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When and Why Does It Pay To Be Green?

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When and Why Does It Pay To Be Green?*

Stefan Ambec†, *Paul Lanoie*‡

Résumé

La vision traditionnelle au sujet de la réglementation de l'environnement est qu'elle représente un coût additionnel pour des firmes, ce qui peut éroder leur compétitivité globale. Cependant, pendant la dernière décennie, ce paradigme a été remis en cause par un certain nombre d'analystes. En particulier, Porter (Porter, 1991, Porter et van der Linde, 1995) argue du fait que la pollution est souvent associée à un gaspillage des ressources (matériel, énergie, etc.), et que des politiques environnementales plus strictes peuvent stimuler les innovations, ce qui peut compenser les coûts entraînés par ces politiques. Ceci est connu comme l'hypothèse de Porter. En fait, il existe plusieurs raisons pour lesquelles l'amélioration de la performance environnementale d'une firme peut s'accompagner d'une meilleure performance économique ou financière, et pas nécessairement d'une augmentation de coût. Pour être systématique, il est important de regarder les deux côtés de l'état des produits et des charges.

Tout d'abord, une meilleure performance environnementale peut mener à une augmentation des revenus par les canaux suivants : i) un meilleur accès à certains marchés, ii) la possibilité de différencier des produits et iii) la possibilité de vendre la technologie de dépollution. En second lieu, une meilleure performance environnementale peut mener à des réductions de coûts dans les catégories suivantes : iv) coût réglementaire, v) coût en ressources, énergie et services (ceci se réfère principalement à l'hypothèse de Porter), vi) coût en capitaux, et vii) coût du travail.

Bien que ces différentes possibilités aient été identifiées d'un point de vue conceptuel ou théorique depuis un certain temps (Reinhardt, 2000 ; Lankoski, 2000, 2006), à notre connaissance, aucun effort systématique n'a été fait pour fournir des évidences empiriques soutenant l'existence de ces opportunités et évaluant leur importance. C'est l'objectif de cet article. Pour chacune des sept possibilités identifiées ci-dessus [de i) à vii)], nous présentons les mécanismes impliqués, une description des évidences empiriques disponibles, et une discussion des lacunes de la littérature empirique. L'objectif du texte n'est pas de prouver qu'une réduction de pollution est *toujours* accompagnée d'une meilleure performance financière, il est plutôt de montrer que les coûts encourus pour réduire la pollution peuvent parfois être compensés, en partie ou complètement, par des gains effectués ailleurs. Par un examen systématique de toutes possibilités, nous voulons également identifier les circonstances pouvant mener à une situation « gagnant-gagnant », c'est-à-dire, une meilleure performance environnementale et financière.

Mots clés : performance environnementale, réglementation environnementale, innovation environnementale, coût du capital, hypothèse de Porter.

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Abstract

The conventional wisdom about environmental protection is that it comes at an additional cost on firms imposed by the government, which may erode their global competitiveness. However, during the last decade, this paradigm has been challenged by a number of analysts. In particular, Porter (Porter, 1991; Porter and van der Linde, 1995) argues that pollution is often associated with a waste of resources (material, energy, etc.), and that more stringent environmental policies can stimulate innovations that may compensate for the costs of complying with these policies. This is known as the Porter hypothesis. In fact, there are many ways through which improving the environmental performance of a company can lead to a better economic or financial performance, and not necessarily to an increase in cost. To be systematic, it is important to look at both sides of the balance sheet.

First, a better environmental performance can lead to an increase in revenues through the following channels: i) a better access to certain markets; ii) the possibility to differentiate products and iii) the possibility to sell pollution-control technology. Second, a better environmental performance can lead to cost reductions in the following categories: iv) regulatory cost; v) cost of material, energy and services (this refers mainly to the Porter hypothesis); vi) cost of capital, and vii) cost of labour.

Although these different possibilities have been identified from a conceptual or theoretical point of view for some time (Reinhardt, 2000; Lankoski, 2000, 2006), to our knowledge, there was no systematic effort to provide empirical evidences supporting the existence of these opportunities and assessing their "magnitude". This is the objective of this paper. For each of the seven possibilities identified above [i) through vii)], we present the mechanisms involved, a systematic view of the empirical evidence available, and a discussion of the gaps in the empirical literature. The objective of the paper is not to show that a reduction of pollution is always accompanied by a better financial performance, it is rather to argue that the expenses incurred to reduce pollution can sometime be partly or completely compensated by gains made elsewhere. Through a systematic examination of all the possibilities, we also want to identify the circumstances most likely to lead to a "win-win" situation, i.e., better environmental and financial performance.

***Keywords**: environmental performance, environmental regulation, environmental innovation, capital cost, Porter hypothesis.*

I. Introduction

Managers have long associated environmental protection with additional costs imposed by the government, which may erode the global competitiveness. This view relies on a basic paradigm which can be described as follows. In general, markets work well to reach an optimal use of scarce resources, so that government intervention is only useful to redistribute revenues, or when markets are no longer fulfilling their role effectively. This is precisely what occurs in the case of environmental problems. One of the prerequisites for the adequate functioning of markets is the existence of well-defined ownership rights. Evidently, in the case of environmental resources such as air or water, these rights are very difficult to assign. Therefore, because air and water belong to no one (or to anyone), economic agents may use them at zero cost, whereas the actual cost of this use for the society as a whole is certainly greater. Polluters receive the wrong signal and, because they use these resources without paying the true price, they are encouraged to do so to excess. Left alone, the market generates too much pollution compared with the desirable or optimal level. Government intervention is then legitimate in order to control pollution and reduce it to a tolerable threshold. To this effect, the government has at its disposal panoply of instruments such as regulation, taxation or pollution permits[1], which may result in the polluters receiving the right signal, once confronted with the true cost of their actions. In short, from this perspective, consideration of the environment is necessarily associated with a cost increase for companies that have used environmental resources with impunity.

However, during the last decade, this paradigm has been challenged by a number of analysts (Walley and Whitehead, 1994; Porter, 1991; Porter and van der Linde, 1995). In particular, Porter argues that pollution is often associated with a waste of resources (material, energy, etc.), and that more stringent environmental policies can stimulate innovations that may compensate for the costs of complying with these policies. This is known as the Porter hypothesis. In fact, there are many ways through which improving the environmental performance of a company can lead to a better economic or financial performance[2], and not necessarily to an increase in cost. To be systematic, it is important to look at both sides of the balance sheet.

First, a better environmental performance can lead to an increase in revenues through the following channels: i) a better access to certain markets; ii) the possibility to differentiate products and iii) the possibility to sell pollution-control technology. Second, a better environmental performance can lead to cost reductions in the following categories: iv) regulatory cost; v) cost of material, energy and services (this refers mainly to the Porter hypothesis); vi) cost of capital, and vii) cost of labour. These possibilities are summarized in Table 1.

[1] In general, it is considered that "market-based" instruments, like green taxes and pollution permits should be preferred over regulation, because they provide incentives for abatement cost minimization and for continuous innovation.

[2] As described by Schaltegger and Wagner (2006), "the environmental performance of a company can be defined by means of its physical performance with regard to environmental aspects based on environmental performance indicators (EPI). Such EPIs can describe mass, energy or pollutant flows through the manufacturing process (e.g. the use of energy or water resources, or the emissions of pollutants from processes or products)" (p.12). The economic or financial performance refers to common measures of profitability like "returns on assets" (ROA), "returns on equity" (ROE), or returns on sales (ROS).

TABLE 1

POSITIVE LINKS BETWEEN ENVIRONMENTAL AND ECONOMIC PERFORMANCE	
Possibilities to Increase Revenues	**Possibilities to Reduce Cost**
i) Better Access to Certain Markets	**iv)** Regulatory Cost
ii) Possibility to Differentiate Products	**v)** Cost of Material, Energy and Services
iii) Selling Pollution-Control Technologies	**vi)** Cost of Capital
	vii) Cost of Labour

Source: Lankoski (2006) adapted by the authors.

Although these different possibilities have been identified from a conceptual or theoretical point of view for some time (Reinhardt, 2000; Lankoski, 2000, 2006), to our knowledge, there was no systematic effort to provide empirical evidences supporting the existence of these opportunities and to assess their "magnitude". This is the objective of this paper. For each of the seven possibilities identified above [i) through vii)], we present the mechanisms involved, a systematic view of the empirical evidence available, and a discussion of the gaps in the empirical literature. Furthermore, in each of the seven cases, we try to identify the circumstances most likely to lead to a "win-win" situation (i.e., better environmental and financial performance)[3], and a diagnostic on the types of firms most likely to enjoy such benefits. The objective of the paper is not to show that a reduction of pollution is *always* accompanied by a better financial performance, it is rather to show that, in many cases, the expenses incurred to reduce pollution can be partly or completely compensated by gains made elsewhere.

The rest of the paper is organized as follows. Section II reviews the possibilities available to improve the environmental performance of a company, while increasing its revenues [i) to iii)]. Section III shows how a pollution reduction can lead a cost reduction; as mentioned above, we consider four categories of cost: iv) regulatory cost; v) cost of material, energy and services; vi) cost of capital and vii) cost of labour. Through the items v) and vi), we will be led to survey two broad and controversial areas in the economics literature: the one related to the Porter hypothesis and the literature on the reaction of capital markets to environmental information. Section IV provides concluding remarks.

