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Industrial restructuring for sustainable development

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Industrial Restructuring for Sustainable Development

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1. Introduction

Until recently, the role of economic or industrial restructuring as a driving force for environmental change has not been widely explored.¹ This may be due in part to the difficulty of collecting suitable data and indicators with which to describe the impacts of an economic structure on the environment. In part it may be due to the fact that the level of economic development or the growth rate of the economy were thought to be more important for explaining the occurring changes in the natural environment.²

The present chapter examines the links between the various sectors (or industries) of the economy and the overall economic performance and addresses the possible delinking of polluting sectors (or industries) from the gross national/domestic product; it thus views restructuring as one way towards a more efficient industrial metabolism.

Such examination could take place on the level of the individual sector (or industry), the aggregate level of all sectors (or industries), but also for the regions of the economy. It, at least, should be undertaken for those sectors (or industries) whose environmentally negative effects are rather certain (*structural environmental impacts*). This would imply a meso-economic, not a micro-economic approach to understanding environmental change. Such examination may make it possible to better assess current structural changes of economies and, based on their environmental implications, may suggest directions of future, environmentally benign structural policy.

The word *structural change* or *restructuring* is generally used to characterize the decline or increase over time of certain sectors, groups of industries, or regions (and, sometimes, technologies) in the gross national/domestic product.³ One may also think of structural change in terms of a transformation in the mix of goods and services produced; or one may refer to a broader set of changes in the economy, not only in its products and employment, but also in the social relations of production (e.g., unionization, part-time vs. full-time jobs), the means of production (e.g., handcrafting, robotics), and the forces of production (e.g., market demand, profits).

Clearly, not all possible classifications and groupings are helpful or find interest of structural research. One has either to make an explicit

choice, or has implicitly made one in using or referring to a well-known, long established concept of structural change. In this chapter, we will use one of several concepts of structure in economics, namely the sectoral production structure, i.e., the share of sectors in the economy and their relation to gross national/domestic product.

Economic restructuring thus subsumes *industrial* restructuring, though the terms are often used interchangeably. Any restructuring of the sectors (or industries) in an economy are, of course, linked to more profound changes in other realms. For our purpose and within this concept, we will deliberately select such sectors whose environmentally harmful potential is beyond question. Thus we will not consider here the regional structure, the employment structure, and the investment structure, even though all of these might be quite relevant perspectives for explaining the given environmental situation of a country, or its change over time.

Regarding the temporal dimension of structural change, there is, as we will see, a differentiation to be made between *discontinuity* and *gradualism*. There is economic restructuring as a discontinuity, or a break in development, and there is gradualism, as an evolutionary or slow transition. Discontinuity may be the outcome of subterranean historical processes, but gradualism is the every day reality of change. Clearly, the two are not mutually exclusive, but rather two sides of the same coin.

As regards impacts, we use the word *structural environmental impact*, meaning the environmental stress or burden that results from a given sectoral production structure, irrespective of pollution control measures taken.

2. Identifying indicators of environmentally relevant structural change

It is not so long ago that sheer quantity of output was considered to be the indicator of a nation's economic success; in some circles it still seems to be so regarded. In Eastern Europe the importance attached to this criterion led to "tonnage ideology". In Western societies steel production and transport volume were once considered to be central indicators of economic success; currently housing starts, energy consumption and the number of cars produced play this role. This accounts for the importance of the motor industry in the political arena. For a number of reasons, however,

such (and other) examples of energy and materials consumption must be understood as indicators of economic failure.

Particularlry in times of increasing costs for energy and materials, a high consumption of such inputs would turn out to be uneconomic. And countries that have drastically reduced their specific energy and materials use today are at the top of the international list of economic performance; resource use efficiency (or "materials productivity") has received a major interest in evolving new strategies towards sustainable development.⁴

No wonder, than, that economists, planners and engineers are seeking for solutions to the question of how to modify or restructure the existing patterns of energy and materials use, to switch from "*high-volume production*" to "*high-value production*".⁵ At the same time, this re-orientation reflects new and potentially strong environmental priorities. The hope of a "reconciliation between economy and ecology", and the envisaged "industrial metabolism" relies on the premise that a reduction in the energy and material input of production will lead to a reduction in the amount of emissions and wastes, will help to facilitate the recycling potential and promote the options of intentionally closing cycles in industrial society.⁶

The industrial system as it exists today is *ipso facto* unsustainable (Robert U. Ayres). While the natural cycles (of water, carbon, nitrogen, etc.) are closed, the industrial cycles (of energy, steel, chemicals, etc.) are basically still open.⁷ In particular, the industrial system starts with high quality materials (like fossil fuels and metal ores) and returns them to nature in a degraded form.

Based on materials cycle analysis, it would appear that industrial society has drastically disturbed, and still is disturbing, the natural system. Ayres proposes two main criteria or measures of an approach towards (or further away from) sustainability, the recycling ratio and materials productivity (ibid.). Put in form of policy suggestions: (1) Reduce the dissipative losses by near-total recycling of intrinsically toxic or hazardous materials, and/or (2) increase economic output per unit of material input.

In this chapter, we will use a somewhat different but comparable approach in focusing on structural change of the economy and its environmental impact.⁸ To assess the empirical dimensions of harmful or of potentially benign environmental effects of structural change we need suitable information concerning the material side of production. This by itself is not an easy task, especially so if we look for cross-national com-

parisons. Resource conservation, materials productivity, and environmentally significant structural change are not appropriately described by the monetary values used in the national accounts, although the national accounts and particularly input-output tables offer some information.⁹ An alternative is to select indicators which act as synonyms for certain characteristics of the production process.

Certain indicators have been in the forefront of the environmental debate since it began, and the availability of data on the emission of various (representative) pollutants has grown considerably.¹⁰ Our present interest, instead, is on environmentally significant input factors.

Given the state of research and data availability, only a few such indicators can be tested in a cross-national comparison of Eastern and Western economies. The result of this test thus cannot be a precise picture of the real world, but at least will offer some patterns of environmentally significant structural change from which hypotheses could be derived for further research. We use four such factors whose direct and indirect environmental significance is indisputable: *energy*, *steel*, *cement*, and the *weight of freight transport*.¹¹

Energy consumption in general is accompanied with more or less serious environmental effects, and energy intensive industries in particular pose environmental threats. Energy intensity thus is probably *the* central ecological dimension of the production pattern of a country. Steel consumption for similar reasons also is an indicator of structural environmental stress in that it reflects an important part of the material side of industrial society. Cement consumption is in itself a polluting process, and cement represents to some extent the physical reality of the construction industry. (For reasons of data availability, in the following we use the production statistics of cement only.) The weight of freight transport can be understood as an indicator of the volume aspect of production, as nearly all kinds of transport are accompanied not only by high materials input but also by a large number and high volume of hazardous emissions. (In the following, we use data for road and rail transport only.)

