Environmental Regulation, Comparative Advantage and the Porter Hypothesis

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Short Abstract :
Empirical surveys find no significant impact of environmental regulation and environmental costs on international competitiveness. In the literature, we can find three hypotheses on the impact of environmental regulation. For the industrial-flight and pollution-haven hypothesis, there is no clear empirical evidence. We show that this is a logical consequence of the principle of comparative advantage. Another explanation can be that developed countries have very diversified exports and most surveys do not link regulation to specific products. We therefore investigate the link between export diversification and two measures of labor productivity. The Porter hypothesis - the third or revisionist hypothesis in our overview - states that environmental regulation can lead to improved competitiveness. Many authors only find 'anecdotal' evidence for this hypothesis but we show that when regulation is linked to specific products, there is clear evidence for the Porter hypothesis. In our model, we work with international CFC-regulation (chlorofluorocarbons) and the export performance of CFC-using industries like refrigerators, freezers and air conditioning machines. A final section does focus on the tradition of cartelization that has been typical in many of the old - and 'dirty' - industries.

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Non-technical Abstract
Empirical surveys find no significant impact of environmental regulation and environmental costs on international competitiveness. This is rather surprising because considerations on competitiveness strongly influence many national and international environmental agreements and measures. In the literature, we can find three hypotheses on the impact of environmental regulation. For the industrial-flight and pollution-haven hypothesis, there is no clear empirical evidence. We show that this is a logical consequence of the principle of comparative advantage. This principle is used to illustrate that for each product that a country exports, the impact of environmental costs will be different. Since these products all have different comparative advantages, some will loose their advantage as a result of new regulation while other products will be able to maintain their advantage. As a consequence, a country will never loose an important part of its exports as a result of an increase in regulatory costs.

This could however be the case for countries that have very concentrated trade flows and are as such vulnerable for product-specific regulations. Another explanation can be that developed countries have very diversified exports and most surveys on environmental regulation and competitiveness do not link regulation to specific products. Most surveys work with total exports or with sectoral exports. Again, this is not the best approach since sectors like the chemical industry make hundreds or even thousands - depending on the level of analysis - of products that are on a different way vulnerable for changes in environmental regulation.

In a next section, we investigate the link between export diversification and two measures of labor productivity. Other variables in our analysis are income pro capita and the inward FDI-stock. We find that productivity explains diversification of exports. We can conclude that the most productive countries have the most means to cope with costly regulation while they are the least vulnerable for new regulation. The weak impact of regulation on competitiveness can be explained in part by this finding.

The Porter hypothesis - the third or revisionist hypothesis in our overview - states that environmental regulation can lead to improved competitiveness : efficient regulations may actually stimulate innovation, efficiency gains, industrial growth and competitiveness. Many authors only find ‘anecdotal’ evidence for this hypothesis but we show that when regulation is linked to specific products - the best approach for estimating the direct impact of regulation -, there is clear evidence for the Porter hypothesis. In our model, we work with international CFC-regulation (chlorofluorocarbons) and the export performance of CFC-using industries like refrigerators, freezers and air conditioning machines. Since all industrial nations signed the Montreal Protocol on Substances that Deplete the Ozone Layer, they all had to impose regulation in line with the agreed CFC-phase-out schedules. We find that the two countries with the most pro-active CFC-policy (the US and Denmark) experienced better export growth for their CFC-using industries than countries that reacted later and with less convincing instruments.

In a final section, we focus on the tradition of cartelization that has been typical in many of the old - and ‘dirty’ - industries in our analysis. Due to their market power, these industries had the capability to influence the regulatory process. Drastic actions that strongly harmed competitiveness are as such very scarce..

1.Introduction

Since the 1960s, the institutionalisation of environmental issues gained momemtum and developed into a World Environmental Regime. Compared to international trade policy, this environmental framework is of very recent date and as such subject to constant changes. This ‘green’ regime has however its origins in the late nineteenth century when the first international environmental associations and environmental treaties saw light. After World War II, environmental intergovernmental organizations were established and the first national environmental ministries date from the early 1970s (Meyer, 1997). Since then, environmental regulation developed into a complex and diversified body that affected all layers of society. In terms of financial impacts, pollution abatement and control expenditures in most industrialized countries increased on average to some 2-3% of GDP (Kalt, 1988).

In an era of globalization, measured by increasing transnational trade and investments, it is not surprising that industrial leaders and policy makers are very sensitive to a possible deterioration of national competitiveness as a consequence of environmental regulation that is relatively more stringent compared to other nations. The argument of competitiveness has not only been used to oppose national and supranational environmental legislation (like the US Clean Air Act or the proposed European CO_2-tax), it also strongly influenced negotiations on global issues like stratospheric ozone, acid rain and climate change. The 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change has clearly been shaped by considerations on possible losses of competitiveness vis-à-vis developing countries that would not incur similar greenhouse abatement expenditures.

Is competitiveness a political issue because of an accellerating globalization or is there clear evidence of a negative impact of environmental regulation on national or regional economic performance? This needs further research because if undesirable impacts of stricter regulation are recognized in advance, environmental policies can be redesigned to reduce them to acceptable levels.

In the next sections, we will present the hypotheses on the impacts of environmental regulation. After an overview of the empirical findings, we will focus on the essence of comparative advantage and add aspects of product differentiation and of export diversification. Our findings will be used to shape the optimal framework for an empirical test of the Porter hypothesis for the sectors that are directly influenced by specific environmental regulation or agreements.

We conclude with some considerations on the nature of competition among major ‘dirty’ industries.

2.The hypotheses on environment and competitivity

From an impressive body of surveys (more than hundred (Jaffe, 1995)) on the link between environmental regulation and competitiveness, we can extract three hypotheses :

- the *industrial-flight* hypothesis : environmental regulation would push an increasing number of industries out of the advanced industrial countries ;
- the *pollution-haven* hypothesis : less-developed countries would use lenient environmental regulations to attract multinational industries ;
- the *Porter* hypothesis : efficient regulation may stimulate innovation, productivity and competitivity.

The first two hypotheses were formulated and investigated by Leonard (1988). He concluded that there is 'no reason to believe that the major trend in international comparative advantage - the gradual shift of many heavy industries such as steel from the most industrialized to rapidly industrializing countries - is being significantly heightened by stringent environmental regulations in the most advanced countries (p.231).'
Recent data on foreign direct investment showed however that this gradual shift of many heavy industries may have reversed during the 1990s. This has been documented by Bhagwati (1997) and when we classify industries to their environmental impact (dirty, clean and medium industries, as measured by pollution abatement expenditures as a percentage of output), we found that the inward foreign direct investment-position in the US of the group of 9 'dirty' industries grew by 67.1% over the period 1991-1995 , while the cumulative growth for the medium group (9 other industries) was only 7.2% and the 'clean' group even lost foreign investments in the US. This is a remarkable result because output and gross fixed capital formation evolved similarly for the three groups of industries. A possible explanation is the large difference in investments in Research and Development (R&D). We found that the 'dirty' group (with the exclusion of primary metal industries) increased its investments in R&D by 45% over the period 1988-1992, while on average the clean industries slightly reduced their R&D-expenditures. Table 1 summarises the results.

Table 1 - Changes in FDI, capital formation and R&D in the US

Group of Industries Variable	Dirty	Medium	Clean	P-value (Anova)
Growth (%) of inward FDI-position	+67.1	+7.2	-8.2	0.0036
Growth of (Inw-Outw)FDI-balance	+267	-53.5	-104.8	0.1029
Growth in Gross Fixed Cap. Form.	-0.9	+3.4	+3.0	0.566
Growth in Research&Development	+45.4		-0.7	0.0288

Source : Albrecht, 1998

There are also indications from business practices that limit the relevance of the pollution-haven hypothesis. With the increase in global environmental scrutiny, environmental performance becomes increasingly transparent. In some countries, firms include (worldwide) environmental liabilities in their annual reports. Securities and Exchange Commission rules

in the United States, for example, dictate that companies clearly must state potential environmental liabilities.
In the aftermath of the Bhophal disaster at a Union Carbide subsidiary in India, a growing number of American chemical plants have made it company policy to apply the same rules and environmental standards worldwide (Cairncross, 1992). Dunning (1993, p.539) refers to a German study which demonstrated that 90% of the firms surveyed claimed to use the same environmental techniques in developing countries as in West- Germany. If this principle would be adopted in national legislations or in supranational agreements, some environmental incentives to move to less stringent countries might be eliminated.
Some industrializing countries and their business associations explicitly demand the use of clean production technologies in investment projects of multinationals. The Thailand Leadership Initiave solicited commitment of multinational companies to halt their use of ozone-depleting substances and the Vietnam Pledge by more than forty multinational companies from seven countries was to invest only in modern, environmentally acceptable technology in their Vietnam projects (Fujimoto, 1997)

3.How have the three hypotheses been tested?