II. A better environmental performance may mean more revenues

i) Better access to certain markets

A better environmental performance may facilitate the access to certain markets. First, generally speaking, reducing pollution and other environmental impacts may improve the overall image or prestige of a company, and thus increase customers loyalty or support sales efforts. Although, this argument seems pretty straightforward, it is difficult to find strong empirical evidence that customers are influenced by the "green" image of a company. Consumers may be aware of the environmental performance of a company through its offer of green products, but they are less

[3] Some authors extend that notion to "win-win-win" strategies in cases where consumers also enjoy a benefit (e.g., Elkington, 1994).

likely to know its environmental performance measured through its emissions in water, in the atmosphere[4], etc.

Second, more specifically, it is useful to scrutinize the purchasing policies of public and private organizations. First, it is becoming more and more common for public administration to include the environmental performance (or performance with respect to sustainable development) as a criterion to choose suppliers of goods or services. This phenomenon is known as green public purchasing (GPP). As an illustration, Kunzik (2003) reports that, in general, the central U.K. government, in its policy *Greening of Government Operations*, aims at (p. 194):

> (….)
> - Encouraging manufacturers, suppliers and contractors through specifications to develop environmentally preferable goods and services at competitive prices;
> - Ensuring that any products derived from wildlife such as timber, plants and leather goods are from sustainable sources…

More specifically, for instance, the U.K. Department of Environment, Transport and Regions has the following objectives (p. 197):

> (…)
> - Buying a minimum of 10% of electricity from renewable sources;
> - Purchasing sustainably produced timber products by, for example, specifying that suppliers provide independently verifiable documentary evidence that their timber has been lawfully obtained from sustainable forests managed "to prevent harm to other ecosystems and any indigenous people."

In the U.S., the *Federal Acquisition Regulations* provide a detailed code of rules governing procurement by all Federal agencies. For instance, these rules imply that "the Environmental Protection Agency (EPA) has to prepare guidelines on the availability, sources, and potential uses of recovered materials and associated products, including solid waste management services; and require federal agencies themselves to develop and implement affirmative procurement programs for EPA-designated products within a year after the EPA's designation" (Kunzik, 2003, p. 203).

Overall, public purchasing is fairly important in the economy. In 1998, it was estimated that government sector expenditures for consumption and investment was responsible for 20% of GDP in OECD Member countries, 9% when subtracting compensation for employees (Johnstone and Erdlenbruch, 2003). It can be argued that green public purchasing "can spur innovation by increasing the competitive advantage of "greener" products in the market which can then be followed by larger commercialisation and diffusion. In particular, public demand may provide "demonstration" effects, giving valuable information to other actors in the economy about potential benefits of newer untried green technologies and products" (p. 12).

[4] Green consumerism is a frequently cited motivation for corporate environmental actions. However, the empirical evidence on the impact of green consumerism is mitigated. For instance, Arora and Carson (1996) find that firms operating in industries with higher advertising to sales ratios were more likely to join voluntary environmental programs launched by the EPA, while Konar and Cohen (1997) find the contrary. Furthermore, Khanna and Damon (1998) find, within the chemical industry, that final good producers were also more likely to join voluntary programs than were producers of intermediate goods. For more discussion, see Lyon and Maxwell (1999).

The magnitude of GPP is difficult to assess, but it seems clearly present. In particular, in May 2001, the OECD Environment Ministers have adopted the *Environmental Strategy for the First Decade of the 21st Century*, in which there is a recommendation "to improve the environmental performance of public procurement practices" (Johnstone and Erdlenbruch, 2003).

We also have examples of private companies which have taken steps for the "greening of their supply chain". Presumably, all plants with the ISO 14001 certification pay attention to the environmental performance of their suppliers since this is one of the criteria to be fulfilled to obtain the certification (Barla, 2005; Hess et al., 1999)[5]. Furthermore, a recent survey of the OECD, covering more than 4000 facilities in seven countries, shows that 43 % of them assess the environmental performance of their suppliers (Johnstone et al., 2007).

Some companies'policies regarding the green performance of their supplier have been well documented in certain case studies. For instance, before choosing a supplier, IBM asks the potential candidates to do a self-evaluation of their environmental performance and, for those who have a satisfying score at the self-evaluation test, there is an on-site visit for a thorough evaluation (Herren et al., 1998). In the same vein, since 1992, Body Shop International has a strict evaluation system for the environmental performance of its suppliers, the "Supplier environmental star-rating scheme" (Wycherley, 1999). As shown in Reichert and Larson (1998), IKEA is also known for its strict requirements for suppliers regarding harmful chemicals (such as formaldehyde), wood sourcing (such as rainforest woods) and packaging materials (which have to be recyclable or reusable and use no PVCs).

Is it worthwhile for firms to incur extra expenses to improve their environmental performance in order to have a better access to certain markets? There is little evidence about that. At best, we can rely on the recent study of Hamschmidt and Dyllick (2006) who provide, to our knowledge, the first cost-benefit analysis of the implementation by an enterprise of ISO 14001. Arguably, in many cases, companies are making the effort of complying with the ISO14000 requirements in order to improve their image, and to reach extra customers (Hess et al., 1999). For their sample of 158 certified Swiss firms, they find that the average payback period of the adoption of ISO 14000 was 2.2 years. More empirical studies of that type would be appreciated.

It seems that most firms can actually obtain a better access to certain markets via an improvement of their environmental performance. However, at this stage, the companies most likely to make these gains are those selling their products or services to public authorities. According to Marron (2003), the most important private suppliers of public administration are in the following sectors: construction, energy services, transport equipments, transport services, shipbuilding, medical equipment, army equipment (including paper), office equipment, electrical machinery and wearing apparel.

ii) A possibility to differentiate products

In the same line as the preceding discussion, it is also possible that a better environmental performance through greener products or services can allow companies to use a differentiation strategy so as to exploit niches in environmentally conscious market segments. In this case, even if green products or services are more expensive to produce, the extra cost can likely be

[5] On January 1st, 2006, there were 103 583 plants worldwide that were certified ISO 14001, see http://www.ecology.or.jp/isoworld/english/analy14k.htm.

transferred to consumers who are willing to pay more for more environmental-friendly products or services[6].

Eco-labelling can make the information about the environmental features of the product or service more credible or attractive. The popularity of ecolabelling is increasing, especially in Europe. In particular, the sales of the products with the European eco-label went from 51 million € in 2000 to 644 millions in 2004[7]. The willingness to buy green products is also important. For example, 80% of the French adults say that they are ready to favour the purchase of ecoproducts, 10% say that they do it regularly (Guilloux, 2006).

Specific examples of enterprises which have adopted this differentiation strategy are numerous. Among the classical ones, there is Patagonia, an American sport garments company, which, in the 1990s, has launched new lines of clothes made in recycled PET (polyethylene terephtalate), or organic cotton. This was a commercial success in spite of the higher price of these products (Reinhardt, 2000). Toyota is also adopting this strategy; it has officially that in 2012, all its models would be equipped with hybrid engines. Already, one can see the success of its first hybrid model, the Prius. For instance, the sales of this model have increased by 139% in the U.S. from 2004 to 2005[8].

The Swiss chemical company Ciba Geigy has created, in the mid 90s, a new type of bioreactive dyes, CIBACRON LS. This new dye had a higher fixation rate, which meant that less dye was required to colour textiles. In turn, this meant that rinsing was simpler and less expensive, and that firms' wastewater treatment costs could be lower. In other words, this dye helped Ciba's clients to reduce their environmental cost. Ciba has protected this new dye via a patent. The dye was a commercial success in spite of a higher price (Reinhardt, 1999).

The development of the "bio" food industry serves as another example of the success of this strategy, although in this case, one can argue that, when buying these products, consumers are also looking for their health attributes. This industry is becoming "sizable"; for instance, the world market for "bio" food products was estimated at 23.1 billion euros for 2004, a rise of 9% over 2003. This represents almost 4% of the world food market[9]. In Europe, the market share for bio-food is estimated at 7%. Similarly, the sales of organic cotton (produced without chemical fertilizers or pesticides) are soaring worldwide from $245 millions in 2001 to an estimated $1 billion in 2006[10].

It is also becoming more and more common to see companies emerging in the "green energy" market, i.e. companies that have access to the grid to sell energy from renewable sources like

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[6] In the economic literature, a better environmental performance is considered as a vertical attribute of a product, similar to high quality (Cremer and Thisse, 1999, Bansal and S. Gangopadhyay, 2003). It relies on the assumption that environmentally aware consumers are willing to pay more for cleaner products. As a result, a market powered firm might find it profitable to offer a green version of its product at a higher price or to specialize in green products. Yet environmental performance might be difficult to asses by consumers. When this performance is firm's private information, it can be signalled through a higher price if less polluting products are also more costly to produce (Mahenc, 2007). Moreover, asymmetric information on product greenest might lead to a lemon-type market failure à la Akerlof (1970) which can be reduced through eco-labelling to the benefit of the producing firms (Ambec and Barla, 2005).

[7] http://160.92.130.69/ecolabels/rubrique.php3?id_rubrique=2.

[8] http://news.techwhack.com/3574/hybrid-vehicles/.

[9] http://seme.cer.free.fr/index.php?cat=filiere-bio.

