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Environmental Policy and the Inward Investment Position of US "Dirty" Industries

Do high pollution abatement costs have a disadvantageous effect on foreign direct investment in countries with a strict environmental policy? While it would seem to make sense to believe that they do, hard evidence based on trade data is hard to find. The following article tests the hypothesis for the USA and comes to some surprising conclusions.

It has become increasingly apparent that there is widespread political and public concern about environmental issues. The environmental effects of economic activity tend to be very diverse and vary between sectors and locations. Local policies aimed at specific sectors lead to pollution abatement and control expenditures (PAC) that can vary significantly between countries due to differences in natural endowments and assimilative capacities, types of pollution (from very toxic and carcinogenic pollution to levels of acceptable noise pollution or landscape distortion), the structure of industry and services, the evolution of political priorities and policy models, attitudes of consumers and pressure groups, possible policy implementation limitations, effective enforceability of regulation, applicability of environmental and economic instruments and so on.

Differences in environmental costs may influence the relative prices of natural assets. This has consequences for industries that are nature-intensive. We may assume that environmental control costs encourage reduced specialization in the production of pollution-intensive outputs in countries with stringent environmental regulations while countries with lax environmental regulation can build up a comparative advantage in these industries.

Since chemical industries, micro-electronics, pulp and paper, oil refining, iron and steel, and many other so-called "dirty" industries are responsible for a very important share of national value added and employment, any new measure that increases environmental (and other) costs, faces strong opposition from groups advocating that the implementation of stiffer measures will reduce the competitiveness of the targeted industries, which could lead to the forced migration of these industries (industrial flight).

This competitiveness issue has been studied by many authors. Complex theoretical models suggest that competitiveness could be endangered as a result of many parameters, but surprisingly there has been very little empirical support, neither when changes in trade flows have been studied, nor in surveys on the migration (industrial flight hypothesis) or attraction (pollution haven hypothesis) of pollution-intensive industries.

In her often cited survey of the existing literature[1] Judith M. Dean concludes that the many empirical surveys on diverse competitiveness-related hypotheses show no evidence to support them. She adds as a partial explanation that there may be room for better estimates of actual environmental control costs incurred by firms, and for estimates by industry of actual losses in output due to these costs.

A recent survey of the literature by Michael Rauscher[2] produced similar results. Specific surveys for the USA were made by Jaffe[3] and Kalt.[4] Most surveys – starting with Arthur Andersen & Co. in 1979, followed by Worldbank, UNCTAD and many authors –

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[1] Judith M. Dean: Trade and Environment: A Survey of the Literature, World Bank Policy Research Working Paper, No. 966 (1992); cf. also World Bank Discussion Papers, No. 159 (1992): International Trade and the Environment, pp. 15-28.

[2] M. Rauscher: International Trade, Factor Movements, and the Environment, Oxford 1997.

estimate environmental costs of around 1% to 3% of GDP for industrial countries. These rather low figures are based on sectoral studies for chemicals, metals, paper etc. But when we consider the social and environmental cost of only the transport sector, the OECD gives an estimate of 5% of GDP.[5] The inclusion of health aspects and costs would clearly result in higher figures. Patrick Low and Alexander Yeats[6] make use of an RCA (revealed comparative advantage) analysis that enables them to conclude that dirty industries account for a growing share of the exports of some developing countries together with an overall world-wide reduction of dirty exports. Of course, many other factors could be responsible for this shift over a period of 20 years. They also suggest that production and FDI-data would enable a better analysis.

James A. Tobey[7] in his analysis of world trade makes use of the Walter and Ugelow index of the degree of stringency of environmental policy. This index ranges from tolerant (index value 1) to strict (index value 7). The environmental policy of only three countries (the USA, Sweden and Japan) is considered as strict. Finland, Norway and Singapore follow closely.

Including a dummy based on this index in his analysis of net exports of certain commodities yielded no significant results. Although Tobey concludes that the empirical effects of domestic policies are not significant, he remarks that trade surveys are in many cases biased by trade barriers that are difficult to deal with at the empirical level.