We gave already some indications on the (limited) validity of the pollution-haven hypothesis for the US. Broader overviews can be obtained from Rausher (1997), Jaffe (1995), Markandya (1994) and The World Bank (1992, edited by Patrick Low).
The World Bank (p.13) draws a number of tentative general conclusions from the analysed surveys :

- dirty industries have expanded faster in developing countries than the average rate for all industries but this pattern can merely reflect growth or industrial migration as well ;
- pollution abatement and control expenditures by firms do not appear to have a significant effect on competitiveness in most industries which suggests that national differences in environmental regulations have not been a major explanatory factor in the changing international pattern of location of dirty industries ;
- pollution intensity per capita appears to fall as income rises (the green Kuznets-curve) ;
- the effects of growth and trade liberalization on environmental quality are ambiguous ;
- fast-growing economies with liberal trade policies have experienced less pollution-intensive growth than closed economies, and
- firms seem to have good reason not to transfer dirtier technologies to lower income countries when they invest in these countries.

Markandya (1994) answers the related question ‘is free trade compatible with sustainable development’ with a (slightly) qualified ‘yes’. Most conflicts between environmental and trade concerns can be resolved by the choice of appropriate instruments in global trade frameworks like the World Trade Organization (WTO).

In their analysis of the maquiladora programme, Grossman and Krueger (1992) find that pollution abatement costs were not a significant determinant of US-Mexican trade. Jaffe (1995) concludes that there is relatively little evidence to support any of the three hypotheses. He states that the literature on the Porter hypothesis remains one ‘with a high ratio of speculation and anecdote to systematic evidence (p.157).’

Some possible explanations for the weak empirical link are also given : limited ability to measure the relative stringency of environmental regulations, the relatively small cost of complying with environmental regulation, relatively small differences between regulations in the US and in the other western industrial democracies and the fact that multinationals should be reluctant to build less-than-state-of-the-art plants in foreign countries.

Similar conclusions are presented by Rauscher (1997). He also stresses two important problems intrinsic to the input-output or Leontief approach that is used in many surveys. First, most analyses are only bivariate and neglect as such many other factors. Secondly, pollution abatement data are only considered for the country under consideration but not for its trading partners. This is a practice that not only depends on the problems with comparing national regulations, but also on the limited information on the enforcement of regulations in many countries with a less explicit environmental profile. There is also the fact that many environmental investments have a ‘once-and-for-all’ character, especially when industries opt for end-of-pipe clean-up investments (UNIDO, 1990). When regulators impose stricter standards, industries make an adapting investment. This means that the environmental expenditures are relatively high in the first years after the new regulations. As a result, when cost profiles or export performances of industries are compared, the period of analysis is crucial when different countries have different periods of regulatory implementation. And this problem is probably too complicated to be captured with lead- and lag-variables in empirical surveys.

Rauscher also mentions the survey of Rowland and Feiock (1991) that concludes that environmental regulation affected investment decisions of the chemical industry in the United States. The relationship is non-linear : there should be a threshold value of pollution-abatement expenditures below which dislocation effects of changes in environmental policy cannot be observed.

A general remark on these (and most of the other) surveys is that environmental costs are rarely directly linked to specific products. Most authors work with ‘dirty’ industries like steel, chemicals and paper. This approach reduces environmental costs to a part of general overheads (like administration). We think it is better to link environmental costs to specific products like detailed chemical subsectors or specific steel or paper products. In a later test of the Porter hypothesis, this product-specific link will generate good results.

A crucial survey (cited in Jaffe), for its methodology and interpretation by other authors, has been made by Kalt (1988). Kalt gives an overview of the environmental regulatory costs and calculates these for 78 SIC-industries making use of input-output tables. Starting from a Heckscher-Ohlin-Leamer framework, Kalt explains the variation in net export performance for 1977 by using as independent variables pollution abatement costs, capital, R&D, human capital and unskilled labor. Without a correction for heteroscedasticity, the environmental variable (pollution abatement) was only significant for manufacturing and not for all input-output industries. With the heteroscedasticity correction, pollution abatement proved only to be significant for manufacturing without chemicals. The coefficient was negative as expected. The other significant variables were R&D and human capital. Rather surprisingly, the sign of human capital was negative. Kalt concludes that environmental regulations had in 1977 a clear negative impact on US trade performance.

Most authors that review the survey of Kalt do not come to the same conclusions. They do not focus on the year 1977 of which Kalt clearly states that, at that time, the fraction of the resources in the US devoted to abatement were 'at the upper end of the distribution' of private sector investments in pollution control in 10 industrialized countries. This suggests however that if the same analysis was made 5 or 10 years later, the results could be different.

Jaffe (1995) states that 'it is troubling however, that the magnitude and significance of the effect [of the environmental variable] was increased even further when the chemical industry was excluded from the sample, because this is an industry with relatively high environmental compliance costs (p.143).' If the impact of pollution abatement would be significant for all industries (what it almost is with a t-statistic of -1.93), most authors would probably agree with Kalt. And this is a recurrent objective of most of the empirical surveys : there should be a clear link between environmental regulation and the (export) performance of *all* 'dirty' industries. In our opinion, this is not a good test.

Since the starting point of many of these surveys is an interpretation of the H-O-framework, why are the results not interpreted according to the fundamentals of the principle of comparative advantage? If a country performs worst in all industries (for reasons of extremely high environmental costs), it will still have a comparative advantage in some of those industries while other activities might be taken over by countries with less stringent regulations.

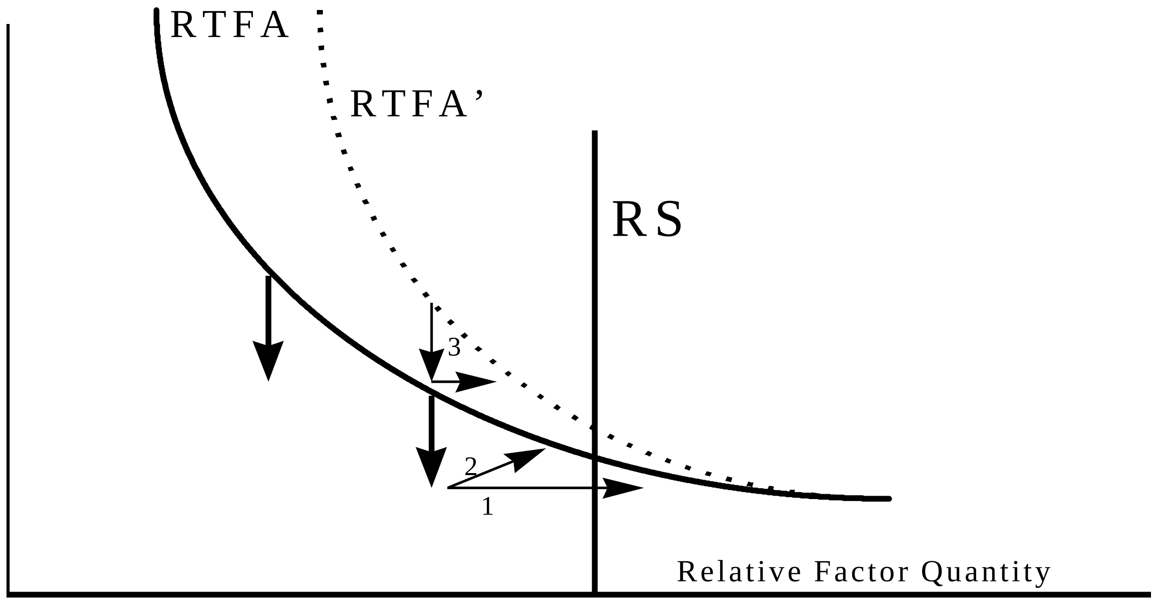
The findings of Kalt could be interpreted as a clear comparative advantage of the US in chemicals compared to the other industries that have to face environmental expenditures. Similarly, if there is clear evidence of a relocation of wood furniture firms from California to Mexico, or from Germany to Poland, this should not be considered as a 'too specific' case, not suitable for generalizations. Wood furniture is clearly one of the industries in which the comparative advantage is lost to countries that offer a mixture of cost advantages of which environmental costs are a part of. That other sectors do not migrate is not a counterargument but an expected logical consequence of the H-O-framework. In a next section, we will discuss the weight of a sector like wood furniture in total trade performance.