[10] *Les Échos*, November, 21st 2006.

biomass, wind or solar. An example that is well documented is the Dutch enterprise PNEM that is producing electricity from a biomass-fired power plant (Hofman, 2005). Such companies can be successful in spite of a higher price.

Here again, we can ask the question: is it worthwhile for firms to adopt this strategy? Here gain, there is not much empirical evidence available. FGCAQ (2004) and Parsons (2005) study the profitability of farms producing bio milk compared to that of farms producing regular milk, and they conclude that there is no significant difference between the two groups. In the same vein, Johansson et al. (2001) report ten commercial success stories from ecodesign[11], like the French company Parkeon who is a world leader for the production of parking ticket machines working with solar energy. Ecodesign can bring commercial benefits in different ways like reducing the quantity of raw material used, reducing the cost of packaging, reducing transportation cost and, of course, helping to reach new niches of consumers[12]. More studies of that nature are needed.

From these examples, it seems that this differentiation strategy is more likely to work when[13] i) the information about the environmental features of the product is credible (e.g., an eco-label); ii) there is a willingness-to-pay by the consumers (it is more difficult with low-end products) and iii) there is a barrier to imitation from competitors (like the patent obtained by Ciba). The variety of the examples that were just presented allows us to believe that a wide range of enterprises can actually reach a better environmental performance and obtain more revenues by using this strategy. Even firms producing fairly homogenous goods usually difficult to differentiate, like agricultural products or energy, can do so.

iii) Selling pollution-control technology

Of course, for decades, solving environmental problems has become a business opportunity for many companies specialized in this area that we can refer to as the eco-industry. A detailed description of this industry and its market structure goes beyond the scope of this paper[14]. We are rather interested by firms which, in their search for better environmental performance, are led to do research and development in the area of pollution-control technologies, so as to optimize their manufacturing or waste management processes. This can lead to technological breakthroughs that eventually can be attractive for others. Companies adopting such a strategy may also enjoy a "first-mover" advantage, and may eventually lobby governments for stricter regulations.

For example, as mentioned above, Ciba has patented its new dye Cibacron LS that could be sold to other companies under licensing agreements. Actually, following its experience with the new dye and wastewater treatment, Ciba Geigy has bought in 1998 Allied Colloids Group, a British firm that manufactured water treatment additives. This was the first step in creating its environmental division. Another example of a large company which has diversified its activity by

[11] E*codesign* refers to all the actions taken and activities carried out originating from the incorporation of environmental performance requirements in a product development project (Johansson et al., 2001, p. 8).
[12] See also UNEP (2001) for other evidences.
[13] See also Reinhardt (2000), for more discussion.
[14] Eco-industries: industries which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems. This includes cleaner technologies, products and services which reduce environmental risk and minimize resource use". In 2005, it was estimated that the eco-industries were representing revenues of 180 billions € and 500 000 jobs http://ec.europa.eu/research/briefings/sustain-devel_fr.html.

opening an "environment" division is General Electric. This division *Ecomagination* is made of 32 clean-technology products like wind turbines. *Ecomagination* had revenues of $10 billions in 2005 and is forecasting 20 billions in 2010[15].

In the same vein, the major aluminium producer ALCAN has developed and tested a spent potlining (SPL)[16] treatment process, the Low Caustic Leaching and Liming (LCLL) process. Up to now, SPL was considered as a hazardous waste that must be stored or landfilled very carefully. With its new process, Alcan will be able to recycle a large part of this waste. It will soon build a new plant in Canada to treat its own SPL and, eventually, that from other companies.

So far, we must say that it was difficult to find examples of companies that were able to benefit from such technological opportunities as a commercial by-product. This is an indicator that "selling pollution-control technology" as one way to turn an environmental problem into an increase in revenues is probably not a widespread phenomenon. The three examples we found suggest that firms must already have research facilities, and a large amount of resources, to eventually sell a pollution-control technology that they have developed for themselves. More empirical work, digging into licensing agreements for instance, would help to have a clearer picture of this issue.

III. A better environmental performance may mean lower costs

iv) Regulatory cost

As suggested in particular by Lankoski (2006), a better environmental performance can be associated with lower regulatory costs in the sense that continuous compliance means lower liability costs, avoiding fines and litigation. In certain areas, less pollution can also lead to a lower amount of environmental taxes to be paid, or a smaller quantity of tradable permits to be bought. In the same vein, a better environmental performance may allow a firm to anticipate future regulation and influence standard development.

As a concrete example, El Bizat (2006) shows, through a survey of the Canadian jurisprudence, that the implementation of a proper environmental management system (EMS), like that recognized by ISO 14001, can be useful to prove due diligence in court when there are cases of illegal spills or other environmental accidents.

Furthermore, firms may find useful to reduce their pollution, or to improve their pollution-control technologies, in order to enjoy a strategic first-mover advantage in case of a tightening of the environmental regulation. For instance, it is well documented that, in the eighties, Dupont has lobbied to ban CFCs and other ozone-depleting substances, because it had the leadership in the research for substitutes (Reinhardt, 2000). In such a case, one can argue that either regulatory costs are reduced, or that revenues are improved.

[15] http://ge.ecomagination.com/@v=020220071742@/site/index.html#home

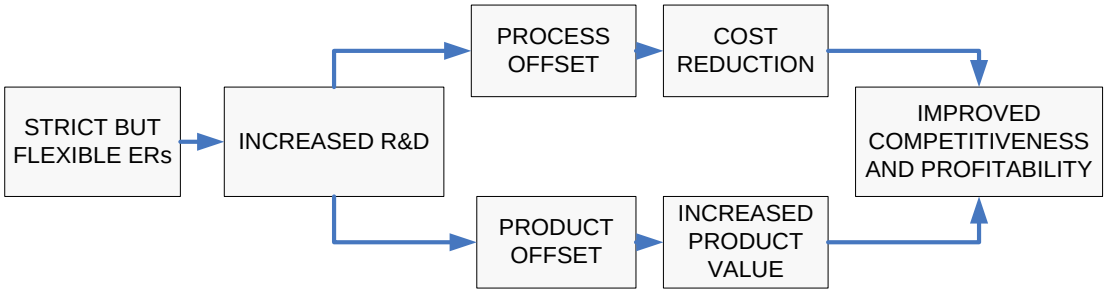
[16] "Spent potlining (SPL) is the main waste residue generated by the reduction process in the smelters producing aluminium. It consists of the internal lining of the pots, which is replaced after five to seven years of use. SPL is classified as hazardous waste by many jurisdictions worldwide due to its toxicity and explosive nature" http://www.publications.alcan.com/sustainability/2005.

The companies most likely to benefit from these costs reductions are those which are heavily regulated. One can include in this category firms with toxic emissions, like the chemical or metallurgic industries, or firms with important polluting emissions like the pulp and paper or the energy sector.

v) Cost of material, energy and services[17]

As mentioned in the introduction, Porter has suggested that pollution is generally associated with the waste of resources, with raw material not fully used, or with lost energy. "Pollution is a manifestation of economic waste and involves unnecessary or incomplete utilisation of resources,…Reducing pollution is often coincident with improving productivity with which resources are used" (Porter and van der Linde 1995: 98, 105). From this reasoning, Porter argues that more stringent and flexible environmental policies (like taxes and tradable permits) would be fruitful for the economy, stimulating innovations that may compensate for the costs of complying with these policies. This is known as the Porter hypothesis (PH). In particular, this line of reasoning implies that reducing pollution can generate a reduction of expenditures on raw material, energy or services. The PH is schematically represented in Figure 1.

FIGURE 1
Schematic representation of the Porter Hypothesis (from Ambec and Barla, 2006)



In the economic literature, the PH has been criticized for its lack of theoretical foundation (Palmer et al., 1995). Profit maximizing firms should not ignore profitable investments in innovation, being regulated or not, in an economy with perfect markets. Recent papers have provided foundations to the PH by introducing a market failure (in addition to the one due to pollution). The environmental regulation, which is devoted to solve the market failure due to the pollution externality, turns out to mitigate the other market failure to the benefit of the regulated firms. Example of such market failures include spillovers in knowledge (Jaffe et al., 2004, Ambec and Barla, 2005), or in learning-by-doing (Mohr, 2002), asymmetric information within firms (Ambec and Barla, 2002), market power (Simpson and Bradford, 1996, Greaker, 2003), and specific investments with contractual incompleteness (Ambec and Barla, 2005). The other theoretical explanations for the PH rely on the assumption that managers do not maximize the firm's future profits because she or he is risk-averse (Kennedy, 1994) or present-biased (Ambec and Barla, 2005).

Given the objective of this paper, it is relevant to review the rapidly growing empirical literature on the Porter hypothesis. We distinguish two set of studies. A first set estimates the impact of environmental regulations on firm's innovation policy and technological choice measured by

[17] The services we have in mind here are mainly wastewater treatment, garbage collection or use of recycling facilities.

investment in R&D, in capital and new technologies, or successful patent applications. These studies test the first premise of the Porter Hypothesis that more stringent environmental regulations enhance innovation. Yet more innovation is a necessary but not sufficient condition for the PH. Therefore, they can only invalidate or provide some support to the mechanism underlying the PH without directly testing it. In the second set, the impact of environmental regulation is estimated on measures of firms' performance such as productivity and costs. The aim is to test whether more stringent environmental policies can be beneficial to the firm. Yet those papers are silent on the process that leads to higher productivity. Table 2 below (adapted from Ambec and Barla, 2006) summarizes several empirical papers that fit in these two sets.

