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RESEARCH IN BUSINESSS AND RURAL SOCIOLOGY

Innovation at the service of the environment and business performance

Is the reduction in the environmental impact of firm's activities to the detriment of their business performance? This is not always the case when we take into account the productivity gains linked to the environmental innovations. A series of works combining theoretical argument, case studies and empirical analysis from survey data were mobilized to find out whether innovating may prove to be profitable for the firm to answer environmental constraints. In identifying the circumstances and mechanisms involved results suggest that if environmental policies favour innovation, they are generally expensive for the firms subject to it.

In 2000, three dairy and meat producers from Champagne-Ardennes (grouped in a Farmland Association) started a project of manure methanisation and cogeneration of biogases in order to heat their residences and produce electricity with a view to reselling. This project launched in 2005 was inspired from the latest technologies in Germany and Luxembourg. It has a twofold interest. On the one hand, it generates an additional source of income thanks to the use of a by-product from dairy production. The 201,400-euro investment, subsidized up to 118,500 euros by various organizations (General Council, ADEME, Crédit Agricole), should be made profitable within 6 years through heating savings and reselling electricity to EDF. On the other hand, it reduces the impact of business activity on the environment. Indeed, manure methanisation reduces emissions of methane and nitrous oxide (N_2O), two powerful greenhouse gases, which contribute to the global warming. Moreover, manure treated by methanisation is almost odourless, reducing olfactory pollution for the neighbouring areas.

Here is the description by Lanoie and Llerena (2007) of one of the examples of green technology, which simultaneously improves business and environmental performances. Innovating to reduce polluting animal waste emissions, contamination risks or rare natural resource consumption (fossil energy, water) can be profitable from an economic point of view. Gains in productivity or market shares associated with better environmental management sometimes compensate for the initial cost or the investment in new technology.

The Porter hypothesis

The so-called "Porter hypothesis" is based on this idea. This hypothesis was put forward by Michael Porter, Professor of strategic management at Harvard University, and his co-author Claas van der Linde. Basing themselves on similar cases of "green" innovations, which turned out to be profitable, the authors state that pollution is often a waste of resources and that a reduction in pollution generally stems from an improvement in the productivity with which resources are used. This implies that stricter but sustainable environmental policies (in particular, using economic tools such as green tax or exchangeable licences) should encourage firms to innovate in order to reduce waste sources and thus cut their costs. So stricter environmental policies may combine social profits (reduction in environmental damage) and private profits for the firms that are subject to them. Still according to this hypothesis, these private profits would often outweigh the costs borne by polluters to conform to the environmental regulation (change in technologies, production organization). We may represent the reasoning underlying the Porter hypothesis by the end-of-text diagram.

The Porter hypothesis met with great success in political debate, especially in the United States, because it refutes the idea that environmental protection may only exist to the detriment of economic growth. It was used as an argument to convince the business world of the appropriateness of an environmental rule, which consists in having firms pay for the cost of their pollution. According to Porter, ruling in this way may be of benefit to all, as it would generate optimal Pareto situations or "win-win" situations.

However, the Porter hypothesis was questioned by economists as it challenges the paradigm of profit maximisation on which corporate rationality is based. If it is actually possible to increase firms' regulated profits, it means that, out of any regulation, profit opportunities would systematically be ignored.

This controversy gave rise to abundant economic literature on the theoretical bases underlying the Porter hypothesis. In critical review of this literature, Ambec and Barla

(2007) conclude that the Porter hypothesis is compatible with the hypothesis of corporate rationality only in the presence of a "market failure" other than the externality generated by pollution. Among market failures, which lead to a situation compatible with the Porter hypothesis, let us mention the information asymmetries within firms or markets, spill-overs between firms in the process of R&D, market power or contractual incompleteness. The environmental regulations may result in reducing inefficiencies due to the above market failure (in addition to that linked to pollution) for everyone's profit, including regulated firms. But this optimal Pareto situation proves to be the exception rather than the rule. It depends on a lot of factors, particularly the choice of environmental policy tools. So a closer analysis of the circumstances leading to the concretisation of the Porter hypothesis is necessary.

What do the facts say?