4.Comparative advantage and environmental costs

The main conclusion of the Heckscher-Ohlin model (and extensions like Leamer, Vanek) is that countries export commodities that are relatively intensive in the relatively abundant factor

in exchange for imports of commodities that are relatively intensive in the relatively scarce factor. There are however many empirical surveys that do not confirm this conclusion.
This depends to a large extent on the assumptions that are crucial in shaping the H-O conclusions. Authors like Staiger (1988) find evidence of misspecifications of the H-O-V model and conclude that endowments affect trade in important ways not captured by the H-O-V relationship.
For the introduction of some specific aspects of environmental regulation in the framework of comparative advantage, we opted to start with the Ricardian presentation as in Krugman and Obstfeld (1994). Figure 1 enables us to compare the industrial-flight hypothesis with the sweatshop labor argument that is used to seek protection from foreign low-wage competition. It seems to be obvious that 'green' protectionists use very similar arguments.
Figure 1 shows a ranking of *n* products according to their relative home productivity advantage.
The products with the highest relative advantages are located in the upper left part of the relative total factor advantage (RTFA). As we include not only labor but also capital and nature, we do not use the term relative labor advantage but relative total factor advantage. RTFA presents a derived world demand for the products of Home.

Figure 1 - Comparative advantage and environmental costs



The supply of Home is determined by the relative prices of the factors used in the production. In this Ricardian world, prices depend on factor availabiliy. The relative supply (RS) of

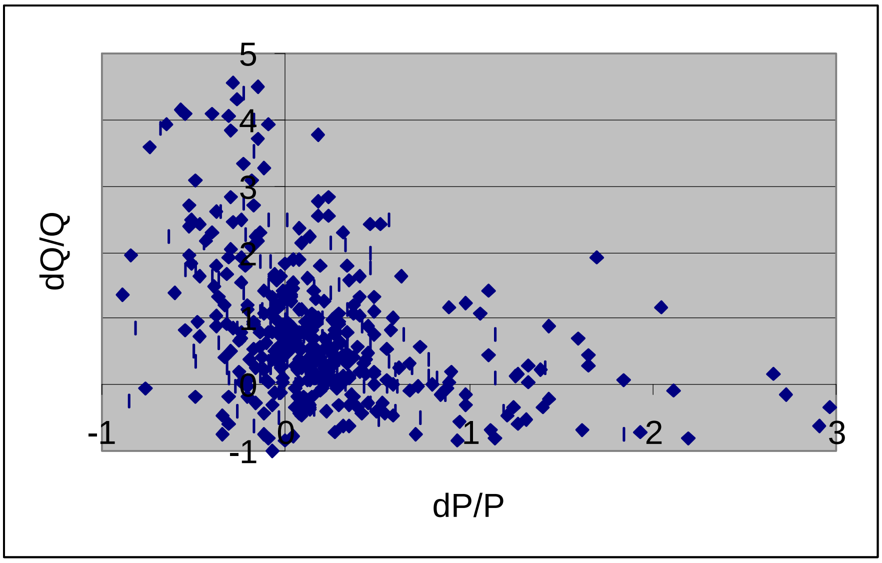
factors determines whether a product with a relative productivity advantage can be sold on the world markets at a competitive price or not.
Suppose an environmental regulation is imposed. Pollution abatement is the result of labor and capital, production factors that are not available anymore for the production of manufactures. If we assume the abatement to be expensive - Porter (1995) suggests that abatement efforts can increase efficiency and hence outweight expenditures - , environmental regulation will lead to a reduction in RTFA.
For each 'dirty' product, the lower RTFA can be presented by an arrow. We indicated only two of those products in figure 1 but there can be many more. Depending on the initial level of RTFA, only for the product for which the new RTFA falls under the intersection with RS, Home will loose its comparative advantage to Foreign. This is case 1 in the figure. The other product or industry (like chemicals in the survey of Kalt) will maintain its comparative advantage after the implementation of the regulation.
If we introduce a second period in the analysis and include the fact that environmental investments are high for specific periods of first implementation (like the late 1970s for the US), it can be that total environmental costs will fall back in the next period. This is situation 2 in figure 1. The recovery of RTFA might compensate the initial loss of the product to Foreign.
In this case, the relocation will depend on information on the duration of the RTFA-loss, the possibility to absorb these costs and the cost of relocation.

Another possibility is presented by situation 3 in figure 1. Productivity advantages are always measured by differences in factor productivity for identical products. This is a hypothesis that is problematic in analyses that cover longer periods. Product changes are typical for most sectors. Each year, new types of manufactured products, chemicals, paper or glass are introduced.
When product lifecycles run shorter and non-price competition gains importance, product-upgrading and positive differentiation can compensate for increasing costs. This is typical for electronics and chemicals, especially in rich economies that value product differentiation. The high R&D-intensity of these sectors can indicate that product characteristics are very important to maintain and improve market share. Since R&D is still largely concentrated in the industrialized countries, the compensation of regulatory costs by product improvements and upgradings can be a partial explanation for the weak empirical link between environmental regulation and export performance.
The dotted line RTFA' in figure 1 shows the new relative demand after a general upgrading as a result of succesful product differentiation and continuous investments in R&D in Home. Evidently, not all products share the same relative upgrading. We assumed that the specific product in our example could maintain its relative position.
If after such a shift from RTFA to RTFA' an environmental regulation is imposed (case 3), a fall in RTFA' will not result in a shift of the comparative advantage in Foreign like it did in the first case. Continuous upgradings can compensate for frequent and expensive regulatory

changes.
In figure 1, we worked with downward arrows to illustrate the introduction of environmental costs. Similar results could be obtained when shifting RS to the right : pollution abatement extracts factors from the pool of available resources for production.
These three aspects of environmental costs illustrate that it is far from easy to integrate all these considerations in a conclusive empirical test.

We looked at the relevance of the last case (i.e. differentiation) for chemicals. Quality improvements can be reflected in price developments. If increasing prices result in export growth, or in very small export losses, this can indicate product upgradings. Another explanation can be that foreign producer prices increased even more than the domestic producer prices. We analysed relative price and quantity changes of US chemical exports for the period 1989-1995. At the 5-digit level, the OECD International Trade by Commodities Statistics includes data for more than 400 chemical products. Since the chemical industry has the highest pollution abatement expenditures, stricter environmental regulations could increase producer prices and influence international competitivity. We see in figure 2 that three-fourth of US chemical products showed increased exports (1995-export quantities compared to 1989-quantities). Notice that the number 1 on both axes represent an increase of 100% over this short period of six years.
For 40% of the chemical products, export prices decreased and this led to increased exports (negative elasticity). But for the chemical products with increased export prices, we see the same positive development of exports. For 82 chemical products, prices increased by more than 50% and only for 24 of these products, export quantities were below the 1989-level. The correlation between relative price change (dP/P) and relative quantity change (dQ/Q), the average price elasticity, was negative but very small (-0.19903). Price increases had only a very limited negative impact on exports. The combination of higher prices and higher exports can be an indication of the positive valuation of product characteristics (improvements and upgradings).

Figure 2 - Relative changes in export prices and quantities for US chemicals and related products, 1989-1995



But if we assume that some industries like wood furniture migrate to or grow faster in developing countries, the fundamental question remains : is this the result from a pattern of growth in developing countries or is it the result of differences in environmental regulation?
The first scenario could be the result of a pattern of global convergence in industrial activity.
Empirical research can not confirm a trend of global convergence. Verspagen (1995) concludes in his historical overview on convergence of national pro capita incomes that there is no global trend. In the post-war period, convergence only took place in the OECD countries.
More related to our analysis of comparative advantage, Bernard and Jones (1996) find for 14 OECD countries during 1970-1987 that manufacturing (including the dirty industries) shows little or no evidence of convergence in labor or multifactor productivity, even after the introduction of a new measure of multifactor productivity.
For other sectors, especially services, they found strong evidence in favor of convergence.
When we compare OECD countries to developing countries, the differences are expected to be more pronounced. As a general indicator of convergence or divergence, we can use indices of export diversification. Does export diversification follow the same pattern in OECD and developing countries or not? In the a section, we will link this index to labor productivity.