In the 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 found 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. Restricting themselves to environmentally-related successful patents, Brunnermeier and Cohen (2003) found a positive but small relationship with environmental regulation. Both studies suggest a weak but positive link between a better environmental performance (through better compliance with regulation) and the firm's innovation policy.

TABLE 2
Empirical studies on the Porter Hypothesis

STUDY	DATA	METHODOLOGY	MAIN RESULTS
I. Impact of Environmental Regulations (ERs) on Innovation and Technology			
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.	▪ R&D significantly increases with ERs. Elasticity: +0.15. ▪ No significant impact of ERs on number of patents.
Brunnermeier and Cohen (2003)	▪ Panel of 146 U.S. manufacturing industries 1983-1992.	▪ Reduced form model. ▪ Innovation proxy: number of environmentally-related successful patent applications. ▪ ERs: Pollution control operating costs and number of air and water pollution control inspections.	▪ Small but significant impact of pollution operating cost on number of patents. ▪ No impact of inspections.
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
Arimura et al. (2007)	▪ Survey of 4 000 manufacturing facilities in seven OECD countries.	▪ Bivariate probit model with (1) Environmental R&D dummy regressed on various measures of environmental policy (perceived stringency, standards, taxes), an environmental accounting dummy and other management practices control variables. (2) Environmental accounting dummy regressed on same variables.	▪ The perceived ER stringency has a positive and significant impact on the probability to a run an environmental R&D program. ▪ The type of ER (standard or tax) has no significant effects on environmental R&D.
Popp (2003)	▪ Patent data and performance measures of flue gaz desulfurization units ("scrubbers") of 186 plants in US (1972-1997).	▪ SO2 removal efficiency of new scrubbers regressed on the flow of knowledge (measured by patents) and policy variables. ▪ Operating and maintenance cost of scrubbers regressed on same variables.	▪ The new SO2 emission permit regulation introduced in 1990 increased SO2 removal efficiency and lowered operating and removal costs.
Popp (2006)	▪ Patent data from the U.S., Japan, and Germany (1967-2001).	▪ Impact of SO_2 (US) and NO_X (Germany and Japan) ERs on patenting and patent citations. ▪ ERs: timing of the introduction of new ERs. ▪ Estimate the cross-countries spillovers using patent citation origins.	▪ ERs regulation followed by an increase of patenting from domestic firms but not from foreign firms. ▪ Earlier ERs for NO_X in Germany and Japan are important components of US patents for pollution control technologies to reduce NO_x emissions.
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.

STUDY	DATA	METHODOLOGY	MAIN RESULTS
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.	▪ 30% of the decline in productivity growth in the seventies due to ERs.
Barbera and Mc Connel (1990)	▪ 5 U.S. pollution intensive industries (paper, chemical, stone-clay-glass, iron-steel, non-ferrous metals), 1960-1980.	▪ Derive the direct (abatement cost growth) and indirect (changes in other inputs and production process) effects of pollution control capital using a cost function approach.	▪ Overall, abatement capital requirements reduce productivity growth by 10% to 30%. ▪ Indirect effect sometimes positive.
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.	▪ 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 to.	▪ Stricter regulations imply higher abatement costs. However, these investments appear to increase productivity.
Lanoie, Lajeunesse and Patry (2005)	▪ 17 Quebec manufacturing industries, 1985-1994.	▪ Total factor productivity growth regressed on lagged changes in the ratio of the value of investment in pollution-control equipment to total cost.	▪ ERs have a significantly positive impact on productivity growth rate, especially in the sectors highly exposed to outside competition.
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.

For the firm's technological choices, two studies emphasize a negative relationship between environmental regulations and investment in capital. Nelson et al. (1993) found that air pollution regulations significantly increased the age of capital in the U.S. electric utilities in the seventies. According to Gray and Shabegian (1998), more stringent air and water regulations have a significant impact on paper mills' technological choice in the U.S. However, their results suggest that it tends to divert investment from productivity to abatement, consistently with the standard paradigm.

The second set of studies has a long tradition in the economic literature (see Jaffe et al., 1995, for a review). Most papers reviewed in Jaffe et al. (1995) highlight a negative impact of environmental regulation on productivity. For instance, Gallop and Robert (1983) estimated that SO2 regulations slowed down productivity growth in the U.S.. in the seventies. by 43%. More recent papers (see Table 2) find more positive results. For example, Berman and Bui (2001) report that refineries located in the Los Angeles area enjoyed a significantly higher productivity that other U.S. refineries despite a more stringent air pollution regulation in this area. Similarly, Alpay et al. (2002) estimated 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.

Although the mentioned studies tend to reject the Porter Hypothesis, one cannot conclude that being green harms the firm. Concerning this research, three caveats are worth to be mentioned. First, it may be argued that previous studies have not well 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 regressed productivity at time 0 on proxies of environmental regulation stringency at time 0 as well, which is not allowing 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. (2005) have found that more severe regulations is leading to modest gains in productivity in a sample of 17 Quebec manufacturing sectors. Furthermore, they show that this effect is more important in industries highly exposed to outside competition.

Second, the cited papers use "traditional" productivity indexes that do not include pollution as an input or an output. The "green" measures of productivity include pollution as an undesirable output with a negative price which might corresponds to the marginal cost of getting rid of pollution or the marginal damage of pollution (see, for example, Fare, et al., 1989). The green productivity would indeed coincide with the conventional one if the firms would bear the full social cost of pollution in line with the polluter-pay principle. With a somehow light regulation, or in an unregulated industry, the gap between the two measures can be substantial. Repetto et al. (1997) estimated an increase of productivity by 0.36 to 0.44 percent each year instead of 0.16 annually in the 1970s and 1980s for the electric power and pulp and paper industries, after including the cost of pollution in the productivity measure.

Third, most studies rely on command-and-control regulatory instruments, such as pollution standards, while environmental regulation is moving to more efficient "market-based" ones, such as tradable emission permits. The economic theory predicts that emission markets reduce compliance costs by assigning those costs where they are lower. In contrasts to standards (that might not be binding after a while), market-based instruments provide constant incentives to

innovate. The Porter Hypothesis is therefore more likely to be satisfied in industries regulated with the new market based instruments, especially tradable emission permits.

In this line, Burtraw (2000) provides evidence that the switch of environmental regulation for SO2 emissions in the U.S. from technological standard with emission caps to an allowance trading program in 1990 reduced considerably compliance cost (40% to 140% lower than projection). It indeed not only enhanced innovation, but also fostered organisational change and competition on the upstream input market. The program was progressive, with permits from 2.5 pounds SO2 per Btus of head input in 1995 to 1.2 in 2000 with a banking system. Firms took advantage of relative low-cost compliance options in early years of the program to bank allowances and, therefore, smoothed their abatement cost with time. It left enough flexibility to the firm to select the best strategy to reduce emissions. A popular one was a switch for coal with lower sulphur content. In the beginning phase of the new regulation, half of the reductions in sulphur have been achieved by switching to low-sulphur coal. It resulted in a more intense competition on the two markets (high and low sulphur coal), which reduced the price of inputs. This competition was fostered by the deregulation of railways, which reduced transportation costs. The industry experienced innovation in fuel blending and in the scrubber market. The former "command-and–control" did not provide incentives to increase SO2 removal by scrubbers from more than the 90% (for high-sulphur coal) or 70% (for low-sulphur coal) standard. With the new program, the incentives are such that upgrading of existing scrubbers through improvements is likely to occur. Lastly, the switch from technological standard to tradable emission allowances led to an organizational change. The responsibility for compliance that rested traditionally with engineers or chemists, typically in charge of environmental issues, has been transferred to top executives such as financial vice-presidents, who are trained to treat SO2 emissions allowance as financial assets.

In the same vein, Hoglund Isaksson (2005) looks at the impact of a charge on nitrogen oxides (NOx) 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 emission 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.

Clearly, the PH hypothesis is an important issue that will continue to draw more research. At this stage, even if the PH cannot be generalized to the "whole" economy, it is clear that some firms, through better use of energy, or materials, have been able to reduce pollution and costs at the same time. Given the purpose of this paper, it is useful to try to verify the circumstances more likely to generate such desirable outcomes.

There are many famous examples of companies which have reduced their pollution and costs at the same time. Let us mention a few. First, British Petroleum has been able to reduce its CO_2 emissions to 10% below their level prevailing in 1990 at no cost through an optimization of the production process, elimination of leakages, reuse of wastes, etc. (Reinhardt, 2001). Second, recently *Fortune* published an article describing five changes made at the headquarters of Adobe systems (going from automatic faucets to motion censors), which have involved an "initial investment" of around $250,000 for "annual" savings of around $246,000 (*Fortune*, 2006). Third, Dow Chemicals is well known for its WRAP Award program (Waste reduction always pays), which was implemented in 1986. "Since the program began, Dow has given the WRAP Award to 395 projects. Worldwide, the projects account for the reduction of 230 000 tons of waste, 13 million tons of wastewater, and 8 trillion BTU's of energy. The (net) value of all these

projects totals roughly $1 billion[18]. Fourth, when implementing ISO 14001, the authorities of GM's Flint plant realized that they were using a lot of energy during week ends when the machines were stopped (448,918 kilowatt hours during the Thanksgiving holiday of 1999). Shutdown efforts were made very systematically so as to generate savings of approximately $250,000 per year (174 299 kwh were used during the same holiday two years later, see El Bizat, 2006).

