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"DIRTY INDUSTRIES"
PATTERNS OF CHANGE IN INDUSTRIAL COUNTRIES

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Zusammenfassung

Dieser Aufsatz behandelt die Entwicklung besonders umweltbelastender Branchen seit 1970. Untersucht werden 11 Grundstoffindustrien, die Elektrizitätserzeugung sowie der Straßengüterverkehr in 32 Industrieländern. Als nötig erweist sich dabei eine ökologische Industriepolitik, da alle anderen Versuche, die Umweltbelastung in Industrieländern zu vermindern – nachsorgender Umweltschutz, Auslagerung in Länder der Dritten Welt, intersektoraler Strukturwandel und ökologische Modernisierung ohne staatliche Einflußnahme –, bislang lediglich Teilerfolge verzeichneten und die Probleme der ”dirty industries” letztlich nicht lösen konnten.

Summary

This article concerns itself with the environmental role of heavily polluting industries since 1970, analysing its development in 11 basic industries, as well as electricity production and road transport, in 32 industrial countries. It argues for a green industrial policy, demonstrating that other mitigations of environmental pressure in industrial countries – end-of-pipe treatment, relocation to the Third World, structural change in the industrial sector and even environmentally oriented modernisation – have so far been unable to solve the problems of “dirty industries”, although some approaches have shown (some) promise.

Content

1. Introduction

Industry in general is seen as an important factor contributing to environmental stress, but in point of fact it is a relatively small area of industrial production – mainly raw materials processing and energy production – which places the largest burden on the environment. This "dirty industry" sector has been the main target of environmental policy, and hopes that its ecological problems could be solved have been to some extent borne out by the solutions available now.

Firstly, hopes were based on the effects of traditional pollution control, i.e. end-of-pipe treatment. This strategy has led to notable improvements, but after a while the limitations of filters, waste water treatment plants and the like became apparent: waste disposal problems persist, economic growth leads to new increases in emissions, problems are shifted intermedially or intertemporally, rather than being solved. For some environmental problems (for example the emission of greenhouse gases such as CO2 or methane) there are no end-of-pipe techniques available, and the results of material flow analysis have made it clear that many problems (resources, storage, transportation, land-use, dissipative losses, etc.) at all stages of the production chain remain unsolved.

Another possibility for reducing the ecological burden of heavily polluting industries in industrial countries seemed to be relocation to developing countries or a change in the global division of labour (cf. Low/Yeats 1992, Stevens 1993).

A third possible solution is presented by structural change, reducing the importance of the heaviest polluters by reducing demand, or by modernisation in the sectors using inputs of these industries (Jänicke 1984, Ayres / Simonis 1994, Schmidt-Bleek 1993, v. Weizsäcker 1994). The theory that the more advanced countries are moving "beyond the era of materials" (Larson et al. 1986) offered hope in this direction.

The fourth possible solution to the ecological problems of heavily polluting industries is their own *ecological modernisation* (Jänicke 1984, Zimmermann et al. 1990). By ecological modernisation we mean a strategy for improving the environment by reducing the intensity (measured against value added) of use of materials, water, land and transportation, and the relative degree of risk brought by technological (or organisational) innovation. All of these are strongly influenced by the type and scale of major material flows.

Leaving aside the well-known end-of-pipe solution (which is now standard in most industrial countries) we would now like to discuss these three other possibilities.

We should first make clear what we mean by "dirty" industries. The main polluters among manufacturing industries are the producers of paper and paperboard, petroleum products, primary metals, stone, clay, glass and chemicals. These sectors have received by far the largest share of pollution control investment in (West) German and US manufacturing industry (Lu-

cas et al. 1992, 83), a clear indicator of their high environmental impact (Low/Yeats 1992, 91), but there are other environmentally important characteristics here. In (West) Germany, the aforementioned sectors accounted for 73% of the energy consumption, 83% of the water consumption and 49% of the solid waste generation of all manufacturing industry in the late eighties (Jänicke et al. 1993, 71, 83 ff.). Outside the manufacturing sector, electricity production, mining and road transport at the very least must also be added to the list of heavy polluters. In this context, "dirty industries" may be described as forms of production which cause above-average environmental stress even with the use of end-of-pipe treatment. We will call this "structural pollution".

Table 1: Indicators Analysed, Sources

Aluminium (PP)	Aluminium, primary production	Metallgesellschaft
Cement (P)	Cement production	UN
Chlorine (P)	Chlorine production	UN
Copper (P)	Copper, refined production	Metallgesellschaft
Crude Steel (P)	Crude steel production	UN / UNCTAD
Fertilizer (P)	Phosphate, potash and nitrogen fertilizers	FAO
Lead (Ref. P)	Lead, refined production	Metallgesellschaft
Paper/-board (P)	Paper and paperboard production	FAO
Pesticides (P)	Insecticides, herbicides and fungicides production	UN
Petrol. Products (P)	Petroleum products	OECD
Zinc (P)	Zinc, smelter production	Metallgesellschaft
Electricity (P)	Electricity production	IEA
Freight Movement (Road)	Freight transport in tkm	UN / ECE / IRF / UIC
GDP	Gross domestic product (constant (1980) Dollar)	OECD / CIA

We propose to analyse development in these sectors, with the exception of mining, in 32 industrial countries since 1970, using physical (as opposed to monetary) data to describe the total, or at least typical output of the above-mentioned sectors (see Table 1). Our intention thereby is to find empirical answers to the following questions:

- Has the relocation of dirty industries to developing countries contributed, so far, to a reduction in structural pollution in industrial countries (Section 2)?
- What role has been played by ecological *restructuring* (intersectoral change), here the decline of heavily polluting industries (Section 3)?
- Has ecological *modernisation* within heavily polluting industries (intrasectoral change) been a relevant factor (Section 4)?

Taking everything into account, the results are disappointing and so we come to the conclusion (Section 5) that a "green" industrial policy is necessary (Jänicke et al. 1987, UNIDO 1991, RWI 1992, RWI/DIW 1993; see also e.g. Krelle 1989, Audretsch 1991, Beirat 1991, Klepsch et al. 1994).

2. Have Dirty Industries been Relocated to Developing Countries?

The opinion that the wealthier countries of the world tend to solve some of their environmental problems by relocating basic polluter industries to developing countries is widely held (see e.g. Mármora 1992, George 1992, Narr / Schubert 1994). But is this the case? Or, if indeed "pollution intensity grew rapidly in developing countries during the 1970s and 1980s ... have they migrated, in the displacement sense?" (Low 1992: 3). This surely cannot be true for electricity production and road transport, and it is also hardly likely in the case of cement production, because of transport costs, but what about other polluting industries?