5.Diversification of exports

Most surveys cited in section 3 analyse exports of chemicals, paper, iron and steel and some manufactured goods. We already suggested that analyses at the level of the product should be preferred. Only a few surveys make use of sectoral classifications at the 2-digit level. Using the OECD International Trade by Commodities Statistics ITCS/SITC, Revision 3, this level of detail (2-digit) results in trade-data for 72 products or sectors. At the 3-digit level, the OECD ITCS includes trade data for 312 products, at the 4-digit level 1170 products are defined and the 5-digit level includes data for 2831 products. The chemical industry should be the most dirty industry. But what part of the chemical industry is dirty and are there clean chemical subsectors? At the 4-digit level of analysis we have already 141 chemical products, at the 5-digit level even 443.

Some manufactured goods are also considered as dirty. But, as an example, wood furniture is only one of the 249 products at the 4-digit level, and one (with subclassifications) of the 804 products at the 5-digit level.

We can conclude that surveys at the 1 or 2-digit level can only generate rather crude approximations of what is the impact of environmental regulations on 'dirty' industries.

A second conclusion is that the loss of a significant part of the wood furniture industry is very bad news for the concerned workers and firms but for the record of national export performance, it will not have a dramatic impact. If the US or Germany would loose over a period of 20 years their comparative advantage for some 20 to 30 chemical subsectors, is this a problem if over the same period 40 new subsectors have been created and developed, or if for some 15 other subsectors the comparative advantage was regained? Recoveries of lost exports are not exceptional ; the product 'sulphides : polysulphides' (ITCS 52315) was imported in the US since 1978 and it entered US exports only in 1989 ($ 12.8 mill.).

UNCTAD calculates an index of export diversification at the three-digit SITC, Revision 2. This index is based on 239 products and is Hirschmann-normalized to calculate values ranking from 0 (perfect diversification, no concentration) to 1 (complete concentration, no diversification), according to the formula :

$$H_j = \frac{\left(\sum_{i=1}^{239}\left(\frac{x_i}{X}\right)^2\right)^{\frac{1}{2}} - \sqrt{1/239}}{1-\sqrt{1/239}}$$

where j is the country index, x_i the value of exports of commodity i and X is total exports of country j.

If we compare indices of diversification for 1980 and 1994, table 2 shows that there is a striking difference between developed and developing countries. The right colum calculates the relative improvement in terms of more diversification (here a reduction in H_j).

Table 2 - Export diversification/concentration of some selected countries, 1980-1994

Country	1980	1994	% change
Canada	0.513	0.410	+20
Japan	0.546	0.417	+22
Germany	0.386	0.270	+30
United States	0.428	0.272	+36.5
United Kingdom	0.333	0.223	+33
France	0.345	0.267	+23
Nigeria	0.771	0.903	-17
Venezuela	0.710	0.767	-8
Malaysia	0.640	0.521	+19
Mexico	0.523	0.397	+24

Source : UNCTAD, 1997, Handbook of International Trade and Development Statistics 1995, p.203

From the 25 rich countries in the UNCTAD-classification, only Norway and Ireland developed a more concentrated export pattern over the period of analysis. From the 105 other countries, only 54 could reduce their export concentration and most improvements were rather modest (like Paraguay: from 0.884 to 0.879). Only the recent industrialising countries like Mexico, Singapore, Malaysia and Korea showed improvements comparable to developed countries.

6.Explaining export diversification

The slow improvement - if we assume there is an improvement - of the export concentration of developing countries is clearly linked to the ability to build up a comparative advantage in new products. Developed countries can use this ability to overcome the negative impacts of pollution abatement expenditures and other regulatory costs. The fundamental determinant of comparative advantage is labor or total factor productivity.

We therefore want to explain the variation in export diversification in 1994 for developed and developing countries by introducing labor productivity as one of the independent variables. Another variable in the analysis is the impact of foreign direct investments (FDI) in the host country because we assume that a high inward stock of foreign capital should improve export diversification. Data on inward investment stocks in 1994 were taken from UNCTAD.

As export diversification is clearly linked to consumer preferences, there should be a significant influence of the average national income. Data on GDP pro capita (1994) were also derived from UNCTAD.

For the data on labor productivity, we followed the Cobb-Douglas approach by Hall and Jones (1997). The main problem with Cobb-Douglas production functions (see formula 6.1) that are used to make comparisons of productivity across many countries, is that the parameter   mostly differs. As a result, entering identical inputs will then produce different output, mostly for reasons of different technological infrastructures. Therefore, we need to find a measure to capture different technological capabilities across countries.
Hall and Jones introduce in the production function the amount of human capital-augmented labor (H_i) and a 'basic' labour-augmenting measure of productivity (A_i).

$$Y_i = K_i^{a} (A_i H_i)^{1-a}$$

Output Y_i in country i is then produced according to
where K_i denotes the stock of physical capital.
The value of the human capital-augmented labor is depending on the years of schooling for each country.
Hall and Jones rewrite the production function in terms of output per worker (y_i =Y/L), with L_i as homogeneous labor ;

$$y_i = \left(\frac{K_i}{Y_i}\right)^{\frac{a}{1-a}} \frac{H_i}{L_i} A_i$$

The decomposition is written in terms of the capital-output ratio rather than the capital-labor ratio.
A value of $\forall = 1/3$ is used which is broadly consistent with national income accounts.
Table 3 presents the results for some countries of the decomposition. Labor productivity and all the contributing factors are expressed as ratios to US values to make comparisons more meaningful.
The presentation offers the advantage that differences in total productivity can be explained by differences in inputs. Italian workers work with less 'human capital skills' and this explains why their total labor productivity is lower than in the US. The Italian 'basis' labor productivity is however higher.
The low Japanese productivity might be a surprise. Probably this is due to the low productivity of services in Japan that is known for its high ratio of employees to clients in the lower levels of the distribution chain.

For 107 countries we found data for all the variables. In the regressions, reported in table 4, the dependent variable was calculated as 1 minus the UNCTAD-value of export diversification. A high (new) value means a high level of export diversification. This makes it more comfortable in the later interpretations of the signs in the OLS estimates.

Table 3 - Productivity calculations : ratios to US values

Country	Y/L	(K/Y) $^{/(1-)}$	H/L	A
United States	1.000	1.000	1.000	1.000
Canada	0.941	1.002	0.908	1.034
Italy	0.834	1.063	0.650	1.207
Germany	0.818	1.118	0.802	0.912
France	0.818	1.091	0.666	1.126
Singapore	0.606	1.031	0.545	1.078
Japan	0.587	1.119	0.797	0.658
Mexico	0.433	0.868	0.538	0.926
India	0.086	0.709	0.454	0.267
Kenya	0.056	0.747	0.457	0.165
Average, 133 countries	0.289 (st.dev. 0.265)	0.854 (st.dev. 0.241)	0.564 (st.dev. 0.163)	0.502 (st.dev. 0.320)

Source : Hall and Jones, 1997, p.28

Since data were available for total and ‘basic’ labour productivity (Y/L and A), we opted to work with two sets of variables. In the first regression (1), we used the Y/L-values as labour-productivity, while A-values were taken for the second regression (2).

We included in the analysis also a dummy to capture the dependency of some countries on oil and minerals. Typical oil countries have a limited export diversification but relatively high average incomes and concentrated foreign investments in resource extraction. We gave a value 1 to coutries for which the export of fuels and minerals accounted for more than 25% of their exports. Data were taken from UNCTAD.
The dummy is not just another indication of export concentration because even some developed countries are relatively specialized in the exports of natural resources. In the Australian exports, fuels accounted for 19.1% and ores and metals for 17.3% in 1995. For Norway, the two percentages are 47.3% and 8.7%. For Saudi Arabia, fuels account still for 90% of total exports.
The correlation between the dummy and the other variables in the analyses was low (between - 0.00036 and -0.14855). A much higher threshold for the dummy (like oil and minerals account for 75% of exports) would of course result in a high correlation between the dummy and export diversification. The results are presented in table 4. None of the models showed indications of heteroscedasticity (Goldfeld-Quandt test and White’s general heteroscedasticity test).