The empirical investigation covers the period from 1970 to 1987 and includes thirty-two countries from the East and the West, i.e., nearly the whole industrialized world. As is well known, certain methodological problems arise when comparing historic data on the national (domestic) product of Eastern and Western economies.¹² For the purpose of this

study, we relied on the data given in the "National Accounts of OECD Countries", on data from the Statistical Office of the United Nations, and on other well established data series, as specified in *Table 1*.

Table 1: Data sources

<i>Energy consumption</i>	International Energy Agency (IEA): "Energy Balances of OECD Countries 1970-1985 and Main Series from 1960"; Department of International Economic and Social Affairs of the United Nations: "Energy Statistics Yearbook"; <i>ibid.</i> : "Yearbook of World Energy Statistics"; <i>ibid.</i> : "World Energy Supplies"
<i>Steel consumption</i>	Statistical Office of the United Nations: "Statistical Yearbook"; Statistical Bureau of the United States: "Statistical Abstracts of the United States"
<i>Cement production</i>	Statistical Office of the United Nations: "Statistical Yearbook"; <i>ibid.</i> : "Monthly Bulletin of Statistics"
<i>Freight transport</i>	Economic Commission for Europe of the United Nations: "Annual Bulletin of Transport Statistics for Europe"; International Road Federation (IRF): "World Road Statistics"; International Railway Federation (UIC): "International Railway Statistics"
<i>Population</i>	Organisation for Economic Cooperation and Development (OECD): "Labour Force Statistics 1965 - 1985"; Statistical Office of the United Nations: "Demographic Yearbook"
<i>Domestic product</i> *	United States Statistical Yearbook: "Comparative International Statistics"; Statistical Bureau of the United States: "Statistical Abstracts of the United States"; Organisation of Economic Cooperation and Development (OECD): "Main Economic Indicators"; <i>ibid.</i> : "National Accounts of OECD Countries"
<p>* The economic performance of the Eastern European countries is expressed in GNP or GDP terms as published in the "Comparative International Statistics" of the United States Statistical Yearbook. For calculating the GNP in US-Dollars, the constant GNP values were determined and then adjusted according to the East-West differences in calculation method. The conversion into US-Dollars is based on the exchange rates published by the World Bank. For the countries of Eastern Europe this method of calculating the GNP or GDP results in a somewhat lower growth rate than that given in their respective national statistics; nevertheless, the method of calculation employed here seems to be fairly realistic.</p>	

3. Structural change as environmental relief

The harmful as well as the benign environmental effects of structural (or industrial) change and the significance of a structurally oriented environmental policy have been cited in recent literature.¹³ According to this insight, environmentally benign effects of structural change are to be expected by actively delinking economic growth from the consumption of environmentally significant resources, like energy and materials. Such delinking, achievable in particular by decreasing the input-coefficients of these resources (*dematerialization, re-use, recycling*) or by increasing their effectiveness (*energy and materials-productivity*) through better use,

- would result in a decrease of a resource consumption and probably also in a decrease in production costs, at least in the medium and long term;
- would mean *ex ante* environmental protection, cheaper and more efficient than *ex post* installation of pollution abatement equipment (*end-of-pipe technology*);
- would be environmentally more effective, since end-of-pipe technologies normally treat only single, "outstanding" pollutants, whereas *integrated technologies* touch upon several environmental effects simultaneously;
- would open up a broad range of options for *technological innovation* or would itself be the result of it.

For certain types of pollution, the effectiveness of structural change has been verified empirically. For example, structural change with respect to energy consumption had greater benign environmental effects than end-of-pipe protection measures, especially regarding such emissions as SO₂ and NO_x. OECD reports on the state of the environment reflect this fact well for a number of countries.¹⁴ Changes in the energy structure, for instance, led to greater environmental protection effects than the installation of desulfurization plants. In Japan, energy conservation (but also water conservation) was particularly successful¹⁵; conventional environmental protection has been superseded by technological and structural change.

Examples like these may support the suggestion for rapidly introducing market instruments, like resource taxes and effluent charges, a policy which would accelerate structural change and lead to economic advantages as well as to environmental relief.

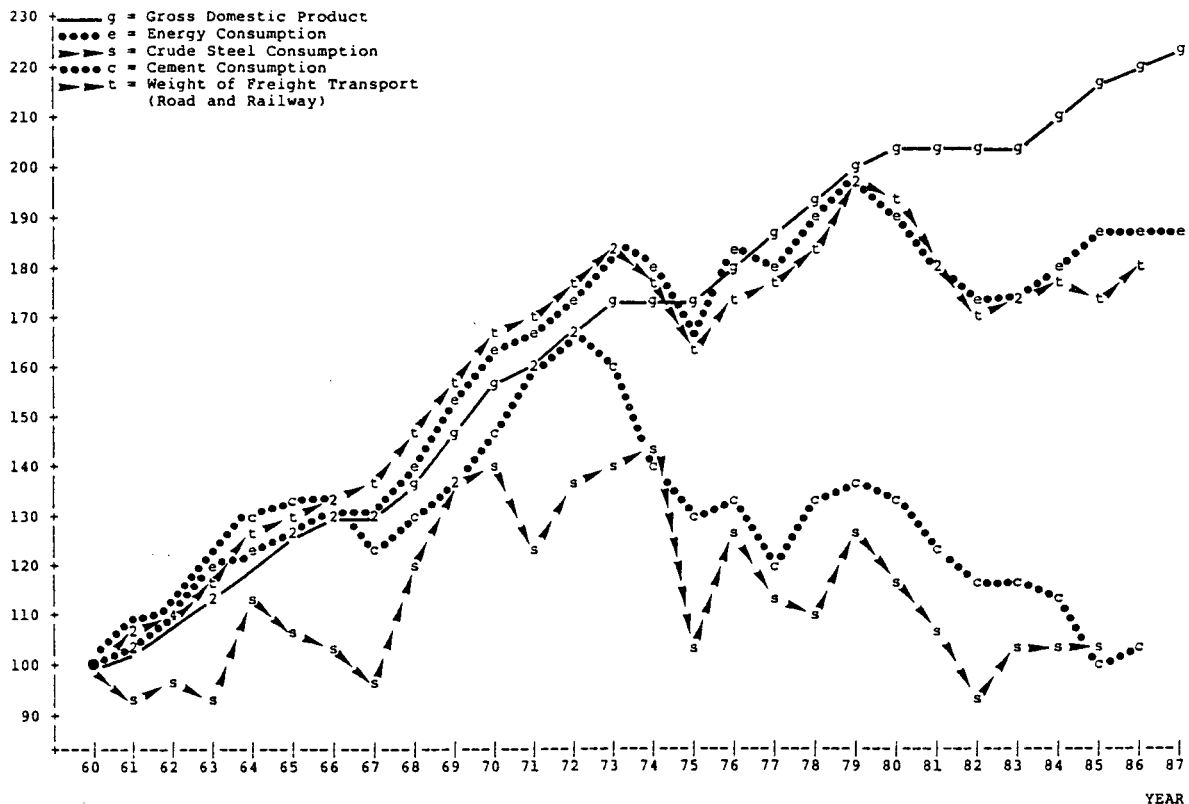
4. Environmentally relevant structural change: Empirical analysis

4.1 Environmental benefits of structural change

Before dealing with the options of accelerating environmentally benign structural change of the economy, it is necessary to consider the ways to describe such processes, especially with respect to international and intertemporal comparisons.¹⁶

Structural change as a more or less continuous shift of labor, capital, and skills to more intelligent uses can also be conceived as a process of successive delinking: The contribution of traditional factors to the gross national/domestic product decreases whilst the contribution of other factors increases, i.e., they tend to change or lose their function over time. This chapter is concerned with the environmentally significant factors (sectors) in this process.