If we can assume that the USA has a very strict environmental policy and data on production and FDI-flows offer an alternative for analysis that excludes problems with trade data (trade barriers, strongly differing "openess to trade"-ratio's etc.) a sectoral analysis of these FDI-flows could give us valuable insights into the possible consequences of strict environmental policies on industrial location patterns.

FDI and Dirty Industries

We wish to analyse to what extent recent FDI-patterns inside and outside the USA could be influenced by the strict environmental policy that is maintained. We do not wish to explain investment patterns by means of a multivariate analysis including variables like market size, factor prices, corporate taxes and tax holidays, government grants, rates of return on foreign investments, and transportation costs. For this kind of analysis, Tobey illustrates that differences in environmental regulation are not easily quantifiable.

The USA has been chosen because of data availability: FDI, production, gross fixed capital formation and R&D are provided on a sectoral base. Data sets were taken from Survey of Current Business, the UNIDO Industrial Statistics Database (3 digit SITC) and the World Bank Discussion Papers 159 (International Trade and Environment).

Assumptions on Location Patterns

Following standard theory, environmental regulation will lead to pollution abatement expenditures that increase input and output price. In competitive markets, increasing production prices will lead to diminishing profits if international competitors do not have to internalize the cost-increasing externalities to the same extent.

Depending on profit margins and the possibilities of reducing pollution by new technologies and new product designs, when standards are increased some sectors or firms will face additional environmental costs which are too high. In very competitive global markets this can force them to relocate their production facilities to regions with fewer environmental constraints, due to different assimilative capabilities or the lack of enforceable environmental regulation.

Of course, this possible relocation will hardly ever take place immediately after the implementation of a new environmental measure. The firm can make some "easy" end-of-pipe abatement investments that in the end do not fulfil legal requirements. In other cases, standards included in the legislation could change after some years and pose a serious problem from that moment on.

We therefore assume that the impact of many new environmental measures during the 1980's becomes

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[3] Adam B. Jaffe et al.: Environmental Regulation and the Competitiveness of the United States Manufacturing: What Does the Evidence Tell Us, in: Journal of Economic Literature, Vol. 33 (1995), No. 1, pp. 132-163.

[4] Joseph P. Kalt: The Impact of Domestic Regulatory Policies on International Competitiveness, Harvard Institute of Economic Research, Discussion Paper No. 1411 (1985).

[5] European Commission: Statements on Sustainable Development, 1997, p. 17.

[6] Patrick Low, Alexander Yeats: Do dirty industries migrate?, in: Patrick Low (ed.): International Trade and the Environment, World Bank Discussion Papers, No. 159, 1992, pp. 89-103.

[7] James A. Tobey: The Effects of Domestic Environmental Policies on Patterns of World Trade: An Empirical Test, in: Kyklos, Vol. 43 (1990), No. 2, pp. 191-209.

visible during the early 1990's or has not yet taken place. Why not compare the diffusion of environmental legislation and its enforceability to the diffusion of information technology (IT) or other major innovations or breakthroughs like electricity? The real impact of IT and electricity was delayed by decades. According to some observers,[8] the real IT-shock has still to come.

In the following, we study inward and outward US FDI-flows during the early 1990's and analyse the impact of strict environmental regulation: do dirty industries leave the USA and does the USA attract clean industries? To complete the picture, it is interesting to note that Bartik[9] and Levinson[10] examined business location decisions in the USA and found that government environmental expenditures had small but insignificant effects on these intra-USA investment flows. In a subsequent analysis, Bartik detected a significant negative impact of state-level environmental regulations on the start-up rate of small businesses.

Identification of Dirty Industries

Following Patrick Low[11] there is no standard definition of dirty industries but they are commonly identified as those sectors with the highest level of pollution abatement and control expenditures. As such, dirty industries tend to be concentrated in relatively few but all-important sectors like chemicals, cement, pulp and paper, certain wood industries, petroleum refining, and ferrous and non-ferrous metal industries. Table 1 lists the industries with the highest relative abatement efforts in 1988. These data are used in the following paragraphs to divide industrial sectors into three groups: dirty, medium (in terms of pollution intensity) and clean industries.

Due to the non-availability of 3-digit data for FDI, the division based on broader (2-digit) categories differs slightly from what would be concluded from the 3-digit data. This is however a very relative problem since the data in Table 1 were compiled from a probability sample and are subject to sampling variations.