Table 4 - OLS estimates for export diversification (107 countries)
(t-statistics in parentheses, 5%-level of significance)

Variable	(1) *OLS with Basic Labor Productivity (A)*	(2) *OLS with Total Labor Productivity (Y/L)*
Constant	-0.2262	-0.0754
	(-4.391)	(-2.381)
LN(GDP pro capita)	0.0213	
	(2.173)	
Labor productivity	0.1279	0.2840
	(2.416)	(6.201)
LN(Inward FDI-stock)	0.0412	0.0399
	(8.333)	(8.400)
Dummy (fuels & minerals)	-0.1094	-0.1097
	(-5.139)	(-5.322)
Adjusted R^2	0.7454	0.7593
F-value	78.591	112.507
Sign.F	2.77E-30	2.25E-32
Number of observations	107	107

In the second regression, the variable LN(GDP pro capita) was excluded because this resulted in a clear case of multicollinearity. In a first estimate of the regression, we found contrary to our expectations, that the coefficient of LN(GDP pro capita) was not significant (t-statistic : -0.2225) and the sign was negative. The very high correlation (0.886) between Y/L and LN(GDP pro capita) was responsible for this result. In regression (1) the basic labor productivity A clearly did not capture the same income-effect (in terms of available human and non-human capital). The correlation with LN(GDP pro capita) is not disturbing. The sign of the coefficient of LN(GDP pro capita) in (1) is positive and the t-statistic is good.
From the results it is clear that labour productivity (both total and 'basic') is a crucial factor in explaining export diversification. Using Y/L gave the best results. The high labor productivity in developed countries will as such guarantee high levels of exports for long periods of time. Total productivity is clearly linked to the level of income and this can explain why rich countries do not face *en masse* migrations of major industries. The results also show that inward FDI can help to improve export diversification. As expected, the sign of the dummy is negative.

7.The Porter Hypothesis

In the previous section, we illustrated that the diversified export patterns of developed countries are only to a very limited extent vulnerable for the negative impacts of

environmental regulation. This conclusion was in fact the expected result of the great differences in labour productivity and the interpretation of the Heckscher-Ohlin model.
Many authors do not consider the H-O-conclusions and link the not finding of a clear negative impact to the hypothesis articulated by Porter (1990,1995) : efficient regulations may actually stimulate innovation, efficiency gains, industrial growth and competitiveness. This is as such not an appropriate test of the latter hypothesis.
This positive effect of environmental regulation can be expected for the industries that directly benefit from stricter regulations like manufacturers of filters and purification equipment or importers of low-sulphur-content-coal. But also for firms in the steel, paper and chemical industry, there is clear case-evidence of reduced total costs as a result of investments in cleaner production methods (UNIDO, UNEP). For these firms, environmental regulation might bring a 'free lunch'.
There are however no surveys that present a general test of the Porter hypothesis for specific sectors or products. Some indications in favour of the Porter hypothesis for the US are offered by Stephen Meyer (1992). He finds that US States with strict environmental laws do not demonstrate poorer economic performance compared to less stringent US States. Jaffe (1995) suggests however that the conclusions of Meyer could indicate spurious correlation : the strongest nations can easily invest in environmental protection while other nations have other priorities. But this remark is of equal importance for any test because if the most competitive nations have the most effective and the most expensive environmental policy, can we ever expect to find clear evidence for the industrial-flight or pollution-haven hypothesis? Organisations like the International Institute for Management Development (IMD) present every year a ranking of national competitiveness that is frequently cited in the financial press. As could be expected, the countries with the clearest environmental profile are on top of this ranking.
The conclusions from the previous sections on the hypotheses of industrial flight and delocalisation are also valid for a test of the Porter hypothesis. Export gains or losses will only be relevant for some specific industries and it is important to work with national environmental regulations that are comparable. The regulations have to be installed and implemented at the same moment, for the same period of time and with similar environmental objectives. Other important considerations should be given to enforceability of the regulations and possible exceptions for specific firms or sectors.
All this conditions make it very difficult to find a general test-case for any of the three hypothesis. In our opinion, the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol), with subsequent amendments, could be an ideal test-case for the hypotheses.

7.1. The Montreal Protocol and policy responses

In 1974, the worldwide scientific community accepted the Rowland-Molina hypothesis that the thin layer of stratospheric ozone could be depleted by emissions of chlorine. After the announcement in 1985 of the existence of a ‘hole’ in the atmospheric ozone layer near the South Pole, worldwide concerns were almost immediately followed by clear actions by the international environmental community. The 1985 Vienna Convention for the Protection of the Ozone Layer was followed by the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. The Montreal Protocol imposed concrete obligations to reduce production and use of chlorine-based ozone-depleting substances (ODSs), with a grace period for developing countries. The most important ODSs are chlorofluorocarbons (CFCs), bromofluorocarbons (halons), methyl chloroform, carbon tetrachloride, methyl bromide and hydrochlorofluorocarbons (HCFCs).

Since 1987, new substances have been added and phase-out commitments have been seriously strenghtened. Export and import of controlled substances to non-parties were prohibited. A multilateral fund to support phase-outs in developing countries has been established.

Ten years after the signing, 162 countries did ratify the Montreal Protocol. Most developed countries ratified in 1988, countries like Argentina, Chile, Brazil and Poland followed in 1990 and the latest ratifications were made by Senegal in 1993 and Morocco in 1995 (UNEP, 1998). All new supplies of ODSs, except HCFCs and methyl bromide, were phased out by developed countries starting January 1, 1996. The respective phase-out deadlines for the latter are 2030 and 2010.

The ratification of the Montreal Protocol ensures that all developed countries face the same technological substitution costs at the same time and this is one of the conditions for an optimal test of any hypothesis on the impact of environmental regulation on specific sectors.

The phasing-out of CFCs had significant consequences for the producing chemicals firms and all the industries that use CFCs. Du Pont (US) was the worldwide leading firm in the production of CFCs with a global market share around 20%, followed by Elf-Atochem, Allied-Signal, ICI, Solvay, Hoechst, Ausimont, Daikin and some other firms. Du Pont played a crucial role in the implementation of the Montreal Protocol (Haas, 1992).

Already in 1979, the firm developed an in-house state-of-the-art atmospheric computer model to evaluate the potential problems associated with CFC emissions. This investment ensured the ability to evaluate the most recent scientific findings and to develop a pro-active strategic policy. In 1988 alone, DuPont spent more than $30 million for process development, market research, applications testing, and small-lot production of CFC substitutes (Haas, p.214) and shortly after the release of the Ozone Trends Panel report in March 1988, the company announced to completely phase out the production of CFCs before the end of the century (see appendix A for the actual position of DuPont). And of equal importance, DuPont would assist its customers in converting to chemical substitutes. The most important substitute for DuPont was HCFCs for which the company gained important patents already in the early 1980s (Howes, 1997). This proved the long-term view of Du Pont because it clearly did not opt to enjoy the higher profits on CFCs that would follow due to the enforced scarcity of chlorofluorocarbons. Since the sales by DuPont of CFCs totalled $600 million in 1987, The New York Times headed «Why DuPont Gave Up $600 Million».

By its announcement, DuPont accelerated the projected phase-out what resulted in less time

for its competitors to find the needed CFC-substitutes. It also increased the attractiveness of the substitutes (mainly HCFCs) that DuPont could present to its customers. The unilateral measures attributed also to the public image of the firm that was the target of several environmental pressure group actions around that time.
The impact of DuPont as the most important market-player is also visible in the American implementation of the Montreal Protocol. As a consequence of the Protocol, the US enacted mandatory controls on CFCs. In order to stimulate substitutions, the Congress passed an excise tax on certain ozone-depleting chemicals sold or used by the manufacturer, producer or importer (Westin,1997). The amount of the tax is determined by multiplying a base tax amount (that is every year increased) by an 'ozone-depleting factor' that reflects the potential ozone depletion of the chemical. This US Tax on Ozone Depleting Chemicals increased prices of CFCs significantly. HCFCs are excluded from the tax, despite their limited but clear ozone-depleting potential. Westin states that this is 'a questionable decision (p.36)'. DuPont, as a producer of HCFCs, clearly will not regret this exception.
In this perspective, it is interesting to note that the unlimited use of HCFCs is also strongly defended by the Air-Conditioning and Refrigeration Institute (ARI, Virginia). The members of ARI manufacture 90% of US production of refrigerators and air conditioning equipment. The ARI strongly opposed Congress proposals to establish an excise tax on HCFC, either on a per-pound basis or weighted according to ozone depletion potential. And after the European Union proposed, at the end of 1997, an accelerated phase-out of HCFCs by 2015, the ARI was one of the most active groups against this proposal. According to ARI (1998), the European proposal could disturb the transition by equipment owners away from the more environmentally-damaging CFCs. Besides, in 1996 the US consumption of HCFC was at 82% of the allowable cap amount.