Figure 1: Structural economic change in the Federal Republic of Germany, 1960 - 1987 (1960 = 100)



Source: Jänicke, Mönch, Ranneberg, Simonis

Focusing on the four factors described above, *Figure 1* illustrates such delinking from the growth of the gross domestic product (GDP), taking the Federal Republic of Germany as a first example. The delinking of energy and weight of freight transport from the GDP became apparent by the end of the 1970s, while for cement this process began in the early 1970s; regarding steel consumption, delinking began already in the 1960s.

In the Federal Republic of Germany, structural change generated *environmentally benign effects* in various ways:

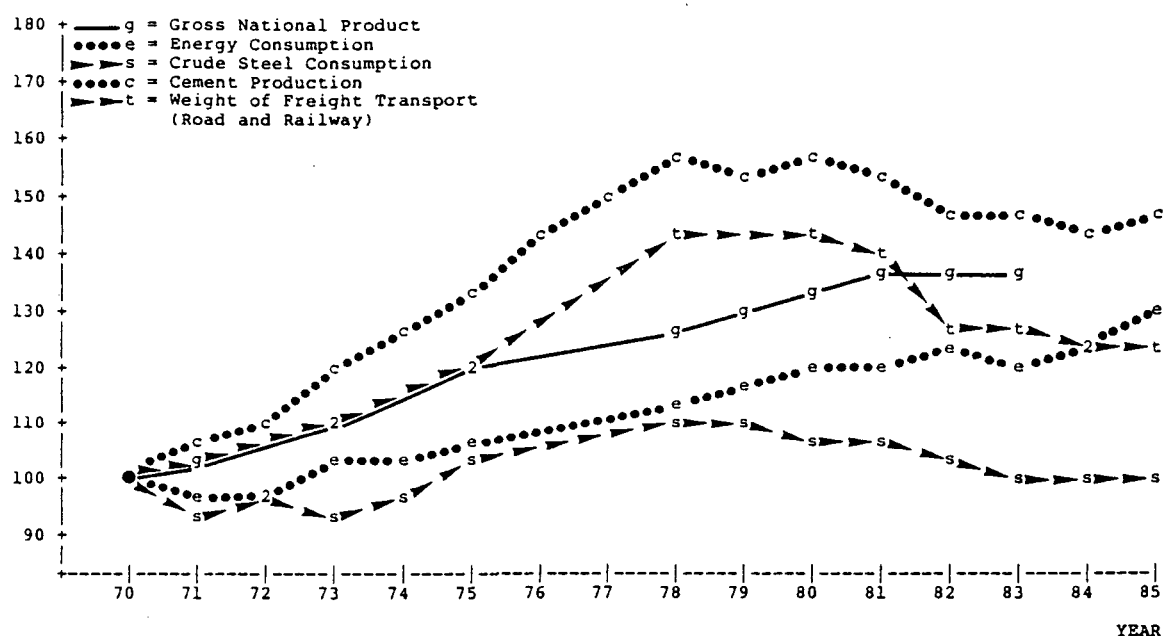
- The growth of the service sector of the economy was environmentally beneficial (if transport activities are excluded from consideration), at least to the extent of adding economic value at relatively little costs in terms of energy and materials.
- The stagnating consumption of *primary energy* made a reduction in emissions possible despite a comparatively sluggish clean air policy in this period; desulfurization and denitrification of the power plants came into full swing only in the second half of the 1980s. (The effect of energy saving could have been even more impressive if there had not been a further increase in the consumption of electricity.)
- The decrease in *steel consumption* accounts for a considerable reduction in emissions as far as production and processing are concerned. The drop is especially noticeable, and partly due to an increased recycling ratio. (However, such benign environmental effects may have to be compared with the harmful effects of an increased use of steel-substitutes such as plastics and other materials and their inherent environmental risks.)
- The fall in *cement production* represents a direct environmental gratis effect as far as the emissions from cement factories are concerned. With regard to the environmentally disputed construction industry, this decrease reflects the trend away from new construction towards modernization of the housing stock. (Again this trend may be reversed due to the large construction programmes launched since unification of Germany.)
- From the development of the *weight of freight transport* it can be concluded that in the period under investigation the volume of materials employed declined rather than increased, i.e., materials productivity has risen.¹⁷ (Germany being a transit country, the European Single Market could reverse the trend again and intensify freight transport drastically.)

Each of the sectors discussed above would of course need to be examined in greater detail, a step that cannot be undertaken here. One of the ensuing methodological questions is whether or not a different set of indicators might be better suited to offer a thorough understanding of the environmentally relevant structural change of the economy.¹⁸ The international comparison of the energy and materials side of nearly all the industrial countries as well as the intention to establish a respective *typology*, however, seems to justify concentrating on the four indicators chosen for this study.

4.2 Environmental protection through resource economy

Figure 2 shows that some delinking was also taking place in the (former) German Democratic Republic (GDR), though different in scope and time.¹⁹

Figure 2: *Structural economic change in the German Democratic Republic, 1970 - 1985 (1970 = 100)*



Source: Jänicke, Mönch, Ranneberg, Simonis

Unlike the FRG, the GDR for long continued to rely on the industrial sector as the main source of economic growth, particularly on polluting heavy industry, while the development of the service sector was woefully

neglected. Regarding energy and steel consumption, a slow process of delinking had begun in the early 1970s, but structural change in terms of "materials economy" was only modest. While, in political rhetoric, an increased energy and materials productivity was considered to be the "most important way of reducing the burden on the environment"²⁰, practice fell short in implementing this concept.

In addition, genuine relief of environmental stress can occur only if an *absolute* reduction of the relevant energy and materials inputs is achieved. The reduction in the GDR was not very significant even in relative terms.