A concluding remark could be that firms with high PAC expenditures could reduce almost all environmental impacts of their products while firms that only need to do some modest investments could still postpone the necessary efforts and are as such dirtier than firms with the greater potential for pollution.

Table 1
Pollution Abatement Expenditures as a Percentage of Output by US Industry, 1988

SIC	Industry	PAC/Output	Share in total Industry Output
324	Cement, hydraulic	3.17	0.17
261	Pulp mills	2.42	0.20
245	Wood buildings/mobile homes	2.39	0.26
333	Primary nonferrous metals	2.35	0.62
281	Industrial inorganic chemic.	2.21	0.86
286	Industrial organic chemicals	2.13	2.34
263	Paperboard mills	2.08	0.63
262	Paper mills	1.97	1.31
287	Agricultural chemicals	1.94	0.63
332	Iron and steel foundries	1.83	0.47
291	Petroleum refining	1.62	4.63
331	Blast furnace/basic steel	1.39	2.50
329	Misc. nonmetallic mineral pr.	1.28	0.43
347	Metal services nes	1.18	0.36

Source: World Bank: International Trade and the Environment, p. 113.

Changes in the US Inward FDI Position

The US Bureau of Economic Analysis[12] offers data on foreign direct investments in the USA by industry. The investment position is presented on a historical cost basis. Following our assumption that in the medium or long term dirty industries could locate in countries with less stringent environmental regulation than in the USA, we wish to know whether foreign direct investments in US dirty industries are falling behind, face zero-growth, or are growing at a slower rate than "non-dirty" industries.

The period of analysis is rather short in order to eliminate possible structural industrial changes. We also tested, however, for a period of eight years, which produced similar results. The test consisted of a simple comparison of growth rates. We defined three categories – dirty, clean and medium (not dirty but not clean) industries – mainly based on pollution expenditures. For each category we selected 9 sectors. A few sectors with exceptional growth rates for inward FDI were elimimated. A (dirty) industry like

[8] The Economist (1996): Survey of the World Economy (1-8), New technology and globalisation are changing the world.

[9] Timothy Bartik: The Effects of Environmental Regulation on Business Location in the United States, in: Growth Change, Vol. 19 (1988), No. 3, pp. 22-44.

[10] Arik Levinson: Environmental Regulations and Manufacturers' Location Choices: Evidence from the Census of Manufacturers, Columbia University, New York 1992.

[11] World Bank Discussion Papers, No. 159, op. cit., p. 106 .

[12] Mahnaz Fahim-Nader and William J. Zeile: Foreign Direct Investment in the United States, in: Survey of Current Business, May 1995, pp. 57-81.

"lumber, wood, furniture, and fixtures" realized a remarkable increase in its FDI-position: from US$ 465 million in 1991 to US$ 2667 million in 1995 (+473% !) We did not include this industry in our analysis, although this sector is often cited as one of the migrating industries from states like California to Mexico as a result of differences in environmental regulations in the NAFTA.

This leads us to the following nine dirty industries :

- ☐ petroleum refining without extraction
- ☐ industrial chemicals and synthetics
- ☐ drugs
- ☐ soap, cleaner and toilet goods
- ☐ other chemicals
- ☐ paper and allied products
- ☐ misc. plastic products
- ☐ non-metallic minerals, except fuels
- ☐ metal mining.

In 1995 these sectors together accounted for an inward FDI in the USA of US$ 96607 million, which is 45% of total manufacturing inward FDI and 17% of total US inward FDI (with the inclusion of services, real estate etc.)

Inward FDI in the USA increased by 33.6% for all industries over the period 1991-1995. For manufacturing, the increase was almost identical, +33.8%. These figures can be compared with the average increase in the dirty, medium and clean group. All growth figures that follow represent cumulative growth over the five year period 1991-1995 and are calculated on data found in the Survey of Current Business.