In the same vein, as we saw earlier, Hamschmidt and Dyllick (2006) provide a cost-benefit analysis of the implementation by an enterprise of ISO 14001, in which they show that 60% of the sampled firms reported decreases in their material and energy flows following the adoption of the certification. We must also add that Lanoie has been collecting more than 50 examples, over the last 8 years, of companies that were able to reduce as the same time pollution as well as the cost of resources, energy and services (see Lanoie and Tanguay, 2000, 2004). These companies are very diversified in terms of size, origin, or industry. The actions taken to reach these win-win outcomes are also fairly diversified (reuses of waste, uses of waste as a source of energy, more efficient production technology, more efficient energy use, etc), which suggests that the set of potential opportunities is fairly wide.

It is not always possible to reduce at the same time pollution and the cost of energy, material and services, but the set of opportunities to do so seems relatively large. These opportunities are more likely to emerge in firms where the production process is flexible, in industries where the competition is fierce so that cost reductions are important, and in industries where market-based instruments (like pollution taxes or tradable permits) are implemented.

vi) Cost of capital

It is also possible that better environmental performance can be associated with a lower cost of capital. First, it is becoming quite clear that greener firms have an easier access to the capital markets through the proliferation of all the green (or ethical mutual funds[19]). Through these funds, green investors can be sure that their money will be invested in firms that respect certain criteria like the existence of a proper Environmental Management System (EMS), or the absence of environmental litigation. Socially responsible investment (SRI) is becoming an important phenomenon. Assets in U.S. socially screened funds have increased by 258% between 1995 and 2005, a rate of growth faster than the average of other professionally managed U.S. funds. In France, the increase was of 92 % between 2002 and 2006. In 2005, nearly one out of every ten dollars (9.4%) under professional management in the United States is involved in socially responsible investing (10 to 15 % in Europe)[20]. Portfolio analyses allows one to compare the performance of these socially screened funds with that of conventional funds.

Second, firms with better environmental performance can borrow more easily from banks. Most banks now have a team of experts to evaluate the environmental performance of possible

[18] http://www.dow.com/commitments/studies/wrap.htm.
[19] In general, the environmental performance is one of the criteria used to select firms in an ethical mutual fund.
[20] http://www.socialinvest.org/areas/research/trends/sri_trends_report_2005.pdf. and *La Tribune* March 1st 2007.

borrowers, in particular the size of potential liabilities due to contaminated assets[21]. Furthermore, around 40 international banks have now adopted the "Equator Principles" to make sure that the projects they finance are developed in a manner that is socially responsible and reflect sound environmental management practices[22]. Montel and Debailleul (2004) argue that the quality of the environmental management of a firm may serve as a proxy its level of risk: i) it contributes to its profitability; ii) it is an indicator of the overall quality of the management; iii) it reflects the legal or regulatory risk, and iv) it is a proxy for market opportunities. Both banks and insurers may use this information.

Third, shareholders in general may be influenced by information on the environmental performance of companies, and their reactions can be perceptible on the stock market. These movements may, in turn, influence the cost of capital. A large number of empirical studies have tried to identify the stock market reaction to news on environmental performance[23]. Three main approaches are dominant in that literature: a) portfolio analyses; b) event studies; and c) long-term studies using regression analysis. In each case, we will present the methodology used, the main conclusions, and the limitations.

a) Portfolio Analyses[24]

Portfolio analysis is used to examine whether SRI funds (or indices) exhibit a different performance from funds in a more general investment context. Such analyses compare the economic performance of portfolios consisting of companies with a higher environmental or social performance with portfolios of companies that have not been screened with these criteria. The comparison is done using indicators like Jensen's alpha, Sharpe and Treynor ratios[25]. In general, it is expected that ethical funds will under-perform over the long run because funds managers are constrained to a subset of the market portfolio.

We came across 16 studies of that type. Table 3 presents the main characteristics of these studies. Eleven of them come to the conclusion that there is no statistically significant difference between the performance of SRI funds and conventional ones, while five of them show results confirming that SRI funds outperform conventional ones.

[21] For instance, the French bank BNP Paribas has a team of 120 professionals in the area of sustainable development http://www.bnpparibas.com/fr/developpement-durable Similarly, the American Citibank was reporting that, in 2004 and 2005, more than 1500 of their employees were trained on environmental issues. http://www.citi.com/citigroup/citizen/community/data/citizen05_en.pdf.

[22] See www.equator-principles.com. One can also refer to the Enhanced Analytics Initiative (EAI) in which members agree to use part of their budget to reward brokers that publish research on extra-financial issues such as climate change or brand management, see http://www.enhancedanalytics.com/

[23] For a shorter survey, see also Wagner et al. (2001).

[24] See also the discussion in Rennings et al (2006) and Plinke and Knorzer (2006).

[25] For more details, see Bauer et al. (2005).

TABLE 3
Portfolio Analyses

STUDY	DATA SET	PERFORMANCE MEASURE AND DATA		MAJOR FINDINGS
		ENVIRONMENTAL	ECONOMIC	
Luther et al., 1992	Returns of 15 ethical unit trusts from UK.	Ethical funds: Those which exclude one or more company groups from their portfolio for non-financial reasons (identified by the EIRIS(2)).	Mean monthly returns.	Weak evidence that ethical funds tend to out-perform general market indices. Bias towards smaller companies for ethical funds.
Hamilton et al. 1993	17 US Socially responsible funds.	US SRI (Socially Responsible Investors) Mutual Funds.	Mean monthly returns.	Socially responsible mutual funds did not earn statistically significant excess return.
Luther and Matatko, 1994	Returns of 15 ethical unit trusts from UK.	Ethical funds: Those which exclude one or more company groups from their portfolio for non-financial reasons (identified by the EIRIS).	Mean monthly returns, with unit prices taken on an offer-to-offer basis, with dividends included.	Confirm the small cap bias (Luhter et al. 92) and show that comparing ethical funds to a small cap benchmark improve their relative performance.
Mallin et al., 1995	29 ethical trusts and 29 non-ethical trusts in the U.K. between 1986 and 1993.	Ethical funds: Those which exclude one or more company groups from their portfolio for non-financial reasons (identified by the EIRIS).	Jensen's measure.	The mean excess returns of ethical trusts appeared to under perform both non-ethical trusts and the market in general. However, on a risk adjusted basis ethical trusts outperformed non-ethical trusts.
White, 1996a	97 firms publicly listed on NYSE(1), 1989–92 (inclusive).	Three-element scale ratings published by CEP (3).	Value-weighted monthly stock-market return data from CRSP (4) used to measure risk-adjusted portfolio performance.	Significantly higher risk adjusted investment returns for portfolios of environmentally high performing firms.
Diltz, 1995	159 firms rated on eleven social criteria by the CEP. Portfolio pairs were designed to contrast firms rated favorably on one or more social criteria against firms that rated poorly on the same criteria.	Eleven social criteria defined by the CEP.	Jensen's Alpha and cumulative excess returns.	No systematic statistically significant differences between portfolios.

STUDY	DATA SET	PERFORMANCE MEASURE AND DATA		MAJOR FINDINGS
		ENVIRONMENTAL	ECONOMIC	
Guerard, 1997	Unscreened equity universe composed of 1,300 equity stocks and a socially screened universe of approximately 950 stocks.	The screens address the following social investing issues: military; nuclear power; product (alcohol, tobacco, and gambling); and environment.	Average monthly returns of the screened and unscreened universes.	No significant difference between the average monthly returns of the screened and unscreened universes during the 1987-1994 period.
Sauer, 1997	400 firms from the Domini Social Index (DSI), from 1986 to 1994.	The DSI excludes firms engaged in the manufacture of alcohol or tobacco, gambling, military weapons, nuclear power, and business tied to South Africa. Firms were also evaluated on their responsiveness to the environment, product quality, consumer needs, etc.	Average monthly raw returns and variability, Jensen's alpha, and Sharpe's performance index.	Performance costs of implementing social responsibility criteria are negligible. Performance of the Domini Social Equity Mutual Fund compares favorably to the performance of the Vanguard S&P 500 Index and Vanguard Extended Market Index Mutua.
Gregory et al. 1997	60 European funds from four countries.	Ethical funds: Those which exclude one or more company groups from their portfolio for non-financial reasons (identified by the EIRIS).	Mean monthly returns.	There is no difference between ethical and non-ethical funds according to the performance measures employed. Neither type of fund displayed any ability to time the market.
Edwards 1998	A total of 51 environmental leaders in eight industry sectors (defined by Financial Times All Share listing); each of these was matched to 3–5 UK firms, for 1992–93, listed on the London Stock Exchange.	In-depth positive assessment of various aspects of each firm's environmental performance and management based on products and services; environmental disclosure by the firm, GHG and ODS (5) emissions; packaging and labelling.	Historical accounting profitability measures (return on capital employed, return on equity) from 1996 REFS (6).	In 31% of comparisons between portfolios of environmentally high performing firms and other firms, the latter perform worse, though not in all cases at a significant level.