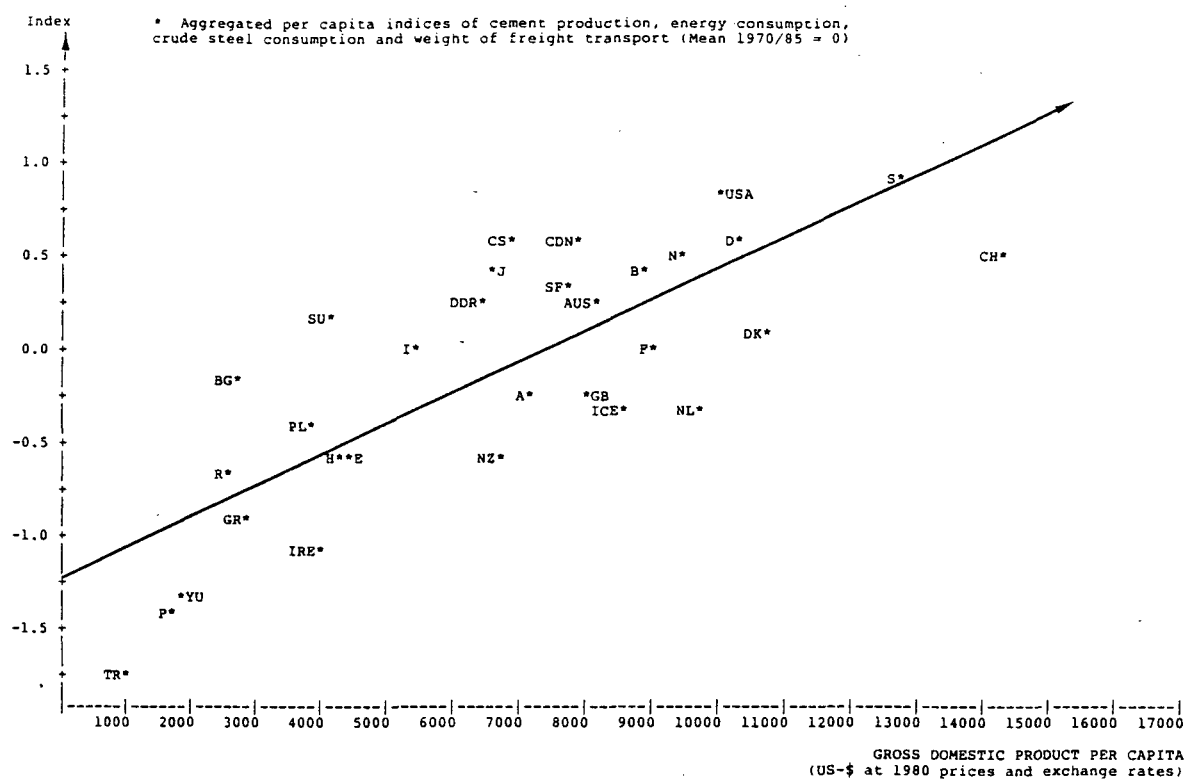
4.3 Structural environmental impacts: East-West comparisons

The differing scales of GDP and of energy and materials consumption within the national economies have not yet been considered in this chapter. This, however, is important since a process of active delinking can generally more easily be achieved where energy and materials consumption are already at a high level. For doing so, three aspects (or types) of environmental impacts of production and consumption have to be differentiated: (a) absolute environmental impact; (b) impact per capita, and (c) impact per unit of gross national/domestic product.

With regard to the absolute impact (a), it is the change over time that is of interest. Without reference to the size of a country, its population and output, however, the absolute impact is unsuitable for international comparisons. Such comparisons become feasible by using the per-capita impact (b), and/or the impact per unit of GDP (c).

In a first round, we computed an aggregated *environmental impact index*, consisting of the per-capita impacts of consumption of primary energy and crude steel, cement production and freight transport weight for all the countries under investigation. In computing the index, equal weight was given to the four indicators, marking the deviation from the mean value of all countries for 1970 and 1985. Thus the relative position and the patterns of change of the countries can be determined. The results of the computations are presented in *Figures 3, 4, and 5*. (The abbreviations used are the international signs for motor vehicle licenses.)

Figure 3: Index of structural environmental impacts per capita and economic performance level (1970 = *) and regression line ($Y = 0.000170x - 1.23615/R = 0.756$)*

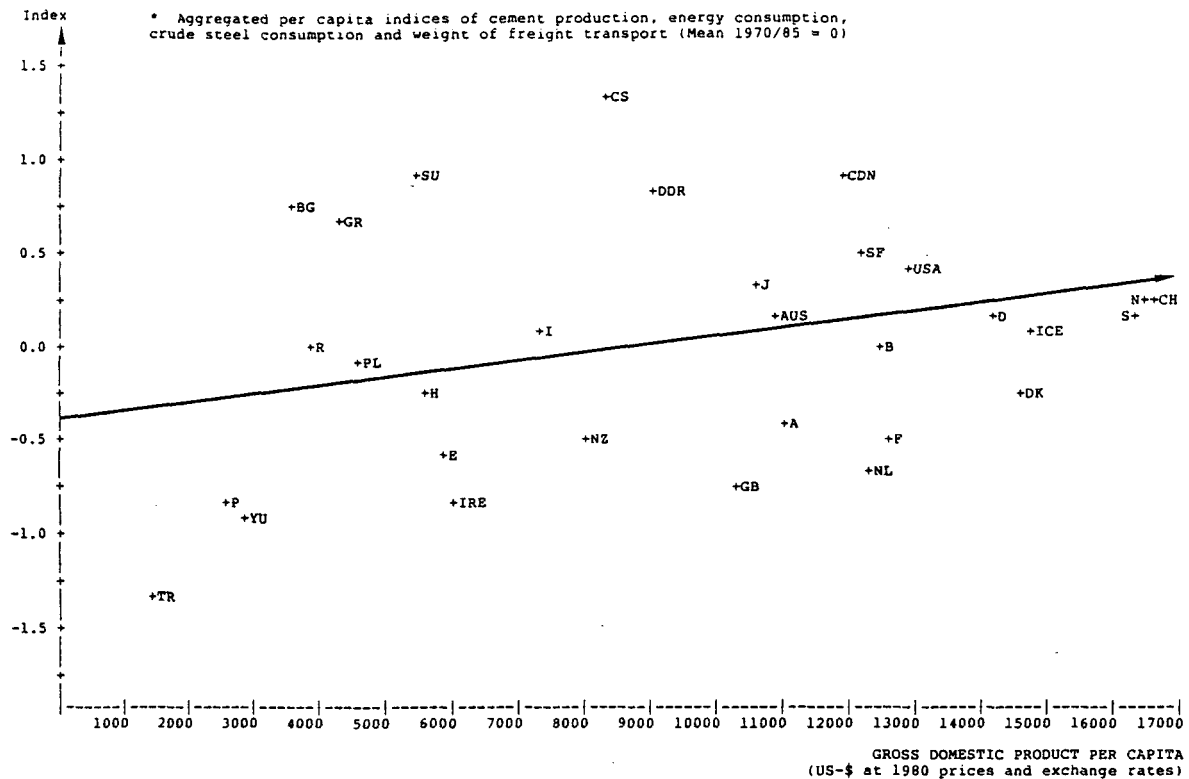


Source: Jänicke, Mönch, Ranneberg, Simonis

As *Figure 3* shows, in 1970 there was a strong relationship between a country's per capita GDP and the structural impacts on its environment regarding the four selected indicators (sectors). The correlation coefficient for the aggregated environmental impact index and the per capita GDP was 0.76 for all the countries considered. This means that around 1970 the gross domestic product of the industrial countries was still strongly based on "hard" production factors (high volume production).