Of course, the impact of industry on politics is not limited to the United States. In France, the Industry Ministry defended strongly the benefits of Elf-Atochem that tried to delay any substitution. Unlike DuPont, Atochem did not have substitutes that could be marketed in a very short period. The French environmental minister even denied in 1987 any definitive link between CFCs and ozone depletion (Haas, p.210). Similar practices are noticed in the Soviet Union, Japan and the United Kingdom.
In 1997, the Montreal Protocol is called by the World Bank (1997) 'the major bright spot in global environmental efforts'. Actual progress is being undermined by excessive CFC-production of lower quality in Russia and black market smuggling. Not every country has an effective enforcement programme to limit these practices (see appendix B for enforcement actions by the US Environmental Protection Agency). The World Bank, in collaboration with production factories and the Russian government, has developed a plan to eliminate all production of CFCs in Russia by the year 2000.

7.2. Export performance of CFC-using industries

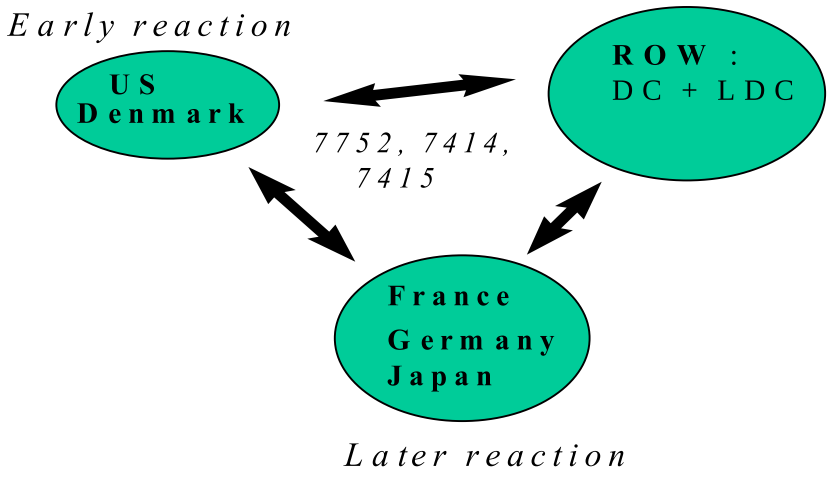
The substitution of CFCs provided an opportunity for firms that invested first in substituting R&D and could influence the political priorities and framework that followed the Montreal Protocol. Ozone policies can provide as such a competitive advantage for the early adaptors. One could see this as an illustration of the Porter hypothesis.
But assuming this pro-active strategy paid well for DuPont, did CFC-using industries also benefit from US policies? Otherwise, if only one industry or firm did benefit and other industries had to pay an 'expensive lunch', this is not at all a confirmation of the Porter hypothesis.
CFCs are mainly used for the production of refrigerators, air conditioning equipment, fire extinguishers, foams, aerosols and solvents (used to clean many types of electronic equipment like computers).
Manufacturers of refrigerating equipment will face the highest substitution costs, followed by the manufacturers of (mainly mobile) air conditioning equipment. In the US, these two sectors form a seventeen billion dollar industry which employs more than 136000 men and women (ARI, 1997).
Since this will be the case for all the industrial countries, we will investigate whether the active national ozone-policies of some countries did improve the competitivity of their main CFC-using manufacturers. If this should be the case, we have a product-specific confirmation of the Porter hypothesis.

According to Haas (1992, p.206), the US position during the Montreal negotiations was supported by Canada, Denmark, Finland, the Netherlands, New Zealand, Norway and Sweden. Most countries of the EC-12, led by Britain and France, favoured only a production cap to minimize the costs to their CFC producers. In the analysis, we therefore take the US and Denmark as the countries that favoured a pro-active strategy. Like the US, Denmark has also a tax on CFC and halon, a statutory order gradually banning the use of ODSs for specific purposes and a development programme to support non-ODS technology (Danish EPA, 1995).
We selected France, Germany and Japan as the countries that were more hesitating about the phase-out of CFCs. For France, we referred already to Elf-Atochem, while the Japanese feared especially the ban of CFC-solvents in their computer industry. The five selected countries represent a significant part of world trade in the related sectors.
Since the protocol went into force on 1 January 1988, we will analyse changes in bilateral trade flows of these five countries to their major trade partners. These trade partners differ of course for each country but it is important to note that they contain also countries like Canada, Sweden, Norway, Finland, the Netherlands and New Zealand that also favoured an early phase-out policy. The other developed countries (Italy, Switzerland, Belgium, Spain, ...) are also included in the analysis next to a number of developing countries like Morocco and Algeria (trade partners of France), Mexico, Brazil, Ecuador and Venezuela (trade partners of

the US).
We analysed trade flows for the three most important sectors that use of CFCs : household type refrigerators and food freezers (SITC-code 7752), refrigerators and refrigerating equipment, except households (SITC 7414) and air conditioning machines, self-contained and parts (SITC 7415). The industrial refrigerators are used in meat industries, cold storage warehouses, transport refrigeration, vending machines and retail food refrigeration.
We used OECD-data (Rev.3) for the period 1989-1995 (not all data for 1996 were available at the moment of the analysis). Only when trade exceeded a minimum level of $50000, the bilateral flows were included in the data sample.

Figure 3 illustrates the model with three poles ; US & Denmark vs. France & Germany & Japan vs. Rest of the World (ROW). The numbers inside the arrows (bilateral trade) indicate the SITC-codes of the concerned industries.

Figure 3 - Presentation of the model



The dependent variable in the analysis was the change in bilateral exports (Export-value in 1995/Export-value in 1989) for the country of origin. The independent variables, next to a constant term, were change in bilateral imports (that the country of origin imported from the country that bought its exports : dM =M1995/M1989), the relative change in bilateral exchange rate (from 1988 to 1994, as an index calculated using IMF International Financial Statistics : dER) and a dummy (Early-d) that expressed the early reaction and pro-active stance of the US and Denmark. For exports originating in these two countries, we gave the value 1 to the dummy. For the exports from France, Germany and Japan, the value for the dummy was 0.
Bilateral trade data have the advantage that they enable it to include changes in the bilateral exchange rate in the analysis. Furthermore, if we link the bilateral change in exports to the

bilateral change in imports, we find a bilateral rate of export-import-substitution. Since the CFC-substitution costs are high, we might expects possible substitutions of trade flows between different countries.
Since we work with very specific sectors, no other sectoral production data (like labour productivity and wage rates) were available for the many countries in the analysis. Compared to the use of absolute trade flows (like in gravity models), the explained variation in the sectoral growth rates of bilateral exports is rather good.
Table 5 summarizes the results for the three sectors, the total refrigerator sector (7752+7414) and the three sectors combined (7752+7414+7415).

Table 5 - OLS estimates for bilateral export growth (1989-1995) of three CFC-using industries (SITC-codes : 7752, 7414, 7415)
(t-statistics in parentheses, 5%-level of significance)
(7752 : household refrigerators and freezers - 7414 : industrial refrigeration - 7415 : air conditioning)

SITC-Sectors Variable	7752	7414	7415	7752+7414	7752+7414+ 7415
Constant	-0.9547	0.1994	1.3316	-0.4707	0.2637
	(-1.403)	(0.722)	(2.910)	(-1.308)	(0.889)
dM	0.0612	-0.0185	0.1952	0.0542	0.0834
	(2.177)	(-0.590)	(5.592)	(2.739)	(4.687)
dER	0.8978	0.4154	-0.1452	0.6492	0.3776
	(2.634)	(2.767)	(-0.606)	(3.475)	(2.425)
Early-dummy	2.5081	0.6887	-0.5022	1.6013	0.8087
	(3.991)	(2.787)	(-1.291)	(5.033)	(3.105)
Adjusted R^2	0.1865	0.1047	0.2510	0.1480	0.0880
F-value	8.8745	5.8345	14.2940	14.2097	12.1952
Sign.F	2.8E-05	0.0009	5.47E-08	1.63E-08	1.32E-07
Number of observations	104	125	120	229	349

The dummy that captures the early reaction of the US and Denmark is clearly significant in all sectors, except for the air conditioning equipment for which the sign of the dummy is even negative. This can be explained by the fact that the category of air conditioners in the SITC is rather general and also includes systems that are less depending on CFCs. For these installations, ozone policies have only an indirect effect. The results would differ if the SITC offered specific data on mobile air conditionings (like the types used in cars).
The significance and positive sign of the dummy in the other calculations proves that the two countries with a relatively active CFC-policy and relatively high CFC substitution costs could improve their competitiveness and hence export performance.
The benefits of the analysis at the product level are clear. Working with the totals of the three sectors (the column at the right in table 5) suggests that also for air conditioning equipment,

the strategy of early reaction in the two countries did stimulate exports. But this conclusion is only valid for the refrigerating sectors. And it is obvious that without export data for refrigerators (at the 4-digit level: 7752), working with household type equipment (SITC-code 775) or electrical machinery (SITC-code 77), would not enable to test the impact of CFC-policies.
Similarly, surveys concluding that the competitiveness of 'dirty' industries is not influenced by environmental regulation, can come to this 'weak' conclusion by compensating at the aggregated sectoral level the benefits of the regulations for specific products by the losses for other products.