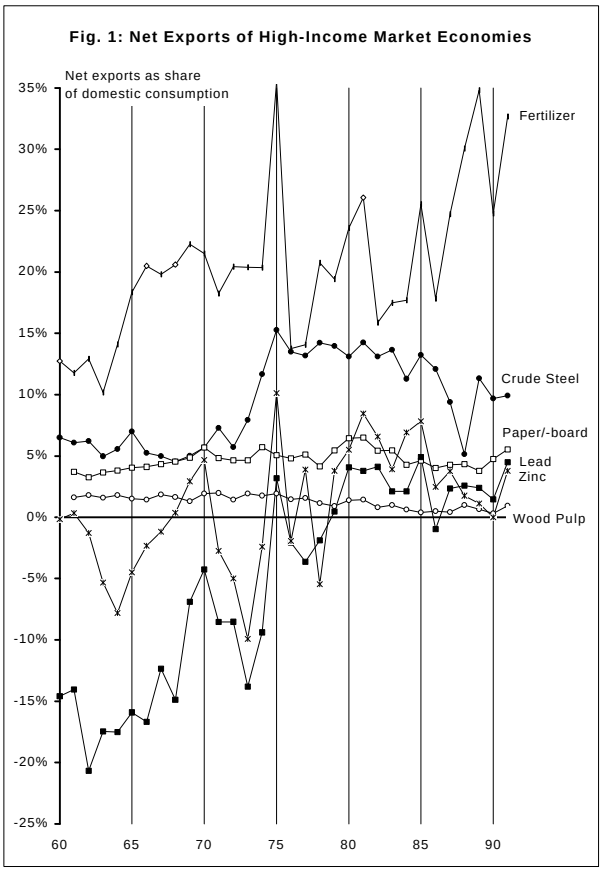
2.1 Empirical Data on North-South Trade

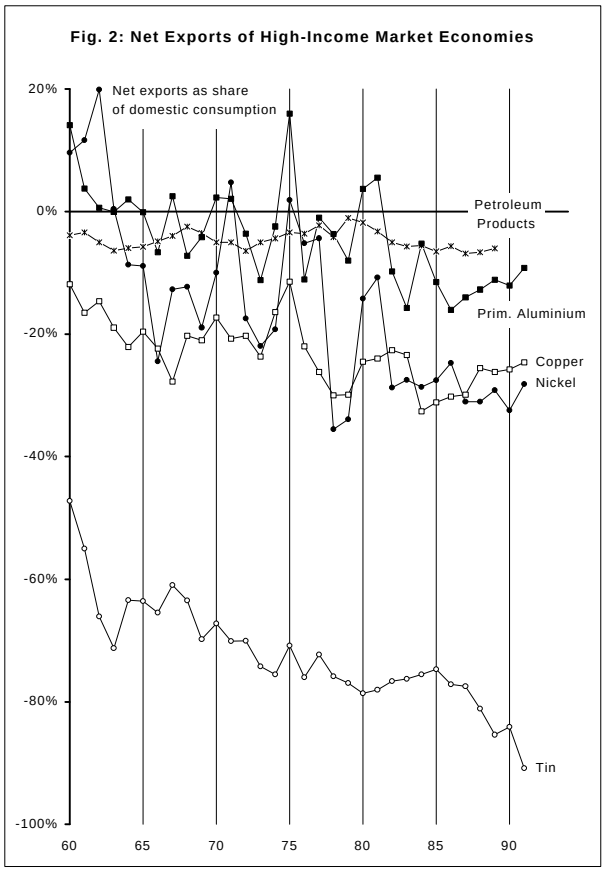
Developing countries' (in the main, newly industrialised countries like Brazil or South Korea) increasing share in world production of, or trade in, certain goods is sometimes taken to illustrate a tendency towards relocation. But if, as a consequence of industrialisation in the South, their share of consumption is increasing similarly, this does not indicate a change in the global division of labour. Even if production is growing faster than consumption in developing countries, the Third World might not necessarily have become a haven for the world's polluters; this could also be due to the effect of import substitution in some developing countries. Nevertheless, there could still be positive side-effects for the environments of high-income countries.

One possibility for testing this hypothesis of relocation or displacement is an analysis of the balance of trade in the industrial countries. For this, we have divided net exports (exports minus imports) of the aforementioned basic materials by domestic consumption in the highly industrialised market economies (i.e. OECD members without Greece, Ireland, Spain, Portugal, Turkey and Mexico). In addition, we will discuss the respective net export/consumption ratios for all industrial countries, i.e. all OECD members (except Mexico) and the former socialist states in Europe. Generally, the poorer OECD countries play a negligible role in these trade balances.

The advanced industrialised countries export large, and continually increasing amounts of **fertilisers** (cf. fig. 1), in both absolute terms and as a percentage of domestic consumption[1]. The main producers are Canada and, since the mid-eighties, the USA. Net export/consumption ratios for the former socialist countries have remained almost unchanged, the Soviet Union being the main exporter. While it is true that the import dependency of developing countries actually declined, this is due to the fact that fertiliser consumption in developing countries is

[1] The outlier for 1974/75 is probably the result of missing import data: in this year the reported world production of fertilisers was 13.4% (11 Mio. t) higher than reported world consumption. For later years this apparent surplus production amounted to only 4% of reported consumption.





today roughly twenty (!) times higher than in 1960, and while imports *from* industrialised countries as a share of developing countries' consumption has fallen from seventy-five to twenty-five percent, there has been no export *into* industrialised countries.

The rich countries continued to produce more **wood pulp, paper and paperboard** than they consumed, but the resulting exports were hardly significant. Production is concentrated strongly in the USA, Canada, Sweden and Finland, where three quarters of OECD wood pulp and nearly two thirds of its paper and paperboard is produced. Again, the former socialist countries hardly participated in foreign trade.

Despite well-known successes in some newly-industrialised countries, the highly industrialised countries' *export* dependency in **crude steel** has declined only slightly in recent years, after a sharp rise in the mid-seventies. Most important are Japan's (slowly declining) net exports, without which the highly industrialised countries' combined balance of trade would be zero, owing to the US importing roughly the same amount as Europe exports. The participation of the former socialist economies in world crude steel trade was insignificant.

When discussing the more heterogeneous group of **non-ferrous metals**, we should bear in mind the relatively low economic importance of these materials when compared to crude steel. The more advanced OECD countries produced more **zinc and lead** in the eighties than they used (fig. 1). Some other non-ferrous metals – especially **tin, copper and nickel** – are mostly smelted and refined in those countries which have their own metal ore resources (fig. 2)- The net import shares of these metals are therefore large in the wealthier countries (80-

100% of domestic tin consumption, about 30% for nickel and copper). The presence of bauxite deposits is however relatively unimportant as regards the production location for the most important non-ferrous metal – **primary aluminium**: crucial in this case is a supply of cheap energy, such as hydroelectric power. Encouraged by the oil crises, primary aluminium production has become more and more concentrated in countries where electricity is particularly inexpensive, such as Canada, Australia, Norway and Brazil. The trend in Japan, a country with high electricity prices, has been extraordinary. By the time of the first oil crisis, Japan had achieved complete self-sufficiency in aluminium production – and that with neither bauxite deposits nor any important domestic energy resources! But then, in 1978, primary aluminium production was abolished by law, and the material was henceforth imported, although recycling increased remarkably. The other OECD countries are net exporters. Net imports from all OECD members were as high as net exports from the former socialist economies (mostly the Soviet Union). Only in 1982-89 was there a 5% deficit (as a share of domestic consumption in all OECD and former socialist countries).

The western industrialised economies, mainly Japan and West Germany, imported **petroleum products** to a small extent (according to IEA calculations), but taken together with that of the *eastern* industrial economies, trade was balanced by immense Soviet exports. In the past there has also been no long-term tendency towards *rising* import dependency in the highly developed countries.

The general tendency has therefore been not towards relocation of "dirty" basic industries to developing countries. The high-income market economies have remained net exporters of fertiliser, paper and pulp, crude steel, lead and zinc, where the net export share in fertiliser, crude steel, lead and zinc is today even higher than it was twenty years ago. The net imports of petroleum products and primary aluminium were balanced by net exports from the Soviet Union (not from developing countries). Rises in net imports from developing countries could only be found in copper, nickel and tin.

Of course, these empirical findings relate only to possible relocation of highly polluting sub-sectors of the economy. Not included in the data are materials that are not directly traded, but used by producer countries themselves for the production of finished or semi-finished goods, such as machines, cars, even services, which may then be exported. It would be logically possible to hypothesise a country which neither produces nor imports basic materials, which is completely dependent on foreign industry, and which consequently imports large quantities of final products, but this is not plausible in the case of highly industrialised countries. On the other hand, it would be very difficult, if not impossible, to measure the content of direct or indirect material and energy use in world trade with any acceptable reliability. We have therefore only checked whether relocation has taken place within heavily polluting basic industries to a greater extent than within other manufacturing sectors, and evidence of this oft-asserted tendency could not be found. According to Low and Yeats, some developing coun-

tries' share of exports from heavily polluting industries has grown. But in 1988 the industrialised countries still accounted for three quarters of world exports in this sector, the EEC for 40% (Low/Yeats 1992: 92 ff.)!

We are not concerned here with the migration of heavy polluter industries and/or the respective change in the division of labour **within** the industrialised world. This is indeed an important trend, and it will be discussed in section 3.

2.2 Why Dirty Industries Are Seldom Relocated to Developing Countries

Should these results be considered surprising? After all, one assumes that pollution control is complicated and expensive, and that poorer societies are inclined to accept far less pollution control than richer ones. Why indeed do the most heavily polluting sectors not seek shelter from the protests of the rich in the slums of the poor?

In the first place, the costs of pollution control should not be overestimated (cf. OECD 1992, RWI/DIW 1993): even with respect to heavily polluting industries, pollution control costs hardly more than 3% of total output (Lucas et al. 1992), and most of these costs are a necessary condition for any proper operation. In the light of the differences – in the cost of labour, capital and transactions, and in political and economical risk – between developing and highly developed economies, the role of lower environmental standards, if there is one, can be only minor (Straubhaar / Wyss 1994).

When these other differences are taken into account, the industries analysed above can scarcely be identified as promising candidates for relocation. They are highly capital-intensive and require much professional skills (see e.g. Brown/McKern 1987), two factors generally considered to be the main obstacles to the development of self-reliance in the Third World.

Furthermore, it is unlikely that industrialised countries would threaten the competitiveness of their domestic industries by introducing strict environmental regulation. There is – not least in the basic industries – a tendency to abandon environmental protection measures as soon as jobs are at stake. In the face of a major economic threat, either the demand for more effective pollution control is reduced, or subsidies and market regulations are introduced to assist the needy polluters. This form of subsidy has attracted criticism on both economic and environmental grounds.

There are good arguments for moving production to parts of the South where demand is rising. But this leaves unanswered the question of whether a general relocation of heavy polluters to developing countries could reduce the pressure – and capacity – for innovation, which is particularly important in this industrial sector. A slowdown in innovation would actually increase global pressure on the environment.

3. Have Dirty Industries Declined as a Result of Structural Change?

Structural change is a permanent concomitant to economic development. Given the tremendous variation in the pollution intensities of different economic sectors, structural change may have important consequences for the environment, in the long run at any rate. Many observers predict long-term structural changes which may have positive side-effects for the environment (section 3.1). To what extent is this borne out by structural changes to date?

First we will analyse the trends within individual industries in all industrialised countries (section 3.2), and then we will turn to the patterns of change in individual countries for our selection of industries (section 3.3).