Countries with high environmental impacts per capita (see *Figure 3*) were Sweden (S), the United States (USA), the Federal Republic of Germany (D), Czechoslovakia (CS), Canada (CDN), Norway (N), Switzerland (CH), Japan (J), Belgium (B), and even Finland (SF). In the lowest third of the scale were Hungary (H), New Zealand (NZ), Romania (R), Spain (E), Greece (GR), Ireland (IRE), Yugoslavia (YU), Portugal (P), and Turkey (TR).

Figure 4: Index of structural environmental impacts per capita* and economic performance level (1985 = +) and regression line ($Y = 0.000046x - 0.39506/R = 0.312$)



Source: Jänicke, Mönch, Ranneberg, Simonis

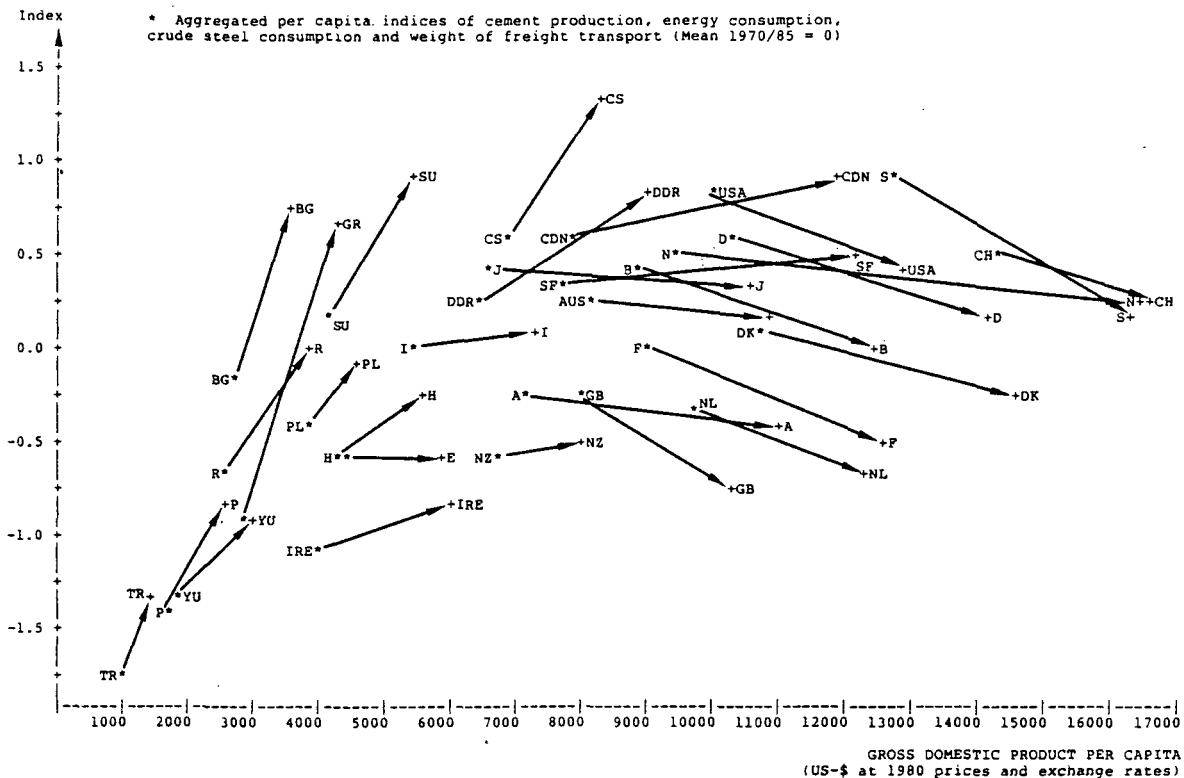
During the 1970s and the early 1980s, this relationship between economic performance (GDP) and structural impacts changed considerably. The correlation coefficient in 1985 was at only 0.31, significantly below that of 1970; *Figure 4* shows the new picture. This means that the process of restructuring in several countries reduced the importance of the "hard" factors (high volume production) in the economy.²¹

Accordingly, the position of several countries has improved over time. This was especially true of Sweden, but also of the Federal Republic of Germany, France, the United Kingdom, and the United States. In contrast, the placing of several other countries has deteriorated. This was especially true of Greece, but also of Bulgaria, Romania, the former USSR, and Czechoslovakia. The group with the highest structural environmental impacts by 1985 was led by member states of the (former) COMECON, namely Czechoslovakia, the USSR, the German Democratic Republic, and Bulgaria; Western industrialized countries showed up in the

second (Canada), sixth (Greece), seventh (Finland), and eighth (USA) position, respectively. Japan, despite its improved position was still in the top half of the scale.

The dynamics and the international pattern of structural change from 1970 to 1985 are indicated in *Figure 5*, which is derived from *Figures 3 and 4*. The main message here is the variation as to the direction of change. In the group of the low- and medium-income countries (among the industrial countries) two different patterns emerged, i.e., increasing environmental impacts, on the one hand, and stabilizing environmental impacts, on the other (see *Figure 5*).

Figure 5: Index of structural environmental impacts per capita and economic performance level (1970 = */1985 = +) and change (---->)*



Source: Jänicke, Mönch, Ranneberg, Simonis

The fact that economically advanced Western industrial countries occupied "leading" positions regarding per capita environmental impacts in 1970 may not be so surprising as it seems at first glance. At that time, Sweden, the USA and Japan, being confronted with high pollution loads and partly with environmental crisis, had to recognize the need for sweep-

ing environmental protection measures. The fact (by contrast) that Czechoslovakia was "leading" in 1985 indicates the problematique of that country's economic structure. At that time, in Czechoslovakia energy consumption per unit of GDP was more than 50 % higher than in most other countries, and specific steel consumption was actually twice that of countries with comparable levels of GDP.

5. Typology of environmentally relevant structural change

As was explained above, the shifts in the international position of countries listed in *Figures 3 to 5* relate to *structural per capita impacts* only, i.e., no account is being taken of the individual country's economic growth rate. For example, the shift in Norway's position coincided with a high rate of economic growth (see *Table 2*) so that the environmentally benign effects of structural change were partly neutralized. To be sure, the absolute (per capita) environmental impacts are of utmost importance for the environmental policy debate. However, structural change in relation to the growth of the economy is also relevant for the environmental situation of a country. There may be no structural improvement in absolute (per capita) terms because high growth rates neutralize the otherwise positive effects of structural change.