This analysis leads to a remarkable and unexpected result. The average increase for the dirty group was +67.1%, the increase for the medium group only +7.2% and the clean industries saw a reduction of their inward FDI of –8.2%. The best performers in the dirty group were: drugs (+188%), paper and allied products (+117%) and metal mining (+84%). The lowest growth rate was found for industrial chemicals and synthetics (+13%). Remember that we excluded "lumber, wood, furniture, and fixtures" from the dirty sample. In the medium group, general industrial machinery performed best (+68%). Negative growth was found for metal cans, forgings, stampings (–29%), computer and office equipment (–37%), refrigeration and service industrial machines (–37%) and rubber products (–9%). In the clean group medical instruments (+57%) and other food and kindred products (+33%) performed very well, but the other sectors showed sharp reductions in their FDI-position.

A simple comparison of averages needs to be complemented by an analysis of variance over the three groups. The ANOVA (Table 2) showed a very good F-value (alpha = 5%, df = 26, P = 0.0036). Also the comparison between dirty and medium – without the clean group – proved very significant (df = 17, P = 0.0182).

These good ANOVA results are strongly confirmed by a Kruskal-Wallis test – one-way analysis of variance by ranks – where the growth rates over the three groups are ranked from 1 to 27. We then found a Kruskal-Wallis H statistic that is very close to the chi-square distribution with 3-1 degrees of freedom because every sample size is at least 5. The calculated H = 8.141093 exceeds the critical value of H = 5.991 at the 0.05 level and even exceeds the critical value of H = 7.824 at the 0.02 level. If the United States attracts far more dirty industries than industries from the medium and clean group, the strict envi-ronmental policy does not seem to be an investment barrier and as such no restriction on US competitiveness.

An analysis using FDI positions is a registration of the preferences of international investors that have the necessary home-country expertise and experience and could as such be better than an analysis based on distorted trade figures where we have to include a lot of other explanatory variables such as labour cost differences, changes in exchange rates, government support, regional trade agreements, etc. FDI leads to local production (same factor remuneration and legal constraints as domestic firms), in direct and fair competition with existing domestic producers.

Of course, it is possible that dirty industries grow faster in the USA than clean industries. This could then be a partial explanation for the impressive growth rate of inward FDI in dirty industries. However, data from the Survey of Current Business and UNIDO Industrial Statistics (3-digit) showed no significant difference in the growth rates of output and gross fixed capital formation for dirty and clean industries. On the contrary, UNIDO-data showed that the output growth rate of dirty industries is somewhat lower than the growth rate of other industries (+14% compared to +18%). The ANOVA showed no significant difference in output growth rate. This makes our FDI findings even more interesting.

UNIDO data on gross fixed capital formation (GFCF) for the 22 manufacturing sectors showed that capital formation over the period 1989-1993 decreased for the dirty industries (with the exclusion of petroleum industries) on average at –0.9% while the other (clean and "medium") industries had a modest increase of +3.2%. The difference proved not to be significant (df = 21, F = 0.34, P = 0.566). This result is in line with the findings resulting from the output data.

The US Outward FDI Position

We found above that the USA attracted more dirty manufacturing industries than non-dirty industries, while these sectors showed a slightly decreasing national capital formation. To complete the picture, we need to analyse the US outward FDI-position because it could be that dirty industries leave the USA to a greater extent than they are attracted by the USA. Some dirty FDI will always take place for reasons of the scale of the home market and transaction costs.

We should also remember that our sectors could consist of some specific subsectors (4-digit level) that do not fit into our a priori categorization of dirty, medium and clean. Even within the chemical industry, differences in toxicity and environmental impact are very great between benzene, lead, sodium sulphate, acetone, ammonium nitrate solutions, ethylene, and so on.

To link inward with outward FDI data, we calculated sectoral (inward minus outward) FDI balances for 1991 and 1995. For most industries, this balance was negative because total US outward FDI is larger than total US inward FDI. An increase in the inward surplus (or reduction of the deficit) proved the attractiveness of the industry. For our analysis, we eliminated in each group one sector that showed a very high growth rate due to an initially very small deficit or surplus.