3.1 Theories of Ecologically Significant Structural Change

Goldemberg et al. (1988, 96-98) – following Larson et al. (1986) – have remarked on "a broad-based trend away from basic materials use in the economy" of highly developed countries. This is in line with earlier contributions from Malenbaum (1973, 1978; see also CEQ / Department of State 1980). The core of their argument is the hypothesis that long-term life cycles of materials such as steel, ammonia, cement, aluminium, chlorine and paper lead first to a reduced significance to GDP for materials, and finally to an absolute decline in material consumption. The authors showed that, generally starting with the first oil crisis in 1973, there has been a decline, in Germany, France and the UK, in per capita consumption of steel, cement and ammonia, and a stagnation in consumption of the others. In the US this tendency appeared even more widespread.

Several factors may contribute to such a long-term decline in material intensity:

- the gradually increasing importance of the service sector, and the corresponding decrease in the manufacturing sector's share of GDP;
- the rise of "post-materialism" and changes in consumer behaviour in advanced societies (Inglehart 1989), which has, among other things, led to an increase in the perceived importance of non-material aspects of consumption, where the value, even of industrial goods, is increasingly based on qualities such as durability, individuality, design, technological sophistication and, last but not least, low environmental impact;
- the declining demand within processing industries for basic materials (increased material productivity), due to cost-reducing modernisation (for example energy efficiency, waste reduction), and assisted by the change from mass production to more flexible and specialised forms of production (Piore/Sabel 1984);
- the decrease in material intensity of the basic industries themselves (increased value added per unit weight of output), through for example improvements in steel quality (McSweeny/Hirosako 1991).

In addition to this, partial substitution of some of the basic materials analysed has taken place:

- petroleum products by other energy sources, such as natural gas or nuclear energy,
- metals by plastics (and other metals).

Finally, the aforementioned trend may have been strengthened for a time by some more temporary factors:

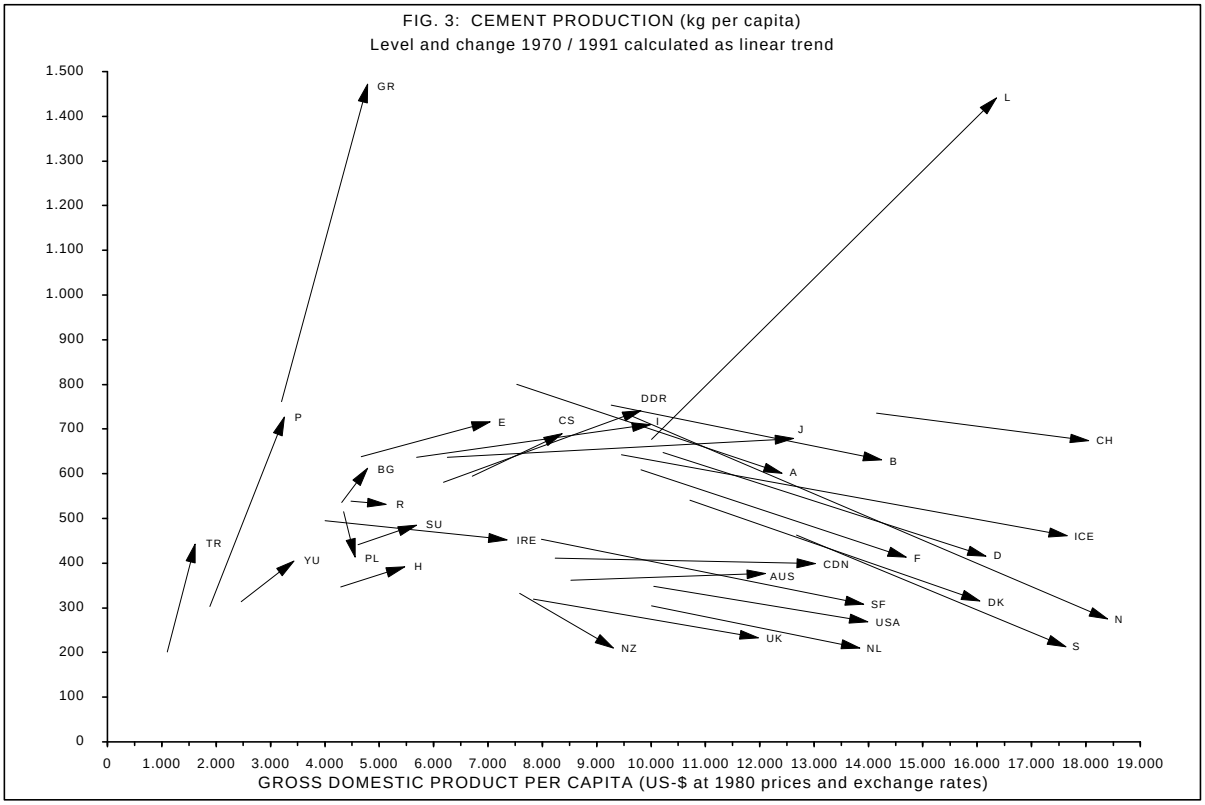
- the tremendous (but only partially long-lasting) rise in world oil prices;
- the sharp reduction in investment during periods of over-capacity, following unexpectedly low rates of GDP growth in the wake of the two oil crises and the collapse of the Bretton Woods system. This resulted in a fall in demand for machines and buildings, correspondingly reducing consumption of cement, metals and other durable materials, as well as of energy.

3.2 Product-specific Patterns of Change

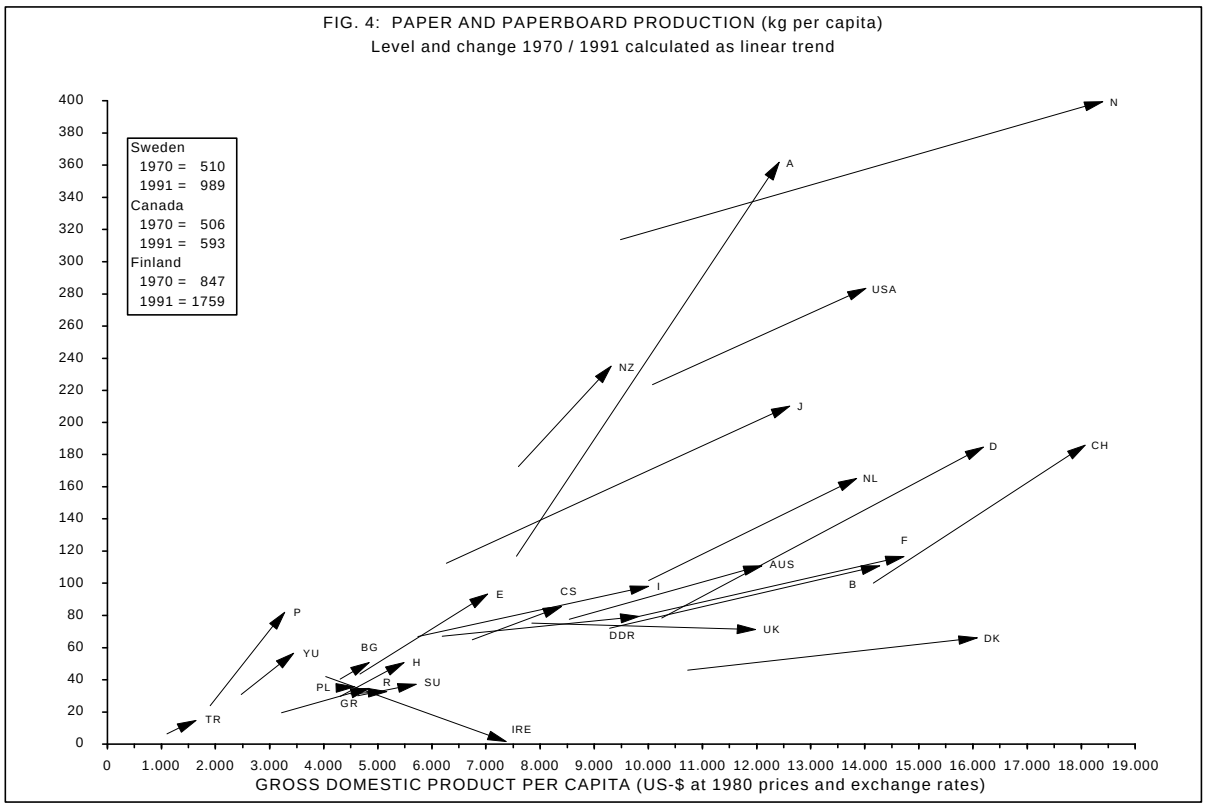
Economic development in the industrialised world in the last two decades has been characterised to a great extent by these trends. But is this sufficient justification for hypothesising the "end of the era of materials"? From an environmental perspective, the results are somewhat disappointing.

Production of cement, crude steel, fertilisers and petroleum products in the more advanced industrial countries has indeed generally decreased. However, the less developed industrial countries of Eastern and Southern Europe have experienced a broad increase (in the case of the eastern countries, up to the late eighties). This two-tier structure within the industrial world can also be found to apply to some environmental pollutants and to industry's energy and water consumption (Jänicke 1996).