To differentiate the patterns of change, the following typology therefore might be useful:

- (a) *Absolute structural improvement*, i.e., absolute (per capita) decline of production factors (sectors) causing high environmental impacts.
- (b) *Relative structural improvement*, i.e., relative decline of production factors (sectors) causing high environmental impacts compared to the growth of the economy.
- (c) *Absolute structural deterioration* (which includes relative deterioration), i.e., a disproportional increase of production factors (sectors) causing high environmental impacts compared to the growth of the economy.

Environmental gratis effects may be defined as those effects that occur when (*ceteris paribus*) the rate of usage of those factors (sectors) having an impact on the environment remains (considerably) below the growth rate of the GDP (Type a and b).

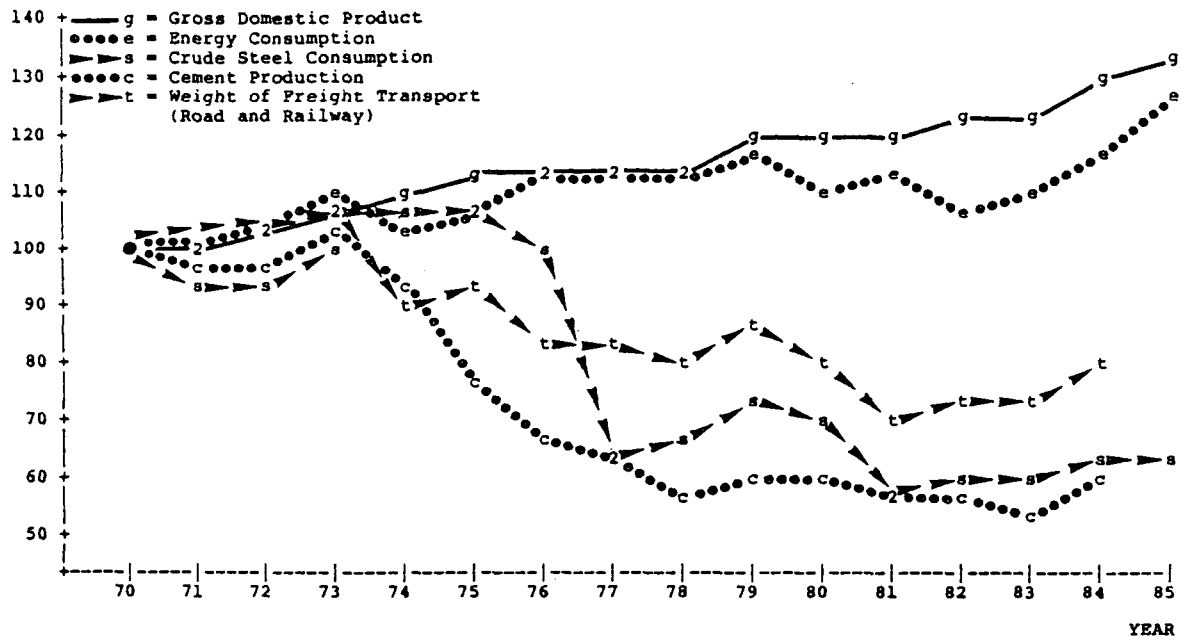
Table 2: Environmentally relevant structural change - percentage changes 1970/1985

Country	Consumption of primary energy	crude steel	Cement pro- duction	Weight of freight transport	GDP*
<i>Group 1: Absolute structural improvement</i>					
Belgium	7.1	-24.5	-17.6	-2.2	42.7
Denmark	-2.7	-15.6	-33.2	20.1	40.8
France	30.3	-34.8	-23.4	-14.5	51.6
FRG	13.4	-26.3	-32.8	4.4	38.4
Sweden	26.4	-37.9	-41.2	-21.4	32.7
United Kingdom	-2.3	-43.5	-28.7	-18.2	32.4
<i>Group 2: Relative structural improvement</i>					
Austria	32.1	-33.9	-6.0	21.3	54.3
Finland	39.6	14.8	-11.2	12.2	65.7
Japan	37.3	-2.3	27.4	7.5	90.2
Norway	51.1	-21.6	-40.3	34.7	87.5
<i>Group 3: Structural deterioration</i>					
Bulgaria	74.9	24.9	42.3	77.5	37.3
Czechoslovakia	31.5	22.5	37.3	62.9	33.9
Greece**	119.3	67.3	162.9	43.1	69.1
Portugal**	89.0	34.2	133.1	27.4	69.0
Soviet Union	76.3	33.4	35.9	70.2	47.7
Turkey	218.8	184.4	173.2	118.6	118.2
<p>* Calculation of the Gross Domestic Product percentage changes on the basis of constant (1980) US-dollars. Bulgaria, Czechoslovakia and Soviet Union data refer to percentage changes 1970/83 of the Gross National Product.</p> <p>** Transport data only take railway transport data into account.</p>					

Source: Jänicke, Mönch, Ranneberg, Simonis

In *Table 2* sixteen countries out of the whole sample of industrial countries investigated are grouped according to these three different development patterns. Again, we use here the above set of indicators of an energy and materials intensive mode of production, i.e., consumption of primary energy and crude steel, cement production and weight of freight transport.

Figure 6: Structural economic change in Sweden, 1970 - 1985 (1970 = 100)



Source: Jänicke, Mönch, Ranneberg, Simonis

Of all the industrial countries studied, Sweden (see *Figure 6*) is the environmentally most positive case. Although the growth rate of industrial production was very low after 1973, Sweden increased its GDP quite considerably, primarily through an expansion of the service sector. The drastic reduction in cement production (-41.2%), the decreasing consumption of crude steel (-37.9%), and the decrease in the weight of freight transport (-21.4%) add up to notable overall environmental gratis effects.