Table 2
Summary of ANOVA:
Growth Rate of Inward FDI Position

Groups	Count	Sum	Average	Variance
Dirty	9	603.9	67.1029	3262.461
Medium	9	65.2	7.2456	1400.329
Clean	9	–73.8	–8.2082	1295.093

Souce of Variation	SS	df	MS	F	P-value	F crit
Between groups	28480	2	14240	7.17	0.003619	3.4028
Within groups	47663	24	1985			
Total	76143					

Table 3
Summary of ANOVA:
Growth Rate of (Inward-Outward) FDI Balance

Groups	Count	Sum	Average	Variance
Dirty	8	2136	267	296338
Medium	8	–428	–53.5	4868.6
Clean	8	–839	–104.8	38866.7

Souce of Variation	SS	df	MS	F	P-value	F crit
Between groups	64975	2	324867	2.539	0.1029	3.46679
Within groups	2686905	21	127948			
Total	3336640					

Again, we found the best results for the dirty industries. Only this group could seriously improve its (inward – outward) balance and is an important (net) host for FDI. Dirty industries are not at all leaving the USA en masse. The contrary is true. We find in Table 3 that the high variance within the groups – which could be expected from working with changes in balances – resulted however in a P-value of 0.1029.

To reduce the variance within the three groups, we express the 1991-1995 change in (inward minus outward) balance as a percentage of the initial inward FDI position. This gives us net inflow of capital as a percentage of existing position. For metal mining, for example, the inward surplus increased by 38% from 1991 to 1995. This increase (US$ 828 million) represented 15.59% of total inward FDI in 1991 (US$ 5312 million). Comparing these percentages for the three groups gave good results, as shown in Table 4. Again, only dirty industries could improve their balance, while medium and clean industries saw more capital flow out of the USA than in. In this case, the P-value is good. A Kruskal-Wallis test gave the same results.

Possible Explanations

The attractiveness of the USA for dirty industries comes as a surprise. It should however be noted that foreign-owned US manufacturing establishments differ from US-owned establishments. A survey of the establishments from the six major investing countries in the USA (Canada, France, Germany, Japan, the Netherlands and the United Kingdom) showed that these foreign establishments tend to be much larger, pay higher wages, and be more productive than the US-owned establishments.[13] These differences vary of course by country of owner and by industry but we can conclude that a higher productivity makes it possible to adapt more easily to changing regulatory and environmental challenges. A pollution abatement cost of only 2 per cent of value added is not dramatic for adaptive and flexible firms with a sound profitability basis. These major investing countries have also increased their environmental standards but comparable sectoral pollution abatement data are not available so we cannot include them in the empirical analysis for the USA.

According to the Porter hypothesis, entrepreneurial efficiency is linked to advantages resulting from environmental regulation. Efficient regulation which reduces uncertainty, creates maximum opportunity for innovation and fosters continuous improvements can result in clear advantages over non-regulated firms and regions.[14] An illustration of the Porter hypothesis can be found in the fact that the most competitive environmental industries are found in countries with stringent environmental regulations. According to Rolf-Ulrich Sprenger[15] from the Munich Institute for Economic Research (Ifo), one of the major reasons for Germany's success in exports of environmental goods and technology is that exacting national policies on environmental protection created an early domestic demand, which ultimately gave Germany a technological edge over its competitors. If we link this with the estimates by Miller and Moore using MITI data[16] that in the first half of the 21st century 40% of global economic output will be from environment or energy linked products and technologies, the development of efficient regulation will be a crucial factor. The choice of instruments that stimulate innovations and improvements will be important. Performance standards, pollution charges, information disclosure and subsidies for environmental R&D are expected to perform better than standards, emissions trading and voluntary agreements.

We will focus on environmental R&D expenditures and try to distinguish dirty from clean industries. We can assume that firms with high R&D expenditures make these efforts for specific reasons such as the development of new products and new designs but

Table 4
Summary of ANOVA:
(Inward-Outward) Balance over 1991-1995
(Change as a Percentage of Initial Inward FDI Position)

Groups	Count	Sum	Average	Variance		
Dirty	8	28.5	3.5	1699.4		
Medium	8	–55.4	–6.9	1695.5		
Clean	8	–506.3	–63.2	3646.6		
Souce of Variation	SS	df	MS	F	P-value	F crit
Between groups	20691	2	10345.5	4.407	0.02522	3.46679
Within groups	49290.4	21	2347.1			
Total	69981.5	23				

[13] Survey of Current Business: Differences in Foreign-Owned US Manufacturing Establishments by Country of Owner, March 1996, pp. 43-60.