Several research works have attempted to test the Porter hypothesis empirically. Two approaches emerge from this empirical literature, analysed by Ambec and Lanoie (2007). The first intends to analyse the link, which Porter supposed positive, between the intensity of environmental regulation and innovation (that is to say the first link in the chain described in the diagram). This condition of the Porter hypothesis, necessary but not sufficient, is sometimes mentioned as the "weak" version. Innovation is assessed through R&D expenses (input) or through the number of registered patents (the product of R&D activity). These works deduce that there is a positive link, but sometimes weak or nonexistent, between both elements. The second approach *in fine* assesses the impact of environmental regulation on the business performance of the firm (the link between the first and last steps in the chain described in the diagram). The "strong" version of the Porter hypothesis is tested, however, without looking at the cause of this variation in performance (linked to innovation or to another cause). The firm's business performance is often measured by its productivity. As a rule, studies come to the conclusion that there is a negative link between the intensity of environmental regulation and productivity, which tends to reject the Porter hypothesis.

A recent work from Lanoie et al. (2007) combines both approaches, assessing for the first time the whole Porter causality chain. The data used come from a unique OECD survey carried out with more than 4,000 companies located in seven industrialized countries (see frame). The method consists in assessing **three equations** by proceeding in two stages with adequate instruments ("two-stage least squares"). Following the diagram's relationships, the three dependent variables are environmental innovation, environmental performance and the business performance. The instrumental approach is motivated by the potential "simultaneousness" relationship between these three variables, that is to say the existence of unobserved factors such as managers' preferences, company structure and so on, simultaneously influencing the three variables.

In the **first equation**, we try to explain environmental innovation (see frame) through a general index of severity of the environmental regulation perceived, linked to certain types of environmental policies (tax, technological or performance standard) to which control variables are added such as the country of origin, sector, age, market power and others, and as an instrument, the percentage of companies in the same sector and in the same country which conduct environmental R&D. The **second equation** explains an index of environmental performance (see frame) from the same explanatory variables, to which are added, on the one hand the predicted value of the firm's environmental performance thanks to the previous assessment, and on the other hand an "instrumental variable" defined as the average environmental performance of the companies in the same sector in the same country. In the **third equation**, we regress business performance perceived by the production unit (see frame) on the same variables, to which are added the values predicted by the assessment of both previous equations.

The **results** first show a positive and significant link between the **perceived severity of** *environmental regulations and environmental innovation*; this is coherent with the weak version of the Porter hypothesis. But does this positive influence of environmental regulations on innovation have a knock-on effect on the *business performance* in an *indirect* way (the complete *causality* chain from left to right)? A positive answer to this question comes from the results of regression, which seeks to explain the business performance. We show that the "predicted" environmental innovation from the first regression has a positive and significant impact on business performance (at the 10% threshold). So for the first time, the whole of the causality chain suggested by the Porter hypothesis[1] is empirically pinpointed. However, when assessing this same third equation, we note that the severity of the environmental regulation also has a *direct* negative effect on business performance.

Faced with the existence of both antagonistic effects, what is then the "net" effect of the severity of environmental policies on the business performance of firms? In other words, which effect dominates, between the *positive* effect of the environmental regulation, which *indirectly* acts on performance via the environmental innovation, and the *direct* effect of the same environmental regulation, which negatively acts on performance? Our first assessments show that the direct negative effect of regulations prevails over the indirect positive effect! To use Porter's own words, **the business gains linked to environmental innovation do not offset for the costs due to regulations**. Environmental regulations lead to a net economy cost. There is no "global miracle".

Among the other results, the second regression, which intends to explain companies' environmental performance, clearly indicates that the severity of environmental policies contributes to increasing environmental performance, which is reassuring about the effect expected of these policies! If we examine the relative efficiency of the various environmental policies (tax, technological norm or performance standard), it appears that performance norms are distinct because of a stronger effect than other instruments on innovation and environmental performance. By setting an environmental performance objective to be reached without imposing a precise way of doing so, a

[1] The detailed results of these assessments are available in Lanoie and al. (2007): http://www.grenoble.inra.fr/Docs/pub/A2007/gael2007-07.pdf

performance norm, which is quite a flexible instrument, appears to perform better than the other technological norms, which involve a specific method of pollution-control.

Lastly, both the theoretical analyses and the empirical works seem to indicate that the Porter hypothesis is the exception rather than the rule. Although environmental regulations favour the firms' environmental innovation and performance, they only rarely improve their business performance, or only in certain contexts, which we must clarify.

All the same, does it pay to be green?

Although the Porter hypothesis does not seem to hold in general, there are several circumstances where a better environmental performance, imposed or not by environmental regulations, may benefit the firm. Ambec and Lanoie (2007) suggest seven channels through which a better environmental performance increases incomes or reduces costs. These possibilities are summed up in the table.