If DuPont and the most important CFC-using industries (7752 and 7414) in the US can benefit from the environmental regulatory settings after the Montreal Protocol, this can be considered as a valid illustration of the Porter Hypothesis. In our analysis, the same conclusion can be linked to the Danish CFC-policies what ensures that this Ozone-Porter case is not depending on specific American market conditions. This is also a reason why we opted to include Denmark and not Canada because in that case, the conclusions could be specific for North-America.

Data at the most detailed level also show that the pro-active CFC-policy gave better export results in sector 7752 than in sector 7414. The difference in the coefficient of the dummy is substantial. Other differences between household and industrial refrigerators are the signs and coefficients of the constant and the change in imports. Only for industrial refrigerators, the growth of bilateral imports had a negative, but not significant, impact on export growth. The market for household refrigerators was clearly in full expansion. For the air conditioning equipment, the change in bilateral exchange rate was not significant for export growth. For the four other regressions in table 5, changes in exchange rates proved to have a significant impact. Of course, the five countries in the analyse experienced very different exchange rate evolutions.

8. Dirty industries and competition

Not finding a clear negative impact of environmental regulation on international competitiveness of dirty industries may be linked to the specific kind of competition that is typical for industries like chemicals, steel, cement, paper and electrotechnical products.

8.1. Cartelization

Before World War II, governments and firms used international cartels or regulation mechanisms in many of these sectors. The international chemical industry had a very clear cartel structure. Worldwide cartel agreements existed for potash, dyestuff, nitrogenious fertilizers, chlorine, explosives and soda,.... There were even chemical cartels that focussed on technological processes. Some chemical firms like the German IG Farben during the interwar period also participated in cartels that grouped other industrial branches (like the important customers of their products). In some countries like Italy and the Netherlands during the 1930s, governments were so strongly in favour of cartels that they passed laws under which outsiders were compelled to become cartel-members (Schröter, 1997). It was also common practice to help the establishment of cartels on timber, pulp and paper by diplomacy. Other important industries with cartel structures were steel, oil, mining, the aluminium industry and cement.

According to Schröter (1997), it took at least 20 years after 1945 to reach a decent standard of decartelisation and the problems of international cartelisation are by no means gone. Even during the 1990s, numerous important competition cases were brought to the European and American courts.

The international aspects of competition policy become very important as a result of worldwide globalisation. Like environmental policy, competition policy is rather 'recent' and this can limit the validity of the assumption of free competition that is frequently used in trade models and empirical analyses. If industries like steel and chemicals are targeted by strict environmental policy, there is always the possibility that they can use their power on international markets to offset possible negative impacts on their competitiveness. This can happen by means of guiding voluntary Gentlemen's Agreements that ensure that many firms make similar adaptations at the same time. If the most powerful market players adopt this policy, they can convince smaller firms to follow their lead.

The important growth in environmental (and other fields of) regulation can also be linked to market power by making use of concepts like 'regulatory capture' and 'rent seeking' (Peltzman, 1976). Like all regulating agencies, the environmental policy makers can become object of capture by interest groups, including producers, consumers and the environmental lobby. The producer group is probably best endowed with resources to influence environmental policies. As such, there is a chance that the regulation is in line with the interests of the regulated industries. The potential impact on competitiveness will be limited.

The related hypothesis on rent-seeking states that most monopolies and oligopolies are created or stimulated by government regulation. The European steel industry is a clear example of an industry that is shaped by many agreements and regulations. Also here, the impact of new environmental regulation on competitiveness will not be dramatic.

In historical overviews of chemical cartels, we find of course corporations like DuPont. In the technological race for the best CFC-substitute, one of the the main competitor of DuPont is ICI from the United Kingdom (Howes, 1997). The collaboration between these two giants was however very intensive during the interwar period with their 1929 Patent and Processes Agreement (Schröter, 1997). The ending of their collaborative links in 1952, as a result of antitrust rulings, was the start of massive foreign investments by DuPont in Europe and by ICI in the United States (Jones,1996). Decartelization was the start of multinational strategies and massive foreign direct investment.

In 1995, DuPont and ICI are among the hundred greatest transnational corporations. Table 6 gives an overview of the most important chemical companies. Pharmaceutical companies are not included. All these companies do already exist for many decades and did build up over time a transnational network. Their foreign assets are more important than their assets in the country of origin. If the Polish and Russian subsidiaries of German chemical firms apply the same environmental procedures and principles as in their home country, they can contribute to diminishing environmental problems in the host country. Multinational corporations clearly have the potential to diffuse clean tecnologies and procedures.

Table 6 - Ranking of chemical transnational corporations by foreign assets, 1995 (billions of US dollars)

Corporation	Country	Position in top 100	Foreign assests	Total assets	Foreign sales	Total sales
Bayer AG	Germany	11	28.1	31.3	19.7	31.1
Hoechst	Germany	24	21.9	36.7	13.4	36.3
DuPont	US	28	17.8	37.3	20.6	42.2
BASF AG	Germany	29	17.6	29.3	23.5	32.3
Rhone-Poulenc	France	33	16.1	27.6	12.4	17.0
Ciba-Geigy AG	Switzerl.	38	14.9	26.5	7.5	17.5
Dow Chemical	US	44	13.5	23.6	11.2	20.2
Johnson&Johnson	US	73	8.2	17.9	9.7	18.8
Solvay AG	Belgium	74	8.1	8.9	8.8	9.3
BHP	Australia	77	7.8	21.8	4.4	12.7
ICI	UK	97	6.1	14.7	9.5	15.9

Source : UNCTAD, World Investment Report 1997, p.29

The products of these corporations are capital-intensive and this can be an important market barrier. Loss of competitiveness is also linked to the entrance of new competitors on the market. But in the European steel industry that has already excess capacity and administered production levels, environmental regulation will never increase costs to a level that invites new entrances. There just isn't a market to enter.

We already mentioned the importance of product differentiation. High capital costs make it difficult for new-comers to find a profitable niche in the market. Since most R&D takes place in the leading corporations, most differentiations will also be situated within these firms.

Before WWII, cartels ensured market power and now the high capital base and international networks can be used to exert market power. In most industries, cartels are an element of industrial history but even now the European steel industry is still partly cartelized and there are also many examples of industries that are stimulated by governments to work together in the field of R&D, just like in the cartels for technologies and processes. These specific aspects of competition provide a practical experience of collaboration and negotiating with competitors and government representatives. These are capacities that can be used to influence the regulatory business framework. On this aspect, powerful companies with a long tradition have advantages to new firms in more competitive markets.

8.2. AFEAS and PAFT

In Europe and in the US, international corporations still work together on many environmental Research & Development projects. For specific programmes like the cleaning up of hazardous waste sites, corporations even work together with environmental agencies. As an example, Monsanto's recent Lasagna^{TM} process was developed by Monsanto in collaboration with DuPont, General Electric, the US Environmental Protection Agency and the Department of Energy.

In the field of finding alternatives for CFCs, 17 of the world's chemical companies joined together to form the Alternative Fluorocarbons Environmental Acceptability Study (AFEAS) and the Programme for Alternative Fluorocarbon Toxicity Testing (PAFT).

These two programmes were set up to provide research on the potential effects of CFC-alternatives on the environment and on human health - through international cooperation with independent scientists, with government research programmes, and among the companies. The proposed alernatives were hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs).

The member companies of PAFT and AFEAS are : AlliedSignal, DuPont, Elf-Atochem, LaRoche, Akzo, Solvay, Ausimont, ICI, Rhône-Poulenc, Hoechst, Asahi Glass, Central Glass, Daikin Industries, SICNG, Showa Denko and Hankook Shinwha.

By close cooperation and by combining their resources, the AFEAS and PAFT companies believe that the usual period of time for environmental and toxicity testing of new chemicals has been substantially reduced.

AFEAS started in 1988 and total funding for the period 1988-1995 was ten million U.S. dollars. For PAFT, the participating companies have contributed at least 21 million U.S. dollars, while the costs for in-house studies are probably of similar magnitude (AFEAS, 1996).