[14] M. E. Porter and C. Van der Linde: Toward a New Conception of the Environment-Competitiveness Relationship, in: Journal of Economic Perspectives, Vol. 6 (1995), No. 4, pp. 119-132.

[15] Rolf-Ulrich Sprenger: Environmental Policy and International Competitiveness: the Case of Germany, IFO Paper, 1996, p. 32.

[16] A. Miller and C. Moore: Strengths and Limitations of Governmental Support for Environmental Technology in Japan, in: Industrial and Environmental Crisis Quarterly, Vol. 8 (1994), No. 2. pp. 155-170.

also for modifications to and improvements in the production process.

An important part of the new technologies can be seen as clean technologies, just because environmental considerations are integrated into the R&D objectives. It is obvious that clean technologies offer an important cost-decreasing opportunity in industries with high pollution abatement costs. The link between global R&D expenditures and cost savings by means of clean technologies is of course complicated and depends on many factors. Investing in new technologies always means a risky and costly involvement for several years, during which new opportunities can arise. Many entrepreneurs could therefore opt to wait and invest when the clean technologies improve overall efficiency.

These "economics of waiting" are not the only limiting factor in the diffusion of clean technologies. Not all firms are aware of the latest technological innovations and possibilities, nor do they all have the means to conduct their own R&D. In many cases, their interaction with the economic environment is limited to a fixed number of other enterprises, federations, suppliers, customers, government agencies, banks, lawyers etc. In order to be aware of recent scientific and technological developments, they need to find a network that can provide them with recent information. And even when firms are aware of the latest technological possibilities, the technological trajectories they have followed in the past can make it impossible or very expensive to install new technologies.

Another limitation to the introduction of clean technologies could be a limited willingness to innovate. This willingness to innovate can differ strongly among industries. Determinants can be: past experience with innovations, the long-term perspective of the current capital structure, uncertain appropriability of new technologies or licences, legal or regulatory uncertainty that forces investors to wait, investment risks which are difficult to estimate, general uncertainty, conjectural market problems etc. However, we can suppose that large-scale firms with high productivity (and hence profitability) that take the risk of investing in a competitive economy with a strict regulatory framework have the necessary means and entrepreneurial spirit to undertake the research and development needed.

Some Selected Cases

The following benefits of introducing clean technologies through process modifications have been identified in most surveys on the subject by UNEP:[17]

- ☐ savings in raw materials and energy;
- ☐ decreased waste management costs;
- ☐ improved product quality;
- ☐ enhanced productivity;
- ☐ decreased down-time;
- ☐ reduced worker health risks and environmental hazards;
- ☐ decreased long-term liability for clean-up of waste-materials that might otherwise have been buried;
- ☐ improved image for the company.

The authors of the UNIDO Global Report 1990/1991, Industry and Development, state that the numerous case-studies at the plant level do suggest that the pollution-prevention investment in clean technologies can lower production costs and at the same time reduce emissions. Of course, this conclusion cannot be generalized across industries and countries. We present a case from the metal industry and one from the paper industry.

In the environmental literature on the opportunities and limitations of BATNEEC (Best Available Technology Not Entailing Excessive Costs) and BPEO (Best Practicable Environmental Option), cases like Ciba-Geigy illustrate improvements to the following technologies with environmental impact resulting from general R&D programmes. The list of improvements is long: chemical and biological effluent treatment, biodegradation of special wastes, wet air oxidation of non-biodegradable wastes, incineration of wastes, biofiltration for waste air purification/deodorization, off-gas purification by absorption, catalytic oxidation, incineration, flue-gas purification, immobilization and stabilization of slags and ashes, site remediation, groundwater decontamination, ecotoxicology, environmental trace analysis, biospheric monitoring and noise abatement.[18]

Case studies suggest that R&D can lead to clean and cost-saving technologies. Of course, data on R&D-expenditures do not distinguish between product and process-oriented R&D, nor between

[17] D. Huisingh: Cleaner technologies through process modifications, material substitutions and ecologically based ethical values, in: UNEP Industry and Environment, 1989, pp. 4-8.