For each of the seven items [i) to vii)], we describe the principle at stake and systematically present the available empirical evidence in order to have a better idea of the phenomena. Moreover, for each of the seven cases, we identify the firms or sectors most likely to report business profits through better environmental performance. It appears that there are several opportunities to transform the environmental constraint into appropriateness. Such a case frequently occurs in the agricultural sector.

The Porter hypothesis and farmers!

In the agricultural sector, there are lots of opportunities to simultaneously reduce pollution and costs through optimisation of fertilizers, pesticides and weedkillers or through soil preservation. For instance, for seven years in the Rhone valley, the Pradal farm has conducted an experiment of technique without ploughing over 300 ha (Lanoie and llerena, 2007). This technique's main benefits are a 10 to 15% cut in nitrogen input, a 33% drop in the value of equipment and one farm employee less, fuel consumption divided by two, which corresponds to a cut in costs of type v) to vii) of the table. Furthermore, the live reserve of water in soils globally improved and in drought times yields are higher by 5 to 15% in relation to the other farms in the same area, with a lesser water supply.

All the same, the potential to increase income by switching to organic farming is not insignificant. A Quebec survey from 2004 compares the financial results of 26 organic dairy farms with 569 conventional dairy farms (Lanoie and Llerena, 2007). It deduces that organic farms are more profitable. They show a lower percentage of expenditure and a higher operating profit. Among other things, the lower expenditure is linked to smaller purchases of fertilizers and higher income is due to a higher price of organic produce through product differentiation and the access to markets such as local authorities which buyorganic produce, these two elements corresponding to an increase in incomes of type i) and ii) of the table.

Conclusion and prospects

Our research on the Porter hypothesis concludes that there is no "global miracle"; which is to say that innovations due to more demanding environmental policies do not systematically compensate all the costs linked to compliance with these policies. Yet opportunities to improve both the firms' environmental performance and business performance are numerous. These opportunities include costs reduction due to better effectiveness in the sense described by Porter (cut in supply quantities, drop in energy costs, etc…), but also in the form of increased business opportunities leading to higher incomes.

Obviously, the works presented here will not close the debate on the Porter hypothesis. Several research areas must still be explored, such as those mentioned at the Grenoble Conference "Environment, innovation and performance" (2007). First of all, since it is difficult to assess the severity of environmental policies, some approaches, assessing their effects in a non parametrical way, are promising, such as the use of stochastic frontiers of production. Moreover, the impact of more flexible environmental policies suggested by Porter, (like green taxes or tradable permits), merits attention. Until recently, these flexible policies were relatively little used, but are starting to become popular and, therefore, worthy of study. Last, better management modes may also contribute to environmental performance without being very expensive. However, we know little about what prompts firms to adopt new modes of management.

Beyond the Porter hypothesis, the more general topic of the links between the environment, innovations and performances seems to be increasingly pertinent. Indeed, many environmental issues raise important challenges as far as innovation and technologies are concerned. Whether it is a matter of reducing greenhouse gas effects, preserving natural resources, producing energy from renewable resources (such as biofuels, for instance), reducing the environmental impacts of transport or improving waste management, new technologies have played a major role in achieving the progress observed and their role is as important in terms of new processes as in terms of new products.

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Table:

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

Frame: a unique survey!

The data used in the work by 2007 Lanoie et al. come from an OECD survey of 4,144 large companies with more than 50 employees, from the manufacturing sector, located in seven countries (Germany, Canada, United States, France, Hungary, Japan, Norway). Twenty-four manufacturing sectors, including agribusiness and the timber industry, are represented. The data covers the managers' perception of the severity of environmental policies, environmental innovation, environmental performance and business performance, making it a unique base of information to test the Porter hypothesis.

The variable assessing environmental innovation is a dichotomous variable (0 or 1) equal to 1 when the company has a research budget specifically assigned to environmental matters and 0 otherwise. Thus, the first equation is assessed by a Probit.

The "environmental performance" variable is built from the answers to two questions regarding the importance and evolution of five potential environmental impacts of the production unit: the use of natural resources (water, energy and so on.), the production of solid waste, the rejection of effluents, local and regional atmospheric pollution, and global pollutants (greenhouse gas effects). The second equation is assessed by double least squares.

The "business performance" variable ranges from 1 to 5 according to the answer to the following question: How do you assess the global profitability of your company over the last three years? Regarding the nature of this variable, the third equation is assessed according to a multinomial ordered Probit.

Diagram: Mechanism Underlying the Porter hypothesis

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