This collaboration might limit the impact of CFC-substitution policies on the competitiveness of the participating firms.

9.Conclusions

Policy makers and industrial leaders use the argument of competitiveness in various environmental debates. Contrary to what most expect, only weak or anecdotal empirical evidence can be collected from the numerous surveys on the impact of environmental regulation. One explanations is that the used methodology is not optimal. Therefore, we did focus on the principle of comparative advantage that should be correctly interpreted. We concluded that most empirical tests were just too strict : not all industries can suffer significant export losses as a consequence of stringent environmental regulation.

If sectoral losses can be found, these losses have to be related to total trade flows of a nation. It is obvious that the loss of some industries is not dramatic for countries with a very diversified trade pattern. Maximal diversification is some insurance against dramatic export losses. We found that rich countries with a high labour productivity have this diversified export pattern what explains why the most competitive nations only suffer marginal losses from stricter environmental regulation.

Measuring diversification of exports requires information at the most detailed level. At the level of the final products, the impact of environmental regulation will be most direct. Therefore, we tested the impact of ozone-policies for the products that use ozone-depleting substances like chlorofluorocarobons. From the overview on the Montreal Protocol and on the strategic policies of firms and governments, we concluded that this framework could be a relevant test for the Porter hypothesis that links environmental regulation to innovations and improved competitiveness.

For most authors, the attractiveness of the Porter hypothesis might be due to the not finding of a clear negative impact of environmental regulation on international competitivity. But this non-negative impact of regulation should not be considered as a ‘free lunch’. Efficiency gains are not generated at random but are the results of continuous efforts and adaptations. The best performing industries can be the first to deal efficiently with new environmental restrictions. Our findings suggest that a pro-active strategy before and after the Montreal Protocol generated clear benefits. We conclude therefore that at the level of the final products, there is more than anecdotal evidence supporting the Porter hypothesis.

In a final section, we did focus on the specific balance of power that characterised many 'dirty' industries. Many of these industries were cartelized in the past and this can explain why increasing environmental cost did not result in significant changes in market structures. Related to the policies after the Montreal Protocol, we find that the major chemical companies closely collaborated in finding and testing CFC-substitutes. The collaboration clearly enabled the fast introduction of HCFCs and HFCs, a very needed outcome, but also can influence competition between the 17 participating firms and other, non-participating firms.

Appendix A : Du Pont on CFCs and Substitutes (as of April, 1998)

The Issue:

Leading atmospheric scientists have determined that a number of man-made compounds deplete the ozone layer. Chief among these are the long-lived chlorofluorocarbons, or CFCs. These gases exist on average for 100 years, working their way up to the stratosphere, where they break down from exposure to ultraviolet rays and subsequently destroy ozone.
CFCs were first manufactured in 1931 as safer substitutes for ammonia and sulfur dioxide, the toxic refrigerants then in use, because they were very low in toxicity, nonflammable, stable and extremely energy efficient. Their use was heralded in the refrigeration industry and applications were soon found in thousands of products -- automobile air conditioners, all home refrigerators and freezers, water coolers and fountains, aerosol sprays, asthma inhalers and cleaning for electronic circuit boards, among others.

The international Montreal Protocol treaty was enacted in Sept. 1987 and initially called for a 50 percent phase down in CFC production in developed countries by 1998. In 1988 the NASA Ozone Trends Panel provided the first scientific consensus that CFCs were linked to ozone depletion. Since then, new science has prompted a more urgent response and the world's developed countries ended CFC production for sale by Jan. 1, 1996.

DuPont Position:

Within 10 days of the NASA Ozone Trends Panel report in March 1988, DuPont became the first company to announce a complete phaseout of CFC production. In 1991, DuPont shut down the world's oldest and largest CFC facility and introduced the first in its line of low or non-ozone-depleting alternatives. Today the company has ceased CFC production at all facilities around the world except in Brazil, where the government has requested continued production as allowable to developing countries under the Montreal Protocol.

DuPont has five families of alternatives commercially available. Most of these are hydrofluorocarbons (HFCs) that do not harm the ozone layer. The company also manufactures a few hydrochlorofluorocarbons (HCFCs), but only those with the lowest ozone depletion potential -- 95 to 98 percent improvements over CFCs and easy to retrofit into the billions of pieces of existing equipment currently operating with CFCs globally.

Appendix B : EPA Enforcement Actions under the regulation on ozone-depleting substances

The US Environmental Protection Agency (EPA) has issued several regulations under Title VI of the Clean Air Act designed to protect the ozone layer and to provide for a smooth transition away from the ozone-depleting substances. EPA is also charged with enforcing these regulations. Some information is featured about enforcement actions, ranging from civil fines to criminal prosecutions. No information is presented here about ongoing investigations.
From a long list, we selected the following cases:

January 26, 1998: EPA Cites U.S. Mint For Clean Air Act Violations

The U.S. Environmental Protection Agency announced that it has cited the U. S. Treasury for Clean Air Act violations at the United States Mint in Philadelphia. In the administrative complaint issued January 23, 1998, EPA charges the Mint violated regulations governing the emission of chromium compounds and chlorofluorocarbons (CFCs). EPA alleged that the coin-making site violated testing, monitoring, and operation and maintenance requirements for chromium electroplating since January 1997. The October 23 inspection also uncovered violations of Clean Air Act regulations on the repair and servicing of equipment containing CFC-based refrigerants. Specifically, EPA alleged that Mint employees serviced air conditioners and water coolers without using required CFC recovery and recycling equipment and that the Mint used an uncertified technician. The complaint also alleged that the Mint failed to evacuate CFCs to required levels before servicing refrigerant containing equipment.
EPA seeks a $129,400 penalty for these violations.

January 21, 1998: Philadelphia Scrap Metal Company to Pay $30,000 For CFC Violations

The U.S. Environmental Protection Agency announced that S.D. Richman Sons Inc., a Philadelphia scrap metal company, will pay a $30,000 penalty for violating regulations on the disposal of equipment containing chloroflorocarbons (CFCs).

September 12, 1997: California Men Charged For Installing HC-12a®

Two men who allegedly installed a flammable refrigerant known as "HC-12a®" in the air conditioners of motor vehicles have been indicted in one of the first criminal cases of its kind.

September 12, 1997: Issuing False Technician Certifications Leads to Guilty Plea

Charles Warren Joseph of Houston, Texas admitted to participating in a scheme that resulted in approximately 100 false chloroflurocarbon (CFC) technician certificates being issued between June 1994 and November 1995. His co-conspirator, Herman Brodzenski of Canton, Ohio, pleaded guilty to charges on June 19.

September 5, 1997: President of Refrigeration U.S.A. Corp. Jailed and Fined $375,000

Roland Wood, President of Refrigeration U.S.A. of Hallandale, Fla., pled guilty for his role in a CFC smuggling operation. Also see the related story below about Refrigeration U.S.A.
On Aug. 29, Roland Wood of North Miami Beach, Fla., was sentenced to serve 37 months in prison and three years supervised release and was ordered to pay a $375,000 fine by the U.S. District Court for the Southern District of Florida in Miami. As part of his guilty plea, Wood will forfeit over $13 million in assets including: property in Miami valued in excess of $1.5 million; 11,200 thirty-pound cylinders of chloroflurocarbon gas worth over $6.7 million; almost $5 million in illegal proceeds held in European Banks; an apartment in London valued at $395,000 and stock in a local bank worth over $80,000. Wood, President of Refrigeration U.S.A. of Hallandale, Fla., previously pleaded guilty to illegally diverting 4,000 tons of ozone-depleting CFC refrigerants into commerce in the United States. The case was investigated by EPA's Criminal Investigation Division, the U.S. Customs Service and the Internal Revenue Service.

August 29 , 1997: Refrigeration U.S.A. Corp. Fined $37 million

Refrigeration U.S.A. previously pleaded guilty to 129 felony counts, and employees previously pleaded guilty to conspiracy to violate the Clean Air Act in connection with a scheme to divert 4,000 tons of CFCs into commerce in the United States.

CFC Smuggling - 1995

United States v. Adi Dara Dubash and Homi Patel (S.D. FL): Adi Dara Dubash was sentenced on July 24, 1995, after pleading guilty to smuggling 8,400 cylinders of the ozone depleting refrigerant gas dichlorodifluoromethane (known as "CFC-12") into the United States in violation of the Clean Air Act. He was sentenced to 22 months of imprisonment, 3 years of probation and a $6,000 fine.

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