[18] Andrew Hutchinson and Frances Hutchinson: Environmental Business Management, London 1997, p. 267.

clean and non-clean technologies. The R&D part of total pollution abatement expenditures seems to be non-constant and can depend on regulatory requirements or cost-reducing opportunities. Unfortunately, we have no sectoral data on environmental R&D. We therefore studied the sectoral expenditures for total R&D. The Bureau of Economic Analysis[19] presents data for most manufacturing sectors (2-digit level). Data on R&D expenditures performed outside the USA by US companies and foreign subsidiaries were also available. Concentrating on the 5-year period 1988-1992, we analyse the growth in R&D expenditures for the group of dirty and the group of clean industries. The period of analysis partly precedes and partly overlaps the period of the inward and outward investment analysis.

It is not surprising that capital-intensive industries have the highest R&D expenditures. In 1992, US$ 16835 million was spent by the chemical (and allied products) industry, US$ 15303 million by "industrial machinery and equipment", US$ 13634 million by "electronic and electric equipment", and so on. Nentjes and Wiersma[20] observed already during the 1980s that the most active sectors in environmental-related industrial R&D are machinery, chemicals, petroleum and motor vehicles. The relation between green R&D and general R&D seems to be obvious.

The growth rate of R&D expenditures over the 1988-1992 period was calculated for the group of dirty and clean industries. The difference was great. On average R&D expenditures in the USA by dirty industries (that were already impressive) increased by 29%, while on average the clean industries reduced R&D expenditures by –1%. The variance within the groups is, however, too great (F = 3.05663, P-value = 0.11854, F crit = 5.31764).

A very significant result was obtained by excluding primary metal industries from the group of dirty industries (R&D opportunities are less available for primary industries) and by including R&D performed outside the USA by US companies and foreign subsidiaries. We can assume that R&D is managed on a transnational basis. We found that the dirty industries invested very strongly in R&D: on average +45.4% for the period 1988-1992! The clean industries reduced R&D expenditures by –0.7 %. The difference proved to be very significant: P-value = 0.02828.

The Same Story for the EU?

Do our findings for the USA also hold for the situation in Europe? A simple comparison between the USA and the EU makes no sense. The EU consists of 15 relatively small countries that experienced specific interactions due to the gradual integration into the EEC/EU. Since the EU increased step by step, investment patterns among EU and non-EU European countries changed significantly for non-endogenous reasons.

Baldwin, Forslid and Haaland[21] analysed investment creation and diversion in Europe with special focus on the consequences of EU membership for the former EFTA-countries. They calibrated EU-integration effects for 15 sectors (with monopolistic competition) with steady-state capital stock and found that the process of trade cost reduction and integrated market prices (market fragmentation, the procompetitive mechanism and scale effects) will lead to an overall increase of 1.8% for the EU-capital base. The sectors with the highest increases in production and investment (FDI included) were chemicals, food products, rubber and plastic products, transport equipment, electrical goods, agricultural and

Table 5
Inward EU-FDI in Selected Sectors, 1984-1993
(in million ECU)

	EU	Germany	Denmark	Spain	France	UK	Italy
Chemicals							
Intra-EU	12080	–1071	–14	1596	1536	2025	1181
Extra-EU	5263	–803	413	1193	1226	2512	1726
Total	17343	–1874	399	2789	2762	4537	2907
% of total	100	–10.8	2.3	16.1	15.9	26.2	16.8
% of intra	100	–8.9	–0.1	13.2	12.7	16.8	9.8
% of extra	100	–15.6	7.8	22.7	23.3	47.7	32.8
Machinery							
Intra-EU	3106	99	98	202	449	1241	–20
Extra-EU	1677	–115	100	230	763	953	–33
Total	4783	–16	198	432	1212	2194	–53
% of total	100	–0.3	4.1	9.0	25.3	45.9	–1.1
% of intra	100	3.2	3.2	6.5	14.5	40.0	–0.6
% of extra	100	–6.9	6.0	13.7	45.5	56.8	–2.0

Source: Eurostat: FDI EU 1984-1993, Luxembourg 1996.