STUDY	DATA SET	PERFORMANCE MEASURE AND DATA		MAJOR FINDINGS
		ENVIRONMENTAL	ECONOMIC	
Goldreyer et al., 1999	49 socially responsible mutual funds and various samples of conventional funds from Lipper Analytical Services. From 1981 to 1997 (partial).	Portfolio selection strategy in which the portfolio manager specifically includes firms in his/her portfolio that conduct some positively regarded social policy and/or firms that have recently abandoned a policy that had some negatively regarded social component.	Jensen's Alpha, the Sharpe Ratio, and the Treynor Ratio.	Sample of socially responsible funds employing inclusion screens outperformed the sample that did not employ such screening.
Statman 2000	Firms from the Domini Social Index and the S&P500 (Standard & Poor). From 1990 to 1998.	DSI Criteria (See Sauer 1997).	Annualized Mean Returns, Annualized Standard Deviation of Returns, Alpha of the DSI with Other Indexes as Benchmarks.	The Domini Social Index, a socially responsible version of the S&P 500, performed better than the S&P 500. The raw returns of the DSI were higher than those of the S&P 500 during the 1990–98 period and so were their risk-adjusted returns.
Kreander et al. 2005	30 ethical funds and a sample of 30 "non-ethical" funds, from 1995 to 2001.	Ethical funds: Those which exclude one or more company groups from their portfolio for non-financial reasons (identified by the EIRIS).	The average weekly return, the standard deviation of these returns, Jensen's Alpha, the Sharpe Ratio, and the Treynor Ratio.	There is not a significant difference between ethical and non-ethical funds with the performance measures.
Schroeder 2003	16 German and Swiss funds, and 30 U.S. funds that concentrate on socially responsible investing. 10 specialised SRI indices. From 2000 to 2002.	Explanation of the ethical approach of each fund.	Jensen´s alpha.	Socially screened assets have no clear disadvantage concerning their performance compared to conventional assets. SRI funds and indices have a relatively high weight in small cap stocks.

STUDY	DATA SET	PERFORMANCE MEASURE AND DATA		MAJOR FINDINGS
		ENVIRONMENTAL	ECONOMIC	
Bauer et al., 2004	Canadian ethical and conventional mutual funds with domestic equity orientation only. From 1994 to 2003.	Criteria and funds from Globefund.com.	Jensen's alpha, multifactor analysis and conditional performance evaluation.	No significant difference in performance between ethical mutual funds and their conventional peers. On average, no evidence that the investment style of ethical mutual funds differs significantly from that of conventional mutual funds.
Bauer et al. 2005	103 German, UK and US ethical mutual funds and 4384 conventional mutual funds,. From 1990 to 2001.	Criteria (ethical screens) from Morningstar (US), EIRIS (UK) and Ecoreporter (Germany).	Jensen's alpha, multifactor analysis.	No evidence of a statistically significant difference in return between ethical and conventional mutual fund returns. Ethical mutual funds exhibit distinct investment styles and they tend to be more growth-oriented.

1 New York Stock Exchange.
2 Ethical Investment Research Services.
3 Council on Economic Priorities (USA).
4 Center for Research in Security Prices.
5 Greenhouse gas and ozone-depleting substances.
6 Really Essential Financial Statistics.

As a general conclusion, it is fair to say that the performance of SRI funds is comparable to that of conventional funds, and not worse as predicted by theory. However, the weaknesses of these studies should be noted. First, the financial success of existing funds depends heavily on the ability of fund management. Portfolio studies cannot easily separate these management effects from social or environmental performance effects. Second, in these analyses, only the average performances of funds are compared. Consequently, the specific form of the influence of environmental performance on the economic performance can hardly be separated from other influences like management of the fund, capitalisation, or regional peculiarities. The identification of specific effects requires econometric methods that include all control variables besides the variable of interest (environmental performance). Bauer et al. 2004, 2005 overcome partly this difficulty through the use of the Carhart's (1997) multifactor performance attribution approach. They also conclude that "any performance differential between ethical mutual funds and their conventional peers is insignificant".

b) Event Studies

The event-study methodology is based on the assumption that the capital market is sufficiently efficient to reflect the impact of all new information (event) on the future expected profits of firms (see Fama et al., 1969). The reaction to the announcement of an event is obtained by predicting

a “normal” return for each firm during an “event window” (usually the day prior to the event, the day of the event and a few days after the event), and then subtracting this predicted normal return from the actual return observed on those days of the event window. If there is a significant difference between the predicted return and the observed return (i.e., an abnormal return), one can conclude that the event had a significant influence on the stock price. Normal returns are usually predicted using a version of the Capital asset Pricing Model (CAPM).

Many researchers have examined the effects of environmental “events” on stock market performance. The events considered have generally the character of negative news, such as information about illegal spills, prosecutions, fines, or the emission data related to the American Toxics Release Inventory (TRI). Only a few studies consider the effects of positive news, such as information about companies winning environmental awards (Klassen and McLaughlin, 1996; Yamashita et al., 1999). Some authors, like Blacconiere and Patten (1994), Jones et al. (1994) and White (1996), have considered only one major event (the Bhopal explosion, the Exxon Valdez Oil spill). We surveyed 14 event studies. Table 4 presents the main characteristics and results of these studies. All of them show that stock markets react significantly to good or bad environmental news.

TABLE 4
Event studies

STUDY	DATA SET	PERFORMANCE MEASURE AND DATA		MAJOR FINDINGS
		ENVIRONMENTAL	ECONOMIC	
Muoghalu et al. 1990	128 lawsuits by the RCRA(1) and Superfund act against firms, and 74 case settlements between 1977 and 1986.	Illegal dumping of hazardous waste material.	Firms equity reaction to lawsuit, measured by the rate of return on security. Daily abnormal return.	Statistically significant 1.2 percent loss in market value (on average) at the filing of the lawsuit. No significant abnormal return at the settlement.
Blacconiere and Patten, 1994	47 chemical firms with operations similar to Union Carbide’s. Five-day window from Dec. 3, 1984 (trading day 0) to Dec. 7, 1984.	Union Carbide’s chemical leak in Bhopal, India during December 1984.	Daily abnormal returns.	Significant negative intra-industry reaction occurred. Firms with more extensive environmental disclosures in their financial report prior to the chemical leak experienced a less negative reaction.
Lanoie and Laplante,1994	47 events involving Canadian firms between 1982 and 1991.	Environmental prosecutions and suit settlements (fines).	Daily abnormal return.	The stock value declined on the day of the announcement of suit settlements resulting in fines (-2%).

STUDY	DATA SET	PERFORMANCE MEASURE AND DATA		MAJOR FINDINGS
		ENVIRONMENTAL	ECONOMIC	
Jones et al., 1994	The stock of Exxon after the Valdez Spill.	Announcement of the Exxon Valdez oil-spill accident.	Abnormal Returns.	The stock of Exxon suffered a sustained drop over 6 months with a value loss ranging from 4.7$ billion to 11.3$ billion.
Hamilton, 1995	Firms reporting under 1989 TRI (2) regulations; disclosure based on 1987 data (n = 463).	TRI emissions for 1987.	Abnormal Returns.	Significant negative returns on the day TRI emissions data was first announced.
Klassen and McLaughlin, 1996	162 Firms in manufacturing, utilities and oil and gas extraction 1985-91.	Environmental awards in NEXIS database; negative news: chemical and oil spills, gas leaks or explosions.	Stock-market abnormal returns (CRSP, NYSE and AMEX) data.	Significant positive or negative cumulative abnormal returns for the (–1, +1) event window of 0.63% and –0.82%, respectively.
White 1996a	Six listed firms that signed CERES principles	Signing up to the CERES principles (until mid- 1995).	Abnormal excess stock market returns.	Significant positive excess returns of +1.05% for signatories.
White 1996b	Firms from the oil industry, March 1988 to September 1989 (n = 1 to 10).	Announcement of the Exxon Valdez oil-spill accident.	Average abnormal returns for various event windows.	Significant cumulative negative excess returns for Exxon (-20% over 90 days).
Blacconiere and Northcut, 1997	72 chemical industry firms. From February 22, 1985 - October 20, 1986.	Event study leading to enactment of SARA(3) 1985-1986.	Daily abnormal market returns.	Chemical firms exhibited an overall negative reaction to announcements of specific legislative actions leading to SARA.
Lanoie et al.,1998	19 Canadian firms which appeared on the list of worst polluters of British Columbia. From 1990 to 1992.	List of the polluting firms from Ministry of the Environment of British Columbia (BC, Canada).	Daily abnormal market returns.	Abnormal loss at the second appearance on the list, and if a firm has more than one plant appearing on the list.

STUDY	DATA SET	PERFORMANCE MEASURE AND DATA		MAJOR FINDINGS
		ENVIRONMENTAL	ECONOMIC	
Khanna et al. 1998	91 publicly traded firms in the chemical industry, listed in the TRI. From 1989 to 1994.	TRI requires facilities to report the quantities of on-site toxic releases to air, water, land, and underground injection and the quantities of off-site transfers on a chemical-specific basis.	Daily abnormal market returns.	Firms known to be polluters: a one-time provision of environmental information may not generate significant reaction among investors. Repeated provision of environmental information does lead to statistically significant negative abnormal returns.
Yamashita et al., 1999	30 companies reported in an article published in Fortune magazine (Fortune, July, 1993).	Announcement of Environmental Conscientiousness scores published in Fortune magazine (Fortune, July, 1993).	Daily abnormal market returns and long term study.	Short term: environmental performance does not appear to be a very important issue to stock investors. Long term: there is a positive relation between environmental conscientiousness and stock returns.
Cram and Koehler, 2000*	Firms reporting under 1989 TRI regulations; disclosure based on 1987 data (n = 463).	TRI emissions for 1987.	Abnormal Returns.	The aggregate average TRI impact on stock price is no longer significant. However, there is a significant market reaction to the news for each individual firm on the event day.
Dasgupta and Laplante, 2001	48 firms from 4 developing countries. From 1990 to 1994.	Environmental news collected from important newspapers.	Daily abnormal market returns.	Capital markets from developing countries appear to react to the announcement of specific positive and negative environmental events.