The most extreme case in our selection of dirty industries is cement production (fig. 3). Here the trend in advanced countries has been quite different to that within other countries: we found drastically declining production, while cement production in Eastern and Southern Europe was rising faster than GDP. We have the impression that the data on GDP for the former socialist countries (which are based principally on official US statistics) tend to overstate substantially their wealth. Given more realistic data, the difference between rich and poor countries in fig. 3 would in all probability be even more impressive. The only high-income countries to show rising cement production have been Japan and Italy, while production in Canada and Australia has remained more or less stable. In most other advanced industrial countries, however, production has decreased, most markedly in Scandinavia – production in Norway has fallen by 50%! As a result, there is no difference today between rich and poor countries in per capita cement production, although variations *within* groups are remarkable (per capita production in Japan, for example, is three times higher than in Great Britain).



In contrast to the above-mentioned “structural improvements”, production by other heavy polluters – paper, chlorine, aluminium, pesticides, electricity and road transport (measured in tonnes-kilometres) – has steadily increased from an already high base, although a sharply negative trend in chlorine production has recently become apparent in some countries (Scan-



dinavia, Germany, France, Great Britain and Italy). These industries are more regionally concentrated than the "traditional" group mentioned above, which is mostly a result of natural competitive advantages such as forestation or cheap hydroelectric power.

Paper and paperboard production is presented in fig. 4 as an example of the more successful "dirty" industries. The specialisation in paper production is worthy of note, where Scandinavia, Austria and North America, due to their rich forest resources, are preeminent. With the exception of the British Isles, not a single country shows a trend towards declining production – on the whole, production increases in step with overall growth in GDP.

To sum up, a *general* decline of heavily polluting industries has not so far become evident in the industrial countries.

3.3 Country-specific Patterns of Change

Although from the oil crisis of 1973 until 1992, at least half of the 32 industrial countries under examination experienced a lower rate of growth in most "dirty" industries than in overall GDP, not one country has experienced an absolute decline of the majority of the industries examined here.

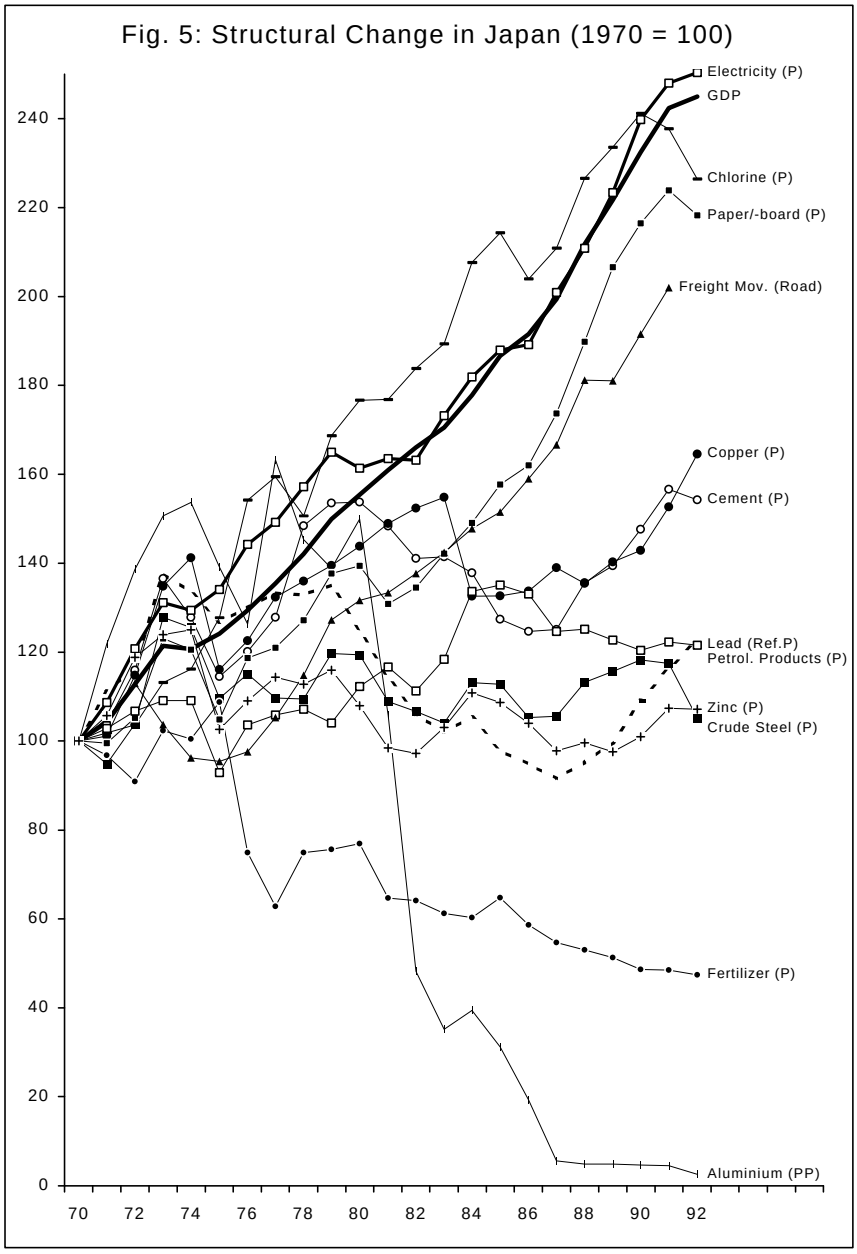
A *relative structural improvemen*t (de-linking of the majority of highly polluting industries from growth in GDP) was found in the cases of Australia, Austria, Belgium, Canada, Denmark, France, Germany, Ireland, Italy, Japan, Luxembourg, Norway, the UK and the USA. Its importance is best expressed negatively however: without it, the environmental situation would have been even worse.

The data for the US offer only partial confirmation of the "trend away from basic materials use" (Goldemberg et al. 1988: 96). This is the case in crude steel, aluminium and cement production, but there was a revival in production of materials such as chlorine and fertiliser in the late eighties. Paper and paperboard production has increased consistently.

The case of Japan is particularly interesting (fig. 5). Its relative improvement up to the mid-eighties was the most impressive within the OECD. Not one "dirty" industry grew significantly faster than GDP. The growth rates in electricity and chlorine production were much the same as that of GDP, as were those in paper and paperboard production and road haulage (after a sharp decline in 1972-76), while production of all other materials hardly rose above 1970 levels (petroleum products, crude steel, zinc, lead) or their levels in the late seventies (copper and cement). A revival in some of the heavy polluters has taken place since 1986/7, most notably in cement and petroleum products (Jänicke et al. 1993, 1993a, Foljanty-Jost 1995).

In the context of the reasons for declining material intensity (of GDP) given above, Japan is of special interest:

Fig. 5: Structural Change in Japan (1970 = 100)

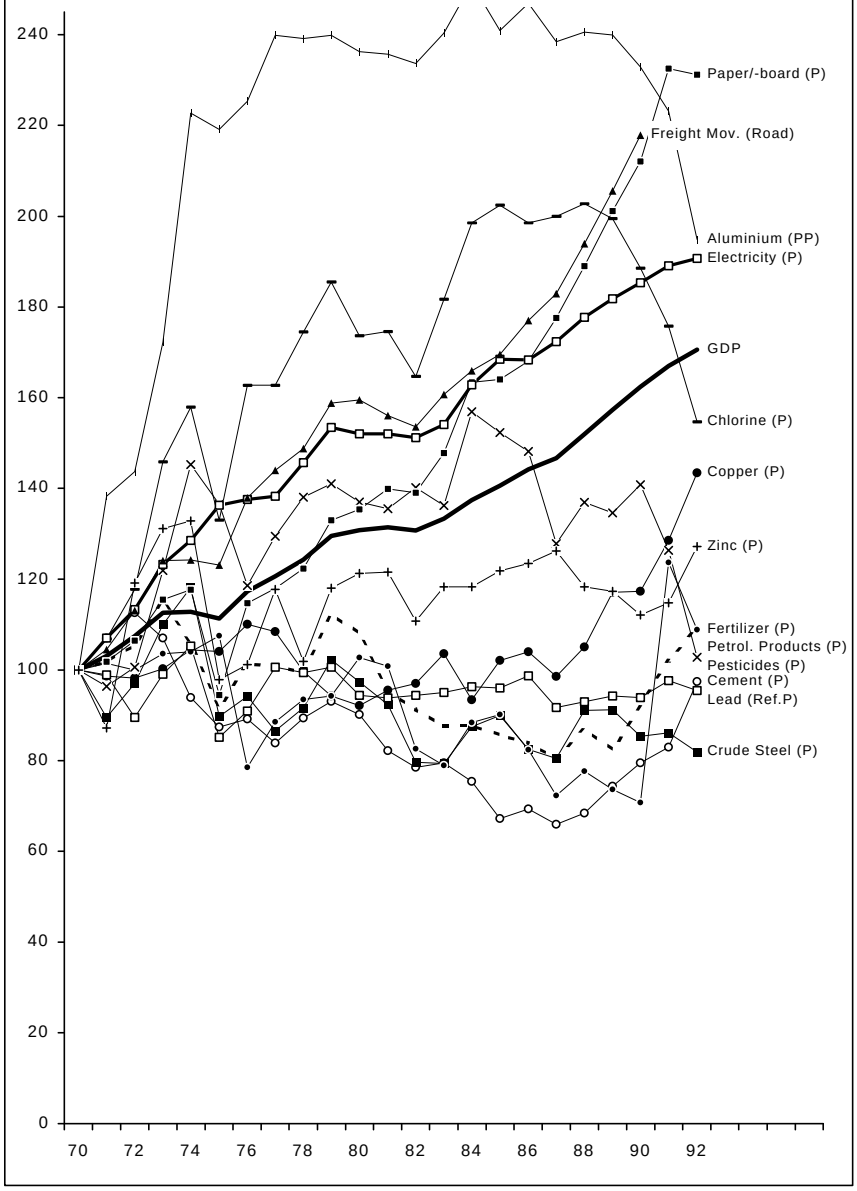


- During the last twenty years, Japan has been one of the very few developed countries whose manufacturing sector has increased its share of GDP.
- In a comparison of public opinion surveys in 21 industrial countries, Inglehart found a predominance of materialistic over post-materialistic values in Japan, exceeded only in Austria, Hungary, Ireland, Italy, Portugal and Spain (Inglehart 1989: 78).
- GDP growth and investment (the share of GNP used for investment) in Japan were the highest in the industrial world.