[19] Survey of Current Business: A Satellite Account for Research and Development, 1994, pp. 37-71.

[20] Andries Nentjes and Wiersma Doede: Innovation and Pollution Control, in: International Journal of Social Economics, Vol. 15 (1987), pp. 51-71.

[21] Richard E. Baldwin, Rikard Forslid and Jan I. Haaland: Investment Creation and Diversion in Europe, in: The World Economy, Vol.19 (1996), No. 6, pp. 635-659.

industrial machines. These sectors make intensive use of capital and nature.

It is clear that inward FDI in EU countries is influenced by integration scenarios. We should be aware of this when we analyse FDI-patterns in Europe. Eurostat[22] offers electronic data on direct investment flows in the EU for the period 1984-1993. The data were not detailed enough however to include them into the empirical analysis for the USA.

We analysed inward investment flows for chemicals and machinery. Data were available for Germany, Denmark, Spain, France, the UK and Italy. Two sources for the inward FDI-flows were also given: intra-EU (Germany invests in Spain,..) and extra-EU (Japan invests in Belgium).

Table 5 shows that Germany has on balance a strong negative FDI-inflow, while the UK seems to be the most attractive country for chemicals and machinery. In many cases, the most attractive countries receive most of their FDI from non-EU countries. This could be the result of an integration effect (or investment creation or diversion), or could just be the consequence of historical patterns (the UK chemical industry was strongly developed long before EU membership). The negative figures for Germany could be surprising but flow figures cannot be compared with the initial capital base, which is largest in Germany. Data on the FDI position of the EU-12 would enable a comparison with the USA but here also integration effects would be very distortive. Table 5 also shows that differences between countries are very great, which could be expected for capital intensive sectors where the size of the home market determines to a large extent the possibilities of exploiting economies of scale. For this – and other – reasons a comparison with the USA is very difficult.

Conclusions

Dirty industries were identified by means of expenditures for pollution abatement and control (PAC). These abatement costs increased slowly over time but from American data we find that they hardly ever exceeded the frequently used 2%-barrier of US GDP. This percentage has a limited relevance, however, because costs should not be compared with value added. For some industrial countries, the total agricultural sector delivers 2% of national GDP but one cannot say that expeditures on PAC and agriculture are of equal importance. Expressed as a share of total firms' costs or investments, high abatement efforts could be a competitive disadvantage faced by countries with a high level of environmental awareness.

In the eyes of most observers, the USA has already implemented a strict environmental policy for many years. This policy increases environmental costs, and we wondered to what extent the investment position of American "dirty" industries could be harmed. We found that the inward foreign direct investment position for the group of dirty industries increased by 67.1% over the period 1991-1995, while the groups of medium and clean industries saw a status-quo or even deterioration of their inward FDI position. We can conclude that the strict environmental policy did not harm the attractiveness of the US for investments in dirty industries. This conclusion holds when we include outward investments in our analysis. We also found that the impressive growth in inward FDI is not the mere expression of a general increase in the capital base of these industries. UNIDO data showed that the gross fixed capital formation in dirty industries is increasing at a slower rate than in the group of clean industries.

For these contra-intuitive results, diverse explanations are possible. Any investment is the result of a complex multi-criteria decision process, and many of these criteria are hard to capture in figures. It could be that investors opted for the USA because they think that the high standards will not change in the coming years or decade. Other less strict countries could lose part of their investment attraction because of regulatory uncertainty. Another explanation could be found by analysing expenditures on research and development. We found that the group of dirty industries invests most intensively in R&D. These efforts not only result in new products and new processes but also in reaching regulatory compliance. Why not follow Michael Porter and assume that the strict environmental policy in the USA stimulated R&D and entrepreneurial dynamism in order to cope with it. These efforts could lead over time to a "first mover advantage" that will become more important in the future.

Based on investment data, we therefore conclude that a strict environmental policy does not necessarily harm national competitiveness. Of course, this will not be guaranteed for every country but the US case could be inspiring for governments that want to integrate environmental priorities in the business environment.

[22] Eurostat: FDI European Union Direct Investment 1984-1993, Theme 2, Series D, Luxembourg 1996.