1 Resource Conservation and Recovery Act.
2 Toxic Release Inventory.
3 Superfund Amendments and Reauthorization Act.

Event studies offer strong econometric results of causality when they are limited to one or at most five trading days after the event to ensure that confounding news do not interfere with the effect of interest. In general, these studies show that financial markets respond significantly in the short run to environmental news. For example, in the five trading days following the 1986

explosion at Union Carbide's plant at Bhopal in India, the market value of that company fell by approximately $1 billion or 27.9% (Blacconiere and Patten, 1994).

Can we conclude from such results that bad environmental performance is leading to an increase in the cost of capital? The potential reaction of capital markets to new information on companies' environmental impact can actually be explained by two basic scenarios[26]. In the first one, new information on liabilities (potential litigation or fine) or clean-up costs enters the market at time *t* causing the stock price to drop because investors expect reduced earnings and dividend payments. The return is unchanged if the fundamentals of the company do not change. This is the cash flow news effect best tested using the event study methodology.

Such a short-run negative price movement does not, however, mean that the price of capital is going up. Short-term price changes do not provide enough substance to formulate buy/sell strategies unless we believe that the environmental performance to be a matter for day traders constantly arbitraging. We can thus turn to the second scenario, the "green investor effect"[27] that may come through the so-called green mutual funds mentioned above. Finding out about bad environmental news, these investors may worry about the quality of the management of the companies involved and decide to sell "dirty" stocks, which reduces their price. Investors'green preferences are likely to be more long-lived, and thus require multi-period analyses to be well investigated (using panel data and regression analysis for instance). In this second scenario, as the price of "dirty" stocks falls, investors will demand compensation with a higher return and, therefore, the cost of capital for such companies will increase, and it will be more difficult to raise new funds. In the context of our discussion on the impact of better environmental performance on the cost of capital, it will be central to find out which of these two scenarios dominates.

Other limitations of the event-study methodology have been recognized in the literature. For instance, Cram and Koehler (2000) have criticized the studies on TRI on the ground that they failed to account for contemporaneous correlations across sample companies, which arise when all of them experience the same event (TRI release) on the same day. Re-analysing Hamilton's (1995) results, Cram and Koehler used Zellner's (1962) seemingly unrelated regressions (SURE) and found that the aggregate average TRI impact on stock prices is no longer significant (although, there is a significant market reaction to the news for each individual firm on the event day). Along the same lines, many authors (e.g. McWilliams and Siegel ,1997, and McWilliams et al., 1999) have noted various methodological concerns with event studies. They criticize the use of the CAPM model, which is often chosen to predict normal returns. They also question the assumption of investors' rational expectations, arguing that investors could be biased.

[26] This part of the presentation is largely influenced by Koehler (2006).

[27] Heinkel et al. (2001) demonstrate that the number of green investors is key to affecting stock prices as in the second scenario. They design an equilibrium model of capital markets assumed to be efficient with two types of risk-averse investors: neutral investors with low sensitivity to environmental concerns and green investors. These investors are faced with opportunities to buy more or less "dirty" stocks. After conducting sensitivity analysis on various parameters, they find that a key determinant of the environmental performance of companies is the fraction of green investors. They conclude that it is necessary to have at least 25% green investors to change corporate environmental investment strategy.

c) Long-Term Studies using Regression Analysis

In these studies, investigators examine, through regression analysis, the relationship between certain characteristics of companies (including their environmental performance), and their economic performance. In contrast to event studies, the analysis concentrates on characteristics of companies and not on specific news about the companies. In contrast to portfolio analysis, researchers do not examine a portfolio of stocks, but single stocks. We identified 12 studies in this category, which are summarized in Table 5. Different measures of economic performance (Tobin's Q[28], return on assets, return on sales, return on equity) and environmental performances (TRI emissions, ISO 14001 certification, the adoption of other international environmental standards) are used in the various studies.

TABLE 5
Long term studies

STUDY	DATA SET	PERFORMANCE MEASURE AND DATA		MAJOR FINDINGS
		ENVIRONMENTAL	ECONOMIC	
Hart and Ahuja 1996	127 firms in SIC listed in S&P 500 with SIC codes below 5000, 1989–92 (economic performance) and 1988–89 (environmental performance).	Emission reductions based on TRI from IRRC(1) Corporate Environmental Profile data.	ROS, ROA and ROE.	Pollution prevention activities have a positive influence on financial performance within 1–2 years; ROE takes longer to be affected than ROA and ROS.
Feldman et al., 1996	300 firms within the Standard & Poor's index.	Implementation of an environmental management system, (EMS) evidences of progress toward reducing pollutant generation and minimizing liability exposure.	Firm's systematic risk, measured by its given stock's volatility relative to the overall market (Beta).	Firms that improve their EMS and their future environmental performance are able to increase shareholder wealth by perhaps as much as 5 %.
Cordeiro and Sarkis, 1997	523 firms in SIC codes 2000–3999 reporting under TRI regulations, 1991–92 (environmental performance), 1993 (economic performance).	Change in the sum of TRI releases that are recovered, treated or recycled on-site and releases from remedial actions or catastrophic or similar events.	One-year and five-year industry analyst earnings-per-share growth forecasts from Zacks Investment Co.	High environmental performance is found to be significantly negative related to one-year and five-year earnings-per share growth forecasts (based on industry adjusted values).

[28] Tobin's Q is the ratio of the market value of a firm divided by its replacement cost.

Study	Data Set	Performance Measure and Data		Major Findings
		Environmental	Economic	
Russo and Fouts, 1997	243 firms rated by the Franklin Research and Development Corporation (FDRC). From 1991 to 1992.	Scores given by the FDRC.	Return on assets.	Higher environmental performance is associated with higher financial performance.
Butz and Plattner, 1999	65 European firms from various industries with an environment rating by the Swiss bank Sarasin May 1996 to May 1997.	Environmental rating classifying firms into 1 of the 4 categories '+ +', '+', '– ' and '– –', based on a number of quantitative and qualitative environmental performance criteria.	Jensen's (i.e. systematic, market risk adjusted excess returns); ratings.	Significant positive regression coefficient for environmental rating variables (three dummy variables) for a subset of firms in environmentally intensive industries (n = 39).
Dowell et al., 2000	89 companies from the S&P 500 that are involved in manufacturing or extractive industries.	Companies all maintain production facilities in potential pollution havens, thus they have the opportunity either to adhere to a single worldwide standard or to adapt their standards to the weaker environmental jurisdictions.	Individual market value of firms.	Firms choosing to employ their own strict global environmental standard abroad were found to have an individual value of approximately $10.4 billion higher than those using less stringent U.S. standards.
McWilliams and Siegel, 2000	524 firms, listed in the KLD data and compustat. From 1991 to 1996.	Firm included, or not, in the DSI 400.	Return on assets.	There is no impact of being socially responsible on financial performance if R&D investments are included in the regression.
Konar and Cohen, 2001	321 firms in the SIC codes 2000–3999, which are listed in S&P 500, 1988–89.	Aggregated mass of toxic chemicals emitted normalised with firm revenues (TRI-based) and number of environmental lawsuits pending.	Tobin's q (as dependent variable in several specifications) and intangible asset value of firms.	Every 10 % increase in TRI is associated with a decline of 34 millions $ in stock value.
King and Lenox, 2001	652 US firms for the period from 1987 to 1996.	Total emissions of toxic pollutants (relative to the mean emissions of the firm's sub-industry).	Tobin's q.	Positive effect of environmental performance on economic performance, but not for all specifications.

STUDY	DATA SET	PERFORMANCE MEASURE AND DATA		MAJOR FINDINGS
		ENVIRONMENTAL	ECONOMIC	
Thomas, 2001	297 firms listed by the Croydon Borough Council. From 1995 to 1997.	Implementation of an environmental agenda.	Monthly stock market return relatively to a risk free asset.	Adoption of an environmental policy by polluting firms is correlated with superior shareholders return.
Wagner at al., 2002;	37 firms from the European paper industry.	Index based on SO2, NOX and COD emissions.	ROS, ROE and ROCE.	Significant and negative relationship between environmental index and economic performance (ROCE), No impact with the other measures.
Hibiki et al., 2003	573 publicly-held firms in the manufacturing industry in the first section of the Tokyo Stock Exchange on March 31, 2002.	Adoption of the ISO14001certification.	Tobin's q.	Introduction of the ISO14001 certification system contributes to a statistically significant increase in the market value of the firms in the manufacturing industry by 11% to 14%.

(1) Investor Responsibility Research Center

Nine studies show that better environmental performance is associated with better economic performance. Two studies show no impact, while one concludes on a negative relationship. Generally speaking, one can say that these results suggest that a bad environmental performance is associated with a lower economic performance on a long-term basis, which implies an increase in the cost of capital.