Thus the (relative) de-materialisation in Japan was the result neither of post-materialism nor de-industrialisation, but of a fast-growing and highly flexible industrial sector under pressure from rising energy prices and a heavy dependency on imports of raw materials (for the flexibility of the Japanese economy, especially of small and medium-sized enterprises, see Friedman 1988).

This is no argument in favour of economic growth, however. In countries like West Germany, the overall reduction in material intensity was much smaller, but weaker growth in GDP made possible an absolute fall in the use of some of the most important materials, whereas in Japan this effect was neutralised by high economic growth. **Differences in growth rates are therefore highly important in determining the environmental effects of industrial change.**

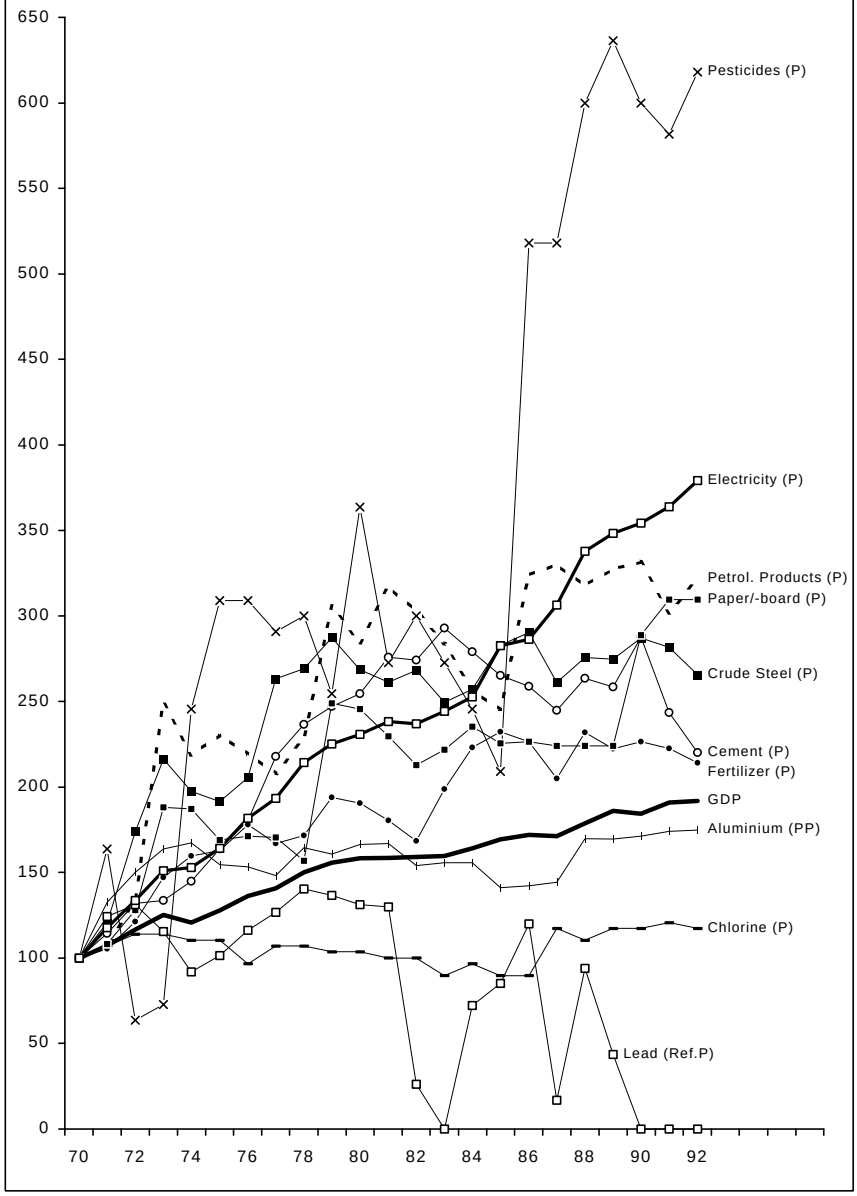
Fig. 6: Structural Change in the FRG (1970 = 100)



The trend in Germany – as in most other industrial countries – has been far more heterogeneous than in Japan (fig. 6). A decrease, in absolute terms, in crude steel, fertiliser, petroleum products, cement and lead production was partly offset by rapid growth in production of aluminium, chlorine, paper and paperboard and pesticides. However, the late eighties saw the beginnings of a rapid decrease in aluminium, chlorine and pesticide production. These materials (especially chlorine) have also been targets of public pressure for environmental reasons.

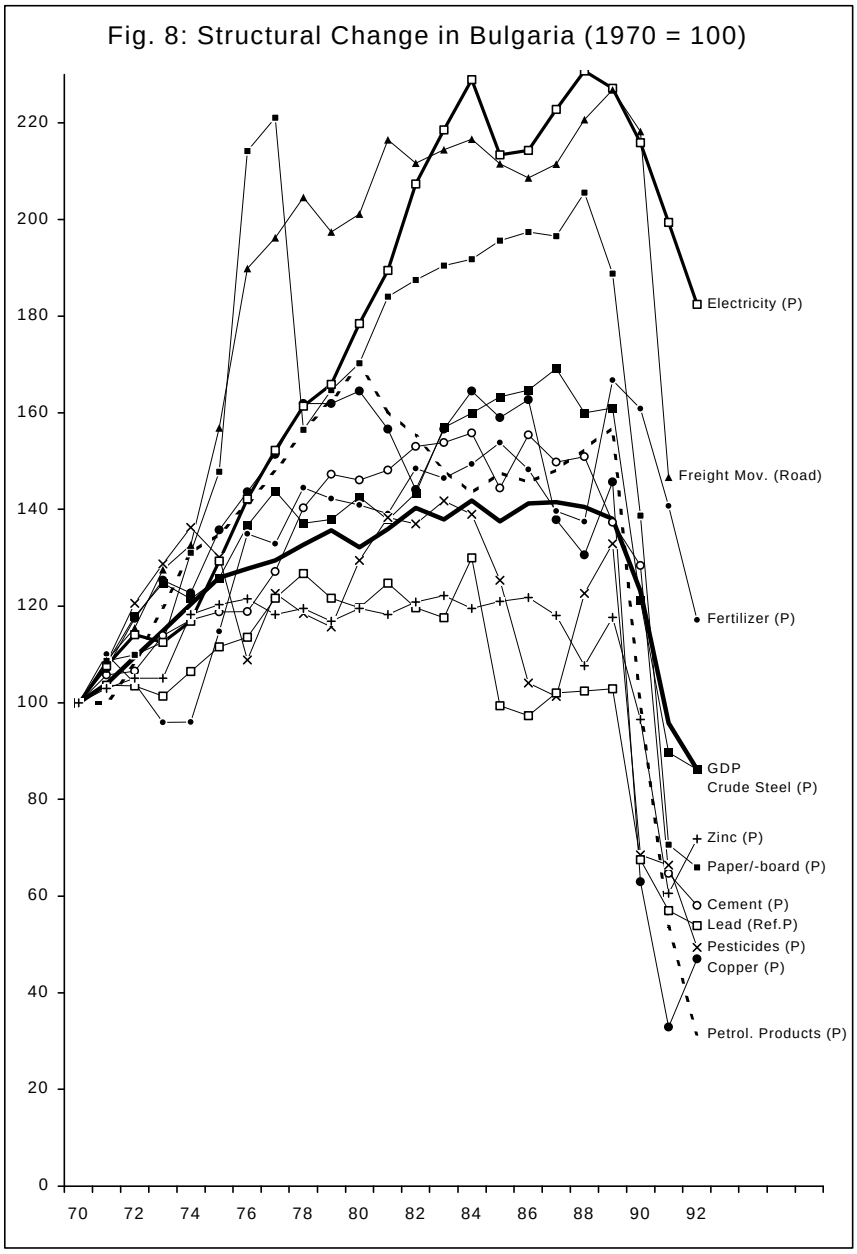
A *structural deterioration* took place in many Eastern and Southern European countries (Portugal, Yugoslavia and the former COMECON countries in Eastern Europe) until the late eighties, as the majority of highly polluting industries grew faster than GDP. A structural deterioration was also in evidence in New Zealand (for similar trends in developing countries see also Hettige et al. 1992, Reed 1992, Paulus 1993).

