights.

Global Studies

As datasets become more global and we increase our ability to make cross-country comparisons with meaningful detailed data, more research might focus on the competitiveness across nations. As mentioned above, evidence is growing (but still not conclusive) that countries with more stringent environmental regulations are less competitive in those sectors (see the reviews in Esty 2001 and Ederington 2010). However, future research might distinguish among command-and-control, performance-based, and market-based instruments to determine whether the form of regulation has an impact on these findings.

7. Conclusions

Twenty years ago, by declaring that well-designed regulation could actually enhance competitiveness, Michael Porter certainly generated enormous interest among scholars, policymakers, businesses, and pressure groups. Indeed, much has been written about what has since become known simply as the Porter Hypothesis (PH).

This paper has provided an overview of the key theoretical and empirical insights on the PH to date. First, on the theoretical side, it turns out that the theoretical arguments that could justify the PH are now more solid than they appeared at first in the heated debate that took place in 1995 in the *Journal of Economic Perspectives* (Palmer et al. 1995). On the empirical side, on one hand, the evidence about the "weak" version of the hypothesis (stricter regulation leads to more innovation) is also fairly well established. On the other hand, the empirical evidence on the strong version (stricter regulation enhances business performance) is mixed, with more recent studies providing more supportive results.[7]

[7] Similar conclusions are reached by Brännlund and Lundgren (2009).

The PH raises important questions for policymakers as to how to design and implement policies that will induce environmental innovation and how to protect and diffuse these innovations among firms. More research is certainly needed to better understand the different mechanisms at play.

By suggesting that better protection of the environment could lead to “win–win” solutions for the whole of society, Porter has certainly opened the minds of many people, leading to significant environmental and economic improvements, and we should thank him for that.

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