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Martin Jänicke\*, Harald Mönch\*, Thomas Ranneberg\*, Udo E. Simonis\*\*

## Structural Change and Environmental Impact

*Although structural change in many industrialized countries has increased since the early 1970s, the environmental policy aspects of this change have hardly been investigated. Using a set of four indicators, this study examines the correlation between structural changes and environmental pollution in thirty-one Eastern and Western industrialized countries from 1970 to 1985.*

It is not so long ago that sheer quantity was considered to be an indicator of a nation's economic performance. In Eastern Europe the importance attached to this criterion led to "tonnage ideology". In Western societies similar ideas can be detected. It is no coincidence that a much-read long-term economic forecast from 1965 singled out energy and steel consumption as central indicators of economic success.<sup>1</sup> For a mature economy, however, such indicators have tended to become indicators of economic failure. The following reasons can be given:

- in times of high or increasing costs for raw materials and energy, high consumption of such inputs is relatively uneconomic;
- countries that have reduced their specific energy and raw materials consumption are today at the top of the international list of economic performance;
- resource economy<sup>2</sup> (or "material economy"<sup>3</sup>) has received a major priority in the search for new ways to develop national economies.

In both the East and the West, economists, planners and engineers are seeking a solution to the problem of how to modify the existing patterns of materials consumption. Ideally, such a reorientation is consonant with Robert Reich's concept of "high value production", the opposite of "high volume production"<sup>4</sup>, and at the same time addresses new environmental priorities. The hope of a "reconciliation between economy and ecology" relies to a large extent on the premise that a

reduction in the resource input of production will lead to a reduction in the amount of emissions and waste and also the costs of production.

In this paper, some of the empirical dimensions of this reorientation will be discussed. The paper is restricted to the quantitative aspect of production. The environmental problem consists, however, not only in the quantity of harmful emissions. The modernized high value economy may well be accompanied by a new quality of environmental risks. This aspect is excluded here.

The concept of "structural change" is used in a broad sense, meaning the technological and the sectoral (branch) structure of the economy.<sup>5</sup> This seems plausible because both are interconnected. If an economy lowers the input level of materials and energy

<sup>1</sup> W. Fucks: Formeln zur Macht. Prognosen über Völker, Wirtschaft, Potentiale, Stuttgart 1965.

<sup>2</sup> Ministry of International Trade and Industry: Direction for Japan's Industrial Structure, Tokyo 1974; OECD: Technical Change and Economic Policy, Paris 1980. For the concept of "resource economy" see the classical account by R. M. Solow: The Economics of Resources and the Resources of Economics, in: American Economic Review, Vol. 64, 1974. See also H. Siebert: Economics of the Environment. Theory and Policy, Heidelberg 1987.

<sup>3</sup> E. K. Fjodorow: Die Wechselwirkung zwischen Natur und Gesellschaft, Berlin (East) 1974; M. N. Lojter: Naturressourcen, Umwelt und Investitionseffektivität, Berlin (East) 1977; collective authorship: Umweltgestaltung und Ökonomie der Naturressourcen, Berlin (East) 1979.

<sup>4</sup> R. B. Reich: The Next American Frontier, New York 1983; idem: An Industrial Policy for America, Washington D.C. 1983; idem: Thoughts on Innovation, in: Dialogue, No. 2, 1984.

<sup>5</sup> M. Jänicke: Preventive Environmental Policy as Ecological Modernization and Structural Policy, ILUG discussion paper 85-2, Berlin 1985; idem: Superindustrialismus und Postindustrialismus. Langzeitperspektiven von Umweltbelastung und Umweltschutz, in: M. Jänicke, U. E. Simonis and G. Weigmann (eds.): Wissen für die Umwelt, Berlin, New York 1985.

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– using more intelligent technology – the share of heavy industries tends to decrease, while the service sector tends to increase. Thus we refer to the popular meaning of “structural change” as an increase in knowledge-intensive and service-intensive forms of production at the expense of the traditional chimney industries. “Structural environmental impact” is the environmental stress resulting from a certain production structure, irrespective of pollution control measures in the form of end-of-pipe treatment.

### Identifying Indicators

To assess the empirical dimensions of potentially beneficial environmental effects of structural change we need suitable information concerning the material side of production. This by itself is a difficult task, especially so if we are looking for East-West cross-national comparisons. Resource conservation by the national economy and the process of environmentally significant structural change are not appropriately described by the production values used in the national accounts, although the national accounts and input-output tables offer some information.<sup>6</sup> An alternative is to select some indicators which act as synonyms for certain characteristics of the production process.

Indicators have played an important part in the environmental debate since it began.<sup>7</sup> The international availability of environmental indicators such as emission data relating to certain “representative” pollutants has grown considerably. Our present interest, however, is for environmentally significant input factors.<sup>8</sup>

Given the present state of research and data availability, only a few such indicators can be tested in a cross-national comparison of Eastern and Western countries. The result of this test thus cannot be a precise picture of the environmental quality in the respective countries. But we can demonstrate at least some patterns of environmentally significant structural change from which hypotheses could be derived for further research. We use four factors whose direct and indirect environmental significance is indisputable:

energy, steel, cement, and the weight of freight transport.

Energy consumption is accompanied by more or less serious environmental impacts. Steel consumption offers a similar general indicator of structural environmental stress. Cement consumption is not only a highly polluting process, it also represents to a large extent the physical reality of the construction industry. (For reasons of data availability we use the production statistics for cement, except in Figure 2). The