Fig. 7: Structural Change in Greece (1970 = 100)



To take Greece as an example, industries which tended to decline in the more advanced countries – cement, fertiliser, crude steel and petroleum products – grew faster than GDP (fig. 7). This was mainly due to sharp increases in production in the seventies, while production in the eighties remained fairly stable. Electricity production grew rapidly. The sharp rise in pesticide production should not be overstressed, as the level of production is still very low (0.65 kg per capita in 1990, compared with e.g. 2.50 kg/cap in Portugal or 5.75 kg/cap in France).

The former COMECON countries of Eastern Europe demonstrate an interesting form of structural change. After Stalin's death in 1953 there had been much criticism of the leading economic role played by heavy industry, or the "tonnage ideology". And since the late seventies there has been much criticism, sometimes on environmental grounds, of the sluggish increases in material and energy productivity (Roos/Streibel 1979), but this found a relatively weak echo in economic reality. Heavy industry, strongly represented in the power structures of the communist countries, resisted rapid structural change, and the price system gave no real incentive to the required increase in efficiency of material and energy use.



With the exception of the GDR (to some extent also Poland), the Eastern European countries showed a comprehensive structural deterioration in terms of the environment up to the late eighties. But "dirty" industries subsequently played a leading role in the sudden economic collapse, most dramatically in Bulgaria (fig. 8).

4. Ecological Modernisation within Industries

For the final possibility for environmentally oriented improvements beyond end-of-pipe treatment, we will now turn to intrasectoral ecological modernisation. In case studies of the Japanese, German and Swedish manufacturing sectors we have analysed some of the aforementioned indicators for ecological modernisation, namely the intensity of final energy – especially electricity – and water consumption. Unfortunately, there were no data available for other ecologically relevant intensities in individual branches of industry. Since we are interested in the potential for improvements above and beyond the end-of-pipe approach, we did not analyse emission intensities.

We were interested in how far inter- and intrasectoral change contributed to the reduction in ecologically important intensities within the manufacturing sector after 1970, and how far

this effect was neutralised by industrial growth. In the manufacturing sectors of Japan, Germany and Sweden, intrasectoral ecological modernisation contributed more to (relative) environmental improvement than the intersectoral decline of heavily polluting industries (tab. 2, for details see Jänicke et al. 1993).

Table 2: Ecological Indicators of Industrial Change: Effects of Intra-/Intersectoral Change and Economic Growth

	Japan			West Germany			Sweden		
	intra	inter	growth	intra	inter	growth	intra	inter	growth
		result			**result**			**result**	
Energy	-58,6%	-12,6%	+179,7%	-30,4%	-13,6%	+37,2%	-27,6%	-2,1%	+25,2%
		+5,7%			**-14,4%**			**-11,4%**	
Electricity	-34,6%	-4,3%	+179,7%	+2,4%	-0,4%	+37,2%	+10,8%	-0,7%	+25,2%
		+79,2%			**+46,7%**			**+38,3%**	
Water	-29,5%	-8,2%	+140,5%	-36,9%	+0,7%	+23,8%		n.a.	
		+61,5%			**-18,1%**				

Japan: energy/electricity consumption 1970-89; water consumption 1970-87
Germany: energy/electricity consumption 1970-89; water consumption 1971-87
Sweden: energy/electricity consumption 1973-88
n.a. not available

Read: In 1989 energy consumption by Japanese manufacturing was 58.6% lower than it would have been without intrasectoral change since 1970, i.e. without changing energy intensities in individual branches of industry.
"intrasectoral change" means changes in the environmental intensities (environmental consumption per unit of value added) of individual industries (sectors).
"intersectoral change" means a change in the composition of value added of manufacturing by industries (sectors). If environmentally highly intensive industries are growing slower than average, the effect of intersectoral change on environmental consumption is negative.
"growth" means growth of manufacturing's combined value added.
"result" means change in the combined environmental consumption of manufacturing.

In 1989 Japan's *industrial final energy consumption* was 58.6% (in Germany 30.4%) lower than it would have been without the technological changes within sectors of industry (intrasectoral change) since 1970. By contrast, a reduction in the importance of energy-intensive sectors (intersectoral change) reduced energy consumption by only about 13% in Japan and Germany. The corresponding figures for Sweden (1988) show a 27.6% reduction due to intrasectoral change, and one of only 2.1% due to intersectoral change since 1973. In spite of the much smaller effects of its own ecological modernisation, Sweden's final industrial energy consumption fell by 11.4% (1973-1988), whereas Japan's rose by 5.7% (1970-89), explained by the striking differences between growth rates in value added: 25.2% in Sweden, but 179.7% in Japan! The overwhelming importance of intrasectoral, as opposed to intersectoral, change in determining industrial final energy consumption has been corroborated by additional studies (Binder 1993). One exception to the rule is Luxembourg, where the radical decline in crude steel production, brought about by concerted industrial policy initiatives, was more environmentally significant than any technological change (Kuckla 1994). In many poorer countries, for example Portugal, technological change seems even to have made the environmental situation worse (Jänicke et al. 1993, 1993a; cf. Howarth et al. 1991).

A more detailed analysis of different primary energy sources would be useful in estimating the environmental consequences of energy consumption, but we have not done this. We only have focused especially on industrial electricity consumption, firstly because electricity consumption patterns differ from energy consumption patterns, and secondly because large energy losses in power production and transmission mean that electricity consumption is especially problematic. In nearly every industrial country there was a rise not only in electricity consumption, but also in electricity intensity. Intersectoral change had almost no effect, while intrasectoral change often led to a substitution of electricity for other energy sources. The most important deviant case is Japan, where industrial electricity consumption was 34.6% lower in 1989 than it would have been without intrasectoral change. Japan is also alone in having had progressive tariffs on industrial electricity consumption since the oil crisis!

Industrial water intensities seem to have been falling in many developed countries, but there are still few national time series available for this. Long-term German statistics show an absolute decline in domestic water consumption since as early as the sixties, which has been entirely the result of intrasectoral change. In Japan, a similar development started in the mid-seventies, and has led to a stabilisation of domestic water consumption since the early eighties.

Fig. 9: Percentage change by indicator and branch 1971/1987: Japan

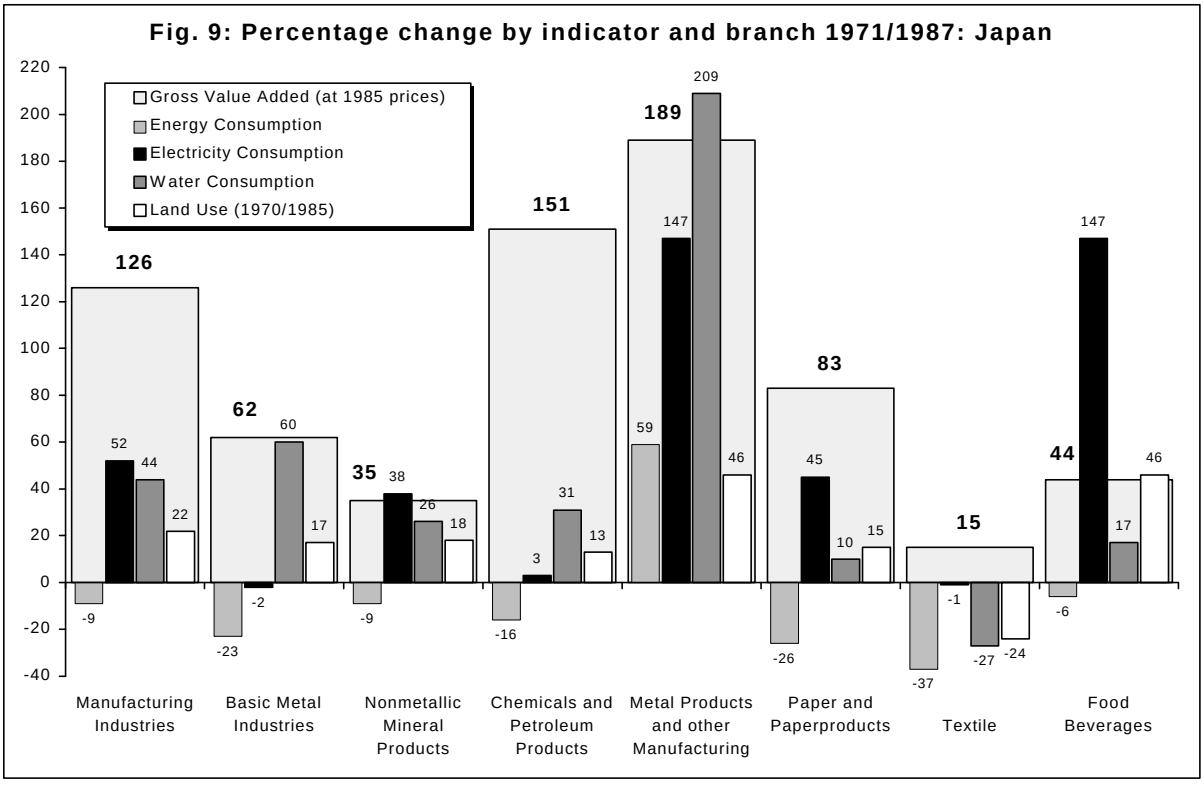


Figure 9 shows the extreme case of Japan (1971-87) in some detail, and includes figures on land use by sectors. The extraordinarily deep structural change against a background of enormous economic growth can be seen from the different growth rates in value added, ranging from +15% in textiles to +189% in metal products (and others). But change within these sec-

tors is even more impressive: in every sector, except the fast-growing metal products sector, final energy consumption fell. Virtually all other indicators were rising in every sector except textiles (electricity consumption in basic metal production also fell), but intensity measured against value added decreased in nearly every case. This intrasectoral ecological modernisation took on a special importance in the "dirty" industries: in 1987, the chemicals sector consumed 16% less final energy (and only 3% more electricity), 31% more water and 13% more land, while adding 151% more value compared with 1971.

Further research is needed to show how far such intrasectoral change is the result of technological innovation (including leaner production methods), and how far it is simply due to structural change within the sectors, but intrasectoral ecological modernisation has certainly been important in some advanced countries. In Japan, the radical improvement in energy efficiency since the oil crisis has contributed to the reduction of SO_2 emissions to an even greater extent than the widespread installation of desulphurisation equipment (Environment Agency 1993: 171). On the other hand, most of the industrial energy savings here were neutralised by rapid growth. Again, different industrial growth rates lead to differences in the long-term environmental effects of structural or technological change.

Ecological modernisation has thus far mainly taken the form of increases in the efficiency of energy and water use and in the extent of recycling. As a form of ecological modernisation, substitution of dangerous materials has played a minor role. And this may be true to an even greater extent for intensity of land use and transportation in industry. But it is reasonable to suppose that the scope of ecological modernisation will expand more and more, coming to influence these ecologically important factors also.

In the long run, an absolute decrease in the material input of production – so-called "de-materialisation" (Herman 1989, Schmidt-Bleek 1993) – may become the most significant imperative. In this case, ecological modernisation would exert a more dramatic influence on the role of basic industries (eco-restructuring). Hitherto there has been only a decoupling of industrial growth from material input in such countries as Japan, Germany, Austria and possibly the US (where the data are insufficient). In Japan, absolute material input remained substantially stable between 1975 and 1985, before increasing again (Environment Agency 1993: 224); in West Germany, a small per capita reduction could even be observed between 1980 and 1990, with a relative increase in the input of biotic materials (Statistisches Bundesamt 1994: 337).

According to the U.S. Bureau of Mines, worldwide per capita consumption of important materials remained stable between 1970 and 1990 (Rogich 1993). This implies an absolute increase in material input, but its decoupling from global economic growth, or at any rate a relative "de-materialisation". One would assume that the more advanced countries have made a relatively high contribution here, but much more research is needed in this area.

5. Conclusion: On the Verge of a New Green Industrial Policy?

We have given thus far a broad (and necessarily approximate) overview of industrial change in developed countries, focusing on the heaviest polluters in the economy. It has been shown that there is immense potential for environmental improvement above and beyond end-of-pipe measures. Without the changes that took place in the wake of the oil crisis, the environmental situation in the most advanced industrial countries would have been considerably worse, in spite of impressive investment in clean-up. However, the actual change has resulted nowhere in absolute and sustained improvements. Even in highly developed countries, neither relocation of "dirty" industries, nor their general decline, nor ecological modernisation within environment-intensive sectors has been a strong enough motor to go beyond a mere delinkage to a real reduction of the structural environmental impact of industry.

This supports the argument that a green industrial policy is necessary. The argument gains particular weight when we regard the fact that the most environmentally harmful industries often cause economic as well as ecological problems. In several industrial countries, coal-mining and many basic industries are directly subsidised. They generally profit from low electricity prices which are in turn "subsidised" by higher prices for domestic users. Indeed, basic industries are still seen by many countries as their industrial backbone. One might almost think that they were the main generators of economic wealth. But society – and the cleaner industrial sectors – pays a high price for them, a price which becomes even higher when we include the externalised damage costs of heavy polluters.

The ecological and economic crisis within industry may be the main challenge facing a new green industrial policy, but there are further arguments for a new industrial strategy (cf. Fischer/Schot 1993, Flavin/Young 1993, Hinterberger/Welfens 1993, Palmer/Simpson 1993, Baccini/Brunner 1991; Enquete-Kommission 1994):

- In a growing economy, a stable environmental situation can only be realised by permanent, increasingly radical technological and structural change. Even if the material flow can be stabilised or reduced, the crucial problem of the accumulation of dangerous stock-piles remains. Scarce waste disposal facilities, soil pollution and the climate problem are strong indications here. And additive clean-up measures are only a first step: in many respects their potential will be exhausted in the foreseeable future, and they are of absolutely no use in handling many urgent problems. Eco-restructuring of, and ecological modernisation within, heavily polluting industries will be needed as additional strategies for environmental improvement (or at least stabilisation).
- End-of-pipe treatment and simple environmental repair (for example cleaning contaminated soil) may well become an intolerable burden to national economies if they are extended to cover other unsolved problems. Other ecologically relevant cost factors – such as transportation, land use, insurance, energy, water and other resources – are also set to rise.

- The coming effects of eco-auditing and eco-balancing may be similarly important. Enterprises in more advanced countries now receive relevant information on the environmental role of their resource inputs, and market competition forces them increasingly to take account of such information. As a consequence of environmental reporting on enterprises, there is now a tendency to place pressure for environmental change onto the shoulders of the supplier: 25% of Norwegian enterprises evaluate their suppliers today according to environmental criteria (Gothenburg Research Institute 1995: 46). This easy route to a green image at the expense of suppliers, first taken by trading companies, will mean great economic risks for heavy polluters. They could be the losers in this "greening" of the supply chain. And this is taking place in the context of market-internal pressure for change which could produce more results than traditional government intervention.
- Environmental as well as fiscal problems will increase the tendency to raise taxes from environmental stress factors.

If this scenario is realistic, a long-term strategy would be needed especially for the heavily polluting industries, for economic as much as for environmental reasons. This is not the place to formulate such a strategy. We would however like to say what a green industrial policy is not:

- In the first place, it should be clear that it does not focus on the promotion of "eco-industries", i.e. the production of additive clean-up equipment. While these measures may have their own merits, we have been discussing the need for green industrial policies precisely because of their limitations.
- Green industrial policy is also more than merely the introduction of eco-taxes, or similar economic instruments. The markets of most "dirty" industries are usually highly imperfect and politically regulated, mostly because the social and economic consequences of free trade are considered unacceptable. This creates limitations on the use of economic instruments, despite their importance. Government-led networking, and concerted action from the relevant groups would be indispensable (Traxler/Unger 1991).
- Thirdly, green industrial policy cannot be a kind of environmental "super-policy", with other relevant policy areas – economic, labour, regional, trade or research – mere subcategories in environmental policy-making.
- Finally, ecological modernisation also creates losers. Green industrial policy should therefore be conceived also in terms of an active and anticipative labour market policy. According to comparative research, environmental policy is most successful within a stable economy with good labour market conditions (Jänicke 1996, 1992). And so a green industrial policy should take its own social conditions into account.

We need information about the global structural changes taking place. And we need much more research on the available options for the existing "dirty" industries: Is an intensification

of ecological **modernisation** the best solution? Is it **transformation** – for example going over to new materials or products, participation in high-tech waste recycling, enlarging the service sector? Or is **reduction**, its effects mitigated through social policy, the optimal strategy?

In any case, if industrial change is inevitable, and especially if economic and ecological crisis is foreseeable as a result, it should be organised sufficiently far in advance and take place sufficiently gradually, alleviating the social consequences and giving early incentives for the creation of new types of employment. And here, organised capitalism may still be the better mode of operation, in comparison to the pure free market model, which abstains strictly from any kind of industrial policy.

The crucial question will be for how long, and at what ecological and economic cost a developed national economy can depend on a large environment-intensive sector. A possible alternative to a green industrial policy certainly exists: ecological and industrial degeneration. Its consequences can be studied in Eastern Europe and in many older industrial regions.

REFERENCES

Audretsch, D. B. (1991): Industrial Policy in the Nineties: An International Comparison, Wissenschaftszentrum Berlin (FS IV 91 - 32).

Ayres, R. U. / Simonis, U.-E. (1994): Industrial Metabolism – Restructuring for Sustainable Development, New York, Tokio.

Baccini, P. / Brunner, P. H. (1991): Metabolism of the Anthroposphere, Berlin a.o.

Beirat für Wirtschafts- und Sozialfragen (1991): Industriepolitik III, Wien.

Binder, M. (1993): Energieverbrauch der OECD, Forschungsstelle für Umweltpolitik Berlin (FFU rep 93-2).

Brown, M. / McKern, B. (1987): Aluminium, Copper and Steel in Developing Countries. Paris (OECD).

CEQ (Council on Environmental Quality) and Department of State (1980): The Global 2000 Report to the President. Wahington.

Enquete-Kommission "Schutz des Menschen und der Umwelt" des Deutschen Bundestages (1994): Die Industriegesellschaft gestalten. Perspektiven für einen nachhaltigen Umgang mit Stoff- und Materialströmen, Bonn.

Environment Agency (1993): Quality of the Environment in Japan 1992, Tokyo.

Fischer, K. / Schot, J. (eds.) (1993): Environmental Strategies for Industry – International Perspectives on Research Needs and Policy Implications, Washington, D. C.

Flavin, Ch. / Young, J. E. (1993): Shaping the Next Industrial Revolution, in: Worldwatch Institute: State of the World 1993, New York, Washington, D. C., 180-257.

Foljanty-Jost, G. (1995): Ökonomie und Ökologie in Japan, Politik zwischen Wachstum und Umweltschutz, Opladen.

Friedman, D. (1988): The Misunderstood Miracle, Industrial Development and Political Change in Japan. Ithaca, London.

George, S. (1992): The Debt Boomerang. London.

Goldemberg, F. / Johansson, Th. B. / Reddy, A.K.N. / Williams, R. H. (1988): Energy for a Sustainable World, New Dehli.

Gothenburg Research Institue / Bedriftsoekonomens Forlag (1995): The Nordic Business Environmental Barometer, Oslo.

Herman, R. et al. (1989): "Dematerialization", in: Ausubel, J. / Sladovich, H. E. (eds.): Technology and Environment, Washington, D. C.

Hettige, H. / Lucas, R. E. B. / Wheeler, D. (1992): The Toxic Intensity of Industrial Production: Global Patterns, Trends, and Trade Policy, American Economic Review, Vol. 82, No. 2, 478-481.

Hinterberger, F. / Welfens, M. J. (1993): Ökologischer Strukturwandel. Wirtschaftswissenschaftlicher Forschungsbedarf für eine zukunftsfähige Entwicklung, Wuppertal Institut (Wuppertal Papers Nr. 6).

Howarth, R. B. / Schipper, L. / Duerr, P. A. / Stroem, St. (1991): Manufacturing Energy Use in Eight OECD Countries. Decomposing the Impacts of Changes in Output, Industry Structure and Energy Intensity. In: Energy Economics, Vol. 13, 135-142.

Inglehart, R. (1989): Cultural Change. Princeton.

Jänicke, M. (1984): Umweltpolitische Prävention als ökologische Modernisierung und Strukturpolitik, Wissenschaftszentrum Berlin (IIUG discussion papers 84-1).

Jänicke, M. (1992): Conditions for Environmental Policy Success: An International Comparison, The Environmentalist, Vol. 12, No. 1, 47-58.

Jänicke, M. / Mönch, H. / Ranneberg, Th. / Simonis, U. E. (1987): Improving Environmental Quality through Structural Change – A Survey of Thirty-one Countries, Wissenschaftszentrum Berlin (IIUG dp 87 - 1).

Jänicke, M. / Mönch, H. / Binder, M. u. a. (1993): Umweltentlastung durch industriellen Strukturwandel? Eine explorative Studie über 32 Industrieländer (1970 - 1990), Berlin, 2nd edition.

Jänicke, M. / Mönch, H. / Binder, M. (1993a): Ecological Aspects of Structural Change, Intereconomics, Vol. 28, No. 4, 159-169.

Jänicke M. (ed.) (1996): Umweltpolitik der Industrieländer, Entwicklung – Bilanz – Erfolgsbedingungen, Berlin.

Klepsch, Th. / Legrand, H.-J. / Sanne, A. (eds.) (1994): Integrierte Strukturpolitik – Eine Herausforderung für Politik, Wirtschaft und Kommunen, Köln.

Krelle, W. (ed.) (1989): The Future of the World Economy – Economic Growth and Structural Change, Berlin a.o.

Kuckla, R. (1994): Ökologische Aspekte des Strukturwandels in Luxemburg. Berlin, Free University, Department of Political Science (unpublished).

Larson, E. / Ross, M. H. / Williams, R. H. (1986): Beyond the Era of Materials, in: Scientific American, Vol. 254, No. 6, 24-31.

Lucas, R. E. B. / Wheeler, D. / Hettige, H. (1992): Economic Development, Environmental Regulation and the International Migration of Toxic Industrial Pollution: 1960-1988, in: Low, P. (ed.): International Trade and the Environment, Washington, D. C.

Low, P. (ed.) (1992): International Trade and the Environment, World Bank Discussion Papers (159), Washington, D. C.

Low, P. / Yeats, A. (1992): Do "Dirty" Industries Migrate? In: Low, P. (ed.): International Trade and the Environment, Washington, D. C.

Malenbaum, W. (1973): Material Requirements in the United States and Abroad in the Year 2000, Philadelphia, PA.

Malenbaum, W. (1978): World Demand For Raw Materials In 1985 And 2000, New York.

Mármora, L. (1992): Sustainable Development im Nord-Süd-Konflikt: Vom Konzept der Umverteilung des Reichtums zu den Erfordernissen einer globalen Gerechtigkeit. in: Prokla 86, Vol. 22, No. 1: 34-46.

McSweeney, C. / Hirosako, M. (1991): Understanding crude steel consumption. The perils of ignoring the role of technological change, in: Resources Policy 17, 258-270.

Narr, W. D. / Schubert, A. (1994): Weltökonomie. Die Misere der Politik, Frankfurt/Main.

OECD (Organization for Economic Cooperation and Development) (1992): The OECD Environment Industry: Situation, Prospects and Government Policies. Paris..

Paulus, St. (1993): Umweltpolitik und wirtschaftlicher Strukturwandel in Indien, Berlin etc.

Palmer, K. L. / Simpson, R. D. (1993): Environmental Policy as Industrial Policy, in: Resources 17.

Piore, M. / Sabel, Ch. (1984): The Second Industrial Divide, Possibilities for Prosperity, New York.

Reed, D. (ed.) (1992): Structural Adjustment and the Environment, London.

Rogich D. G. (1993): United States and Global Material Use Patterns, Presented at the ASM International Conference "Materials and Global Environment", Sept. 13-15, 1993.

Roos, H. / Streibel, G. (1979): Umweltgestaltung und Ökonomie der Naturressourcen, Berlin (GDR).

RWI (1992): Umweltschutz, Strukturwandel und Wirtschaftswachstum, Essen.

RWI/DIW (1993): Umweltschutz und Industriestandort – Der Einfluß umweltbezogener Standortfaktoren auf Investitionsentscheidungen, UBA-Bericht 1/1993, Berlin.

Schmidt-Bleek, F. (1993): Revolution in Resource Productivity for a Sustainable Economy – A New Research Agenda, in: Fresenius Environmental Bulletin, Vol. 2, No. 8, 485-490.

Statistisches Bundesamt (Ed.) (1994): Datenreport, Bonn.

Stevens, C. (1993): Do Environmental Policies Affect Competitiveness? The OECD Observer No. 1983, 22 - 25.

Straubhaar, Th. / Wyss, M. (1994): Ausländische Direktinvestitionen in Nicht-OECD-Ländern, in: Zeitschrift für Umweltpolitik und Umweltrecht, Vol. 17, No.1, 98-121.

Traxler, F. / Unger, B. (1991): Institutionelle Erfolgsbedingungen wirtschaftlichen Strukturwandels, in: Wirtschaft und Gesellschaft, Vol. 16. No. 2, 189-223.

UNIDO (United Nations Industrial Development Organization) (1991): Proceedings of the Conference on Ecologically Sustainable Industrial Development, Copenhagen, Denmark 14-18 October 1991.

Weizsäcker, E. U. von (1994): Earth Politics, London.

Zimmermann, K. / Hartje, V. J. / Ryll, A. (1990): Ökologische Modernisierung der Produktion. Strukturen und Trends, Berlin.

STATISTICAL SOURCES

Bureau of Statistics, Office of the Prime Minister: Japan Statistical Yearbook, Tokyo, sev. vol.

Central Intelligence Agency: Handbook of Economic Statistics, Washington D.C., sev. vol.

DIW (Deutsches Institut für Wirtschaftsforschung): Verkehr in Zahlen 1991, Ed.: Der Bundesminister für Verkehr, Bonn.

FAO (Food and Agriculture Organization): Yearbook Fertilizer, Rome, sev. vol.

FAO (Food and Agriculture Organization): Yearbook Foorest Products, Rome, sev. vol.

IEA (International Energy Agency): Energy Statistics and Balances, Paris, February 1993.

IRF (International Road Federation): World Road Statistics, Washington D.C., Geneva, sev. vol.

Metallgesellschaft AG: Metallstatistik, Frankfurt/Main, sev. vol.

OECD (Organization for Economic Cooperation and Development): Main Economic Indicators, Paris, sev. vol.

OECD: National Accounts of OECD countries, Paris, sev. vol.

Tsusho sangyo daijin, kanbo chosa tokei-bu: Kogyo tokei-hyo (Industrial Statistics), Tokyo, sev. vol.

UIC (Union Internationale des Chemins de fer): International Railway Statistics, Paris, sev. vol.

UN (United Nations) /ECE (Economic Commission for Europe): Annual Bulletin of Transport Statistics for Europe, Genf, sev. vol.

UN: Industrial Statistics Yearbook, New York, sev. vol.

UN: Statistical Yearbook, New York, sev. vol.

UNCTAD (United Nations Conference on Trade and Development): Yearbook of International Commodity Statistics, New York, sev. vol.