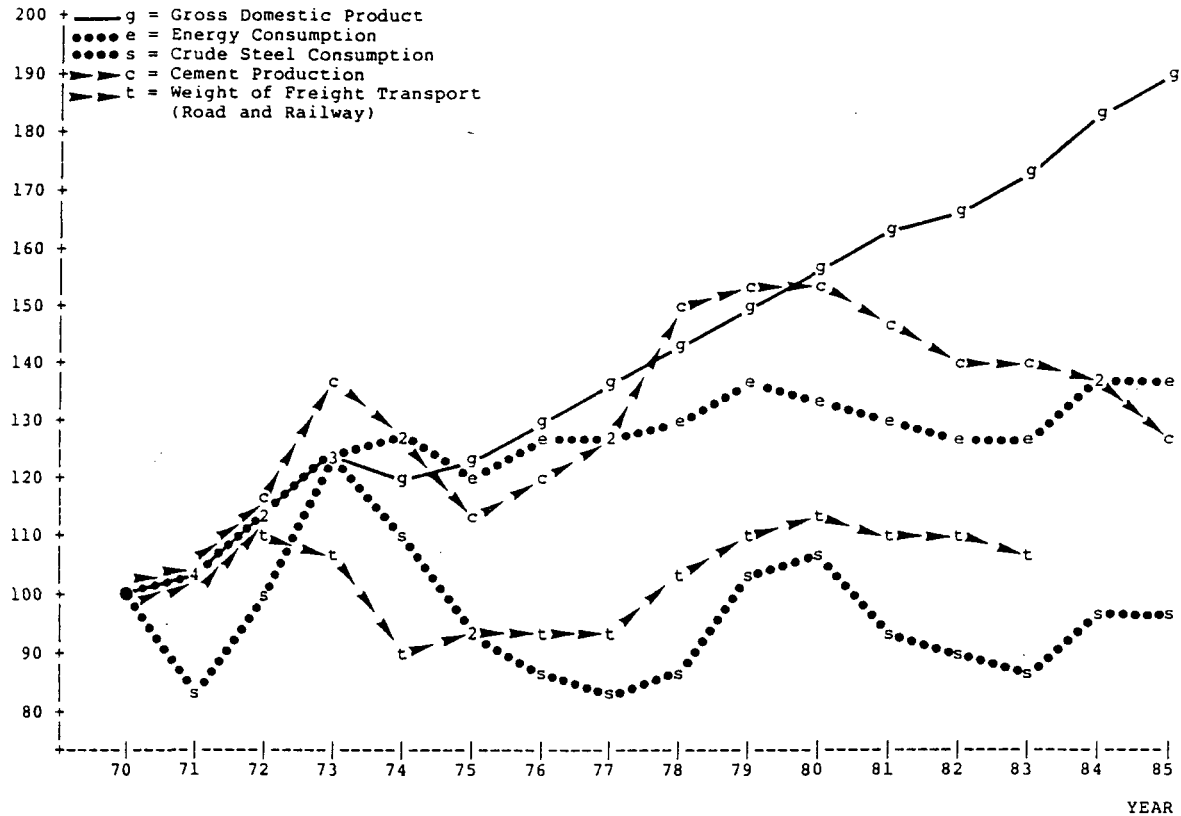
Also in the *United Kingdom*, the four structural impact factors decreased between 2.3% and 43.5% but, in contrast to Sweden, these reductions were connected with, or induced by high mass unemployment.

In *Denmark*, too, structural change in the economy decreased the importance of the energy and materials intensive sectors quite considerably. Between 1970 and 1985, the GDP grew by some 40.8%, while three of the four impact factors decreased by between 2.7% and 33.2%.

In *Japan* (see *Figure 7*), the process of delinking was partly neutralized by the rapid growth in overall industrial production and thus only resulted in relative structural improvement (see Group 2 in *Table 2*). The conclusion can be drawn that a forced rate of industrial growth interferes with the environmental relief from structural change. Countries with high growth rates must therefore strongly engage in remedial (curative) envi-

ronmental protection measures in order to achieve a net relief for the environment.

Figure 7: Structural economic change in Japan, 1970 - 1985 (1970 = 100)



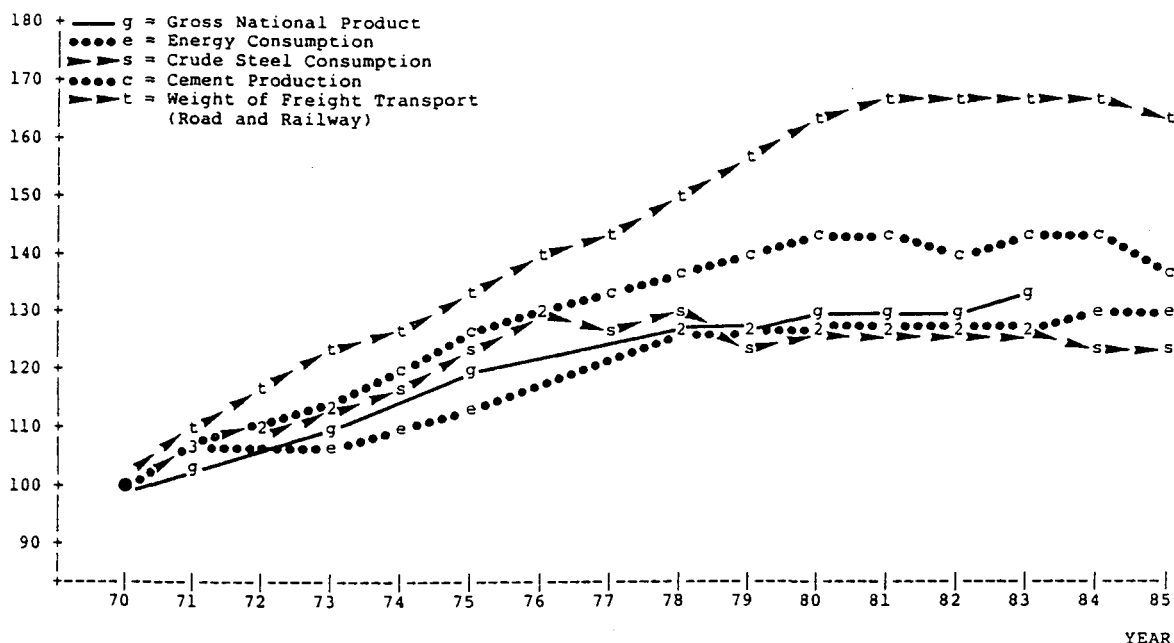
Source: Jänicke, Mönch, Ranneberg, Simonis

In *Czechoslovakia* (see Figure 8), no real delinking of economic growth from the four impact factors took place; some of them even increased. After the oil price hike of 1979 the economy entered a crisis. The development profile of Czechoslovakia, with lacking structural change for the time under investigation, was representative of the economies of Eastern Europe. Group 3 of the countries (see Table 2) consists for the most part of industrial latecomers, still being in an early stage of industrialization. But with Czechoslovakia, it was a relatively old industrial economy that (in 1985) was at the top of the rankings of countries suffering from high structural environmental impacts per capita.

This leads at least to two specific questions: (1) Do all latecomers have to go through stages of increasing environmental impacts, and (2), what prevents old industrial countries from reaching an environmentally friendly development path? And a third, more general, question is: What

is to be learned from past experience, under what conditions can economic restructuring become a strategic variable, or point of departure, for sustainable development?

Figure 8: Structural economic change in the CSSR, 1970 - 1985
(1970 = 100)



Source: Jänicke, Mönch, Ranneberg, Simonis

6. Specific conclusions

First of all, the method used in this study leaves room for refinement.²² Certain problems remain as regards data; also the question of substitution processes (steel/plastics, for example) is of high relevance and should be further investigated.²³ Additional information is needed if, for instance, *industrial* and not overall consumption of energy, or if the specific impacts of energy *production* (such as lignite vs. gas) are taken into consideration; and the international trade in wastes and the transfer of polluting industries and technologies need further study, etc. That means, economic structural change is not only about quantity of energy and materials inputs, it is also, and increasingly more so, on quality, transformation, and interrelations.