A difficulty with these studies is to determine the sense of the causality. A first plausible mechanism is that environmental performance leads to changes in financial performance, as postulated in the studies discussed above. Second, the sense of the causality may be reversed, where profitable enterprises can afford to invest in environmental performance. Third, there may be another omitted factor, influencing both environmental and economic performances, that is responsible for the apparent statistical relationship.

Apart from Wagner et al. 2002, very few attempts have been made to tackle the question with simultaneous equation models. Their results are mitigated: i) with two out of three measures of economic performance that they use (ROE, ROS), there is no significant relationship between environmental and economic performance; ii) with the other one ROCE[29], they find a negative relationship. More of that work is needed in the future.

Furthermore, some researchers have addressed the concern that omitted variables influencing both phenomena may be at play. They have noted that gains in companies financial

[29] ROCE: return on capital employed.

performance associated with environmental performance may be coincidental (interact) with the adoption of the latest technology (Dowell et al., 2000), an environmental management system (Schaltegger and Synnestvedt, 2002), or an increase in R&D expenditures (McWilliams and Siegel, 2000).

Another possible criticism is the common use of the TRI as an indicator of the environmental performance. In particular, TRI does not provide any information about emissions from non-toxic substances (like carbon dioxide emissions), or through energy or material use. Finally, in the perspective of sustainable development, through which one is concerned with the triple bottom line, environmental, social and economic, it would be useful to also look at the influence of social performance on economic performance[30].

Overall, what can we conclude from this extensive literature regarding the impact a better environmental performance on the cost of capital? It seems clear that a large majority of the portfolio analyses, event studies and long-term studies show that a better environmental performance is associated with a better financial performance (or, at least not worse). As we discussed, the long-term studies are the most reliable and, in spite of their weaknesses, they offer converging evidences to support that a lower environmental performance is leading to a lower financial performance, and thus to a higher cost of capital.

Furthermore, it is clear that in, day-to-day life, banks (and insurers) examine the environmental performance of their clients and adjust lending conditions according to that performance. It is also evident that green or ethical mutual funds are getting more popular, which is providing green firms with a better access to capital. Thus, we can conclude that **there is strong evidence that a better environmental performance does not lead to an increase in the cost of capital; there is some relatively convincing evidence that a better environmental performance leads to reduction in the cost of capital. Large firms with shares exchanged on the stock markets are more likely to benefit from these gains.**

vII) Cost of labour

Some authors also argue that a better environmental performance can lead to a reduction in the cost of labour. As stated by two managers of Ciba Geigy: “An improved image of the company results in an improved atmosphere in the workplace and hence in higher productivity…People who feel proud of the company for which they work not only perform better on the job, but also become ambassadors for the company with their friends and relatives, enhancing good will and leading to a virtuous circle of good repute. Of course, this is impossible to quantify, but it seems clear that it is true…This is especially important in recruiting talented young scientists, managers, and engineers, many of whom…simply would not work for a company with a poor social and environmental reputation…No one wants to work for a dodgy company, and the brightest people obviously have a choice” (Reinhardt, 1999, p. 11). Similarly, De Backer (1999) provides anecdotal evidence that ISO14001 has significant effects on the employees’ morale and productivity much more than the ISO 9000 certification.

If this is the case, a better environmental performance can indeed reduce the cost of labour by reducing the cost of illnesses, absenteeism, recruitment and turnover. A few analysts, like Lankoski (2006), have put forward this argument in favour of labour cost reduction. However, even if the argument is fairly compelling, to our knowledge, there is no direct empirical evidence supporting it. In order to provide empirical evidences of labour cost reductions associated with

[30] For an example of such a study, see Rennings et al. (2006).

less pollution, one would need a data base including observations on proxies of labour cost, like turnover rates and absenteeism, and data on environmental performance. We are not aware of a database including all these elements, a new survey would have to be designed to test this hypothesis. Such an exercise would certainly be helpful.

However, indirect evidence exists from surveys indicating that employees and unions constitute an important source of pressure on firms to reduce pollution. For instance, Henriques et al. (2007) find that workers' pressure is a significant determinant of a firm's commitment toward a better environment (e.g., the implementation of an EMS). Grolleau et al. (2006) show that improving human resource management is a significant motivation for the decision to obtain the ISO-14000 certification.

What types of companies could eventually reach labour costs reductions associated with a better environmental performance? Basic intuition suggests the following: i) companies whose emissions can affect the health of their workers; ii) companies that seek to attract young well educated workers, like scientists and engineers, and iii) companies located in areas where sensitivity to environmental concerns is more acute (e.g., West Coast of North America).

IV. Conclusion

The conventional wisdom about environmental protection is that it comes as an additional burden for companies imposed by the government. However, during the last decade, this paradigm has been challenged by a number of analysts who suggest different ways through which improving the environmental performance of a company can be associated with better economic performance. To be systematic, it is important to look at both sides of the balance sheet.

First, a better environmental performance can lead to an increase in revenues through the following channels: i) a better access to certain markets; ii) the possibility to differentiate products and iii) the possibility to sell pollution-control technology. Second, a better environmental performance can lead to cost reductions in the following categories: iv) regulatory cost; v) cost of material, energy and services (this refers mainly to the Porter hypothesis); vi) cost of capital, and vii) cost of labour. For each of these seven possibilities, we presented the mechanisms involved, a systematic view of the empirical evidence available, and a discussion of the gaps in the empirical literature.

The objective of the paper was not to show that a reduction of pollution is *always* accompanied by a better financial performance, it was rather to show that the expenses incurred to reduce pollution can be partly or completely compensated by gains made elsewhere. Through a systematic examination of all the possibilities, we also wanted to identify the circumstances most likely to lead to a "win-win" situation, i.e., better environmental and financial performance. These circumstances are summarized in Table 6.

TABLE 6

POSITIVE LINKS BETWEEN ENVIRONMENTAL AND ECONOMIC PERFORMANCE – A SUMMARY	
Possibilities to Increase Revenues	**Circumstances Making this Possibility More Likely**
i) Better Access to Certain Markets	More likely for firms selling to the public sector: (construction, energy services, transport equipments, medical products, and office equipments).
ii) Possibility to Differentiate Products	More likely when: a) credible information about the environmental features of the product; b) willingness-to-pay by the consumers; c) barrier to imitation. Wide range of possibilities.
iii) Selling Pollution-Control Technologies	More likely when firms already have R&D facilities.
Possibilities to Reduce Costs	
iv) Regulatory Cost	– More likely in industries that are highly regulated like chemical, pulp and paper, metallurgy, etc.
v) Cost of Materials, Energy and Services	– More likely when a) firms have a flexible production process; b) firms are in highly competitive industries where optimization of resources is important; c) firms are in industries where market-based environmental policies are implemented
vi) Cost of Capital	– More likely for firms with shares exchanged in stock markets.
vii) Cost of Labour	– More likely for: a) firms whose emissions may affect the health of their workers; b) firms that seek to attract young well-educated workers; c) firms located in areas where sensitivity to environmental concerns is important.

This table allows us to have in mind a taxonomy of the firms who are more likely to benefit from a better environmental performance. For instance, an energy company located on the West Coast of the U.S., and selling a part of its production to public authorities, is very likely to make a financial gain from an improvement in its environmental performance. However, farms which, in general, are less scrutinized by regulators, are not on the stock market and have few

employees are less likely to benefit from a better environmental performance (Lanoie and Llerena, 2007).

It is interesting to try to "forecast" how robust our arguments will be in the next future. On one hand, even if there is a wide range of possibilities, one must recognize that there are probably diminishing returns[31]. Concerning cost-reducing opportunities, it is likely that there are some obvious "low-hanging" fruits, but that more efforts are required after these fruits have been harvested. Similarly, the sales-enhancing potential of environment performance improvements is probably limited by the willingness-to-pay of consumers for environment-friendly products. On the other hand, many of the trends we described in this paper are likely to become more and more important in the future like green consumerism, social investing or employees looking to be hired by green companies.

Other temporal aspects are worth discussing. It is common for investments in environmental performance that, while many costs occur in the short term (e.g., green buildings, extra cost for the purchase of a hybrid car, etc), the associated benefits are uncertain and may arise only in the longer term. Due to this temporal asymmetry in the distribution of costs and revenues, the period over which the economic impact is examined has an important effect on the outcome of the examination. In most cases, the smaller is the discount rate, the longer is the time-period considered, the more win-win situations there are. Managers focusing on short-term returns for impatient shareholders are thus less likely to identify profitable opportunities to reduce pollution[32].

Lastly, from a sustainable development perspective, which is oriented toward a triple bottom line (economic, environmental, social), it would also be interesting to examine the social performance of firms and its relation with economic performance[33]. We have deliberately tried to avoid to mix environmental and social performance, although in certain areas, like ethical mutual funds, it is almost impossible. This is a difficult topic since there is no clear consensus on the measures of social performance but, given the importance of sustainable development in the minds of politicians, NGOs, academics, it is certainly worthwhile making the effort.

[31] See also Wagner et al. (2001)
[32] This discussion draws on Lankoski (2006). Ambec and Barla (2006) show that (time-inconsistent) present-biased managers tend to postpone the investments needed to harvest those "low-hanging fruits".
[33] See in particular, Margolis and Walsh (2001) and UNEP (2001).

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