Beyond these analytical limitations, however, the advantages of comparing the development patterns of individual countries become evident:

- Restructuring, in the sense of delinking energy and materials inputs from economic growth, was significant in many of the industrial countries. In the period under investigation, less than half of these countries clung to the traditional modes of quantitative growth in physical output *per se*. Countries that did so were the low-income Western countries and most of the countries of Eastern Europe.
- Certain Western countries enjoyed environmental gratis effects as a result of structural change. In some cases, especially in Sweden, these beneficial effects were quite considerable.
- In other Western countries, the possibly beneficial environmental effects of restructuring were levelled off by the rapid economic growth pursued. This was especially true in the case of Japan and of Norway.
- The relationship between the scale of the economy (GDP) and environmental impacts from energy and material intensive production, still evident in 1970, had partly dissolved in the 1980s. The economically advanced countries featured fairly rapid structural change.
- In the low- and medium-income countries among the industrial countries, distinct development patterns emerged. There were cases of rapid quantitative growth and also cases of qualitative growth, i.e., economic growth with constant or decreasing energy and materials input.

All in all, it is, unfortunately, not yet possible to speak of *one* dominant development trend among the industrial countries towards dematerialization, recycling, improved industrial metabolism, or sustainable development.

7. General conclusions

The differences in the development patterns observed should be of particular interest for future environmental and economic policy in general, and structural policy in particular. It seems that the reasons for such differences and their consequences deserve further attention.

Economic or industrial restructuring is more than an economic phenomenon, particularly if understood to convey a break in energy and materials intensity and in pollution trends, i.e., a shift towards a significantly

different environmental impact pattern. Structure is the key to many theoretical problems, industrial restructuring can be a key to solving present and preventing future environmental problems. Structure is both a comforting and a disturbing notion; restructuring should be made a comfortable, environmentally relieving strategy.

By implication, the temporally uneven development of the economies studied (discontinuity and gradualism) manifests itself in uneven spatial and social patterns. Our concern here was with the environmental impacts involved and induced by structural change. The better the environmental impacts of industrial structures are understood and the earlier they are taken into consideration, the easier it should be to channel industrial development in a way concomitant with environmental conservation, and thus to improve on industrial metabolism.²⁴

In this sense, the "economic latecomers" need not fall into the environmental trap most of the "economic forerunners" ended in. By the same token, there is enough evidence that some of the "economic forerunners" could do much better to escape from being "environmental latecomers". This, however, would require not only proactive structural change of the economy but also a preventative environmental strategy. This means that environmentally benign market forces would have to be stimulated by structurally innovative policies.

References

- 1 For instance, in the book *Restructuring the City* by Susan S. Fainstein et al., New York: Longman, 1986, the relationship between economic or industrial restructuring and the natural environment was not even mentioned, let alone elaborated.
- 2 The latter point was somewhat focused on after the first report to the Club of Rome, D. H. Meadows, D. L. Meadows, J. Randers and W. W. Behrens: *The Limits to Growth*. London: Earth Island Limited, 1972.
- 3 For these and other approaches to the concept see R. A. Beauregard: "Space, Time, and Economic Restructuring". In: S. S. Fainstein et al.: *Restructuring the City*, op. cit., pp. 209-39.
- 4 World Commission on Environment and Development: *Our Common Future*. London: Oxford University Press, 1987.
- 5 This concept was well developed by R. B. Reich: *The Next American Frontier*. New York: Penguin, 1983.
- 6 See R. U. Ayres: "Industrial Metabolism. Theory and Policy", in this volume.
- 7 Ibid.

- 8 The following data and arguments rely on M. Jänicke, H. Mönch, Th. Ranneberg, U. E. Simonis: "Structural Change and Environmental Impact. Empirical Evidence on Thirty-One Countries in East and West". In: *Environmental Monitoring and Assessment*, Vol. 12, 2, 1989, pp. 99-114.
- 9 See W. Leontief: "Environmental Repercussions and the Economic Structure. An Input-Output Approach". In: *The Review of Economics and Statistics*, Vol. 52, 1970, pp. 262-71.
- 10 See OECD: *The State of the Environment 1991*. Paris: OECD, 1991; UNEP: *Environmental Data Report*, 3rd edition. Oxford: Basil Blackwell Ltd., 1991.
- 11 If one would wish to include indicators on the agricultural sector (like fertilizers, or pesticides), the service sector (like computers, or paper use), and other industries (like chemical industry), data collection and interpretation, no doubt, is getting more complex.
- 12 See F. L. Pryor: "Growth and Fluctuations of Production in OECD and East European Countries". In: *World Politics*, Vol. 2, 1985.
- 13 Particularly so in German literature. See H. H. Härtel et al.: *Zusammenhang zwischen Strukturwandel und Umwelt*. Hamburg: Verlag Weltarchiv, 1987; Rheinisch-Westfälisches Institut für Wirtschaftsforschung: *Strukturwandel und Umweltschutz*. Essen: RWI, 1987. See also R. G. Healy: *America's Industrial Future. An Environmental Perspective*. Washington, D. C., 1982; J. G. Speth: *Needed: An Environmental Revolution in Technology*. Washington, D. C.: World Resources Institute, 1990; Idem: "Can the World Be Saved?" In: *Ecological Economics*, Vol. 1, No. 4, 1989, pp. 289-302.
- 14 OECD: *The State of the Environment*. Paris: OECD, 1985 ff.
- 15 See Environment Agency: *Quality of the Environment in Japan 1982*. Tokyo, 1983, pp. 52 ff.
- 16 Ibid., Note 8.
- 17 Not considering local deliveries, in the early 1980s some 65 percent of the weight of freight transport in the Federal Republic of Germany consisted of natural resources and materials. See Federal Ministry of Transport: *Verkehr in Zahlen*. Bonn, 1983, p. 175.
- 18 As indicated, the environmental significance of the chemical industry would be important, and might somewhat change the overall picture shown in this chapter.
- 19 This and the following figures are based on the source cited in Note 8.
- 20 Translated from K. Steinitz: "Veränderungen in den Produktionsbedingungen der Volkswirtschaft der DDR". In: W. Sydow (ed): *In die Zukunft gedacht*. Berlin, 1983, p. 16.
- 21 One may call this the "dematerialization effect" of structural change. See E. D. Larson, M. H. Ross, R. B. Williams: "Beyond the Era of Materials". In: *Scientific American*, Vol. 254, 6, 1986; and R. Herman, S. A. Ardekani, J. H. Ausubel: "Dematerialization". In: J. H. Ausubel and H. E. Sladivic (eds): *Technology and Environment*. Washington, D. C.: National Academy Press, 1989, pp. 50-69.
- 22 Extending on the data and method used above, such a refinement is available in German. See M. Jänicke, H. Mönch and M. Binder: *Umweltentlastung durch industriellen Strukturwandel*. Berlin: edition sigma, 1992.
- 23 Ibid., Note 21.
- 24 See Timothy O'Riordan: "The Precaution Principle in Environmental Management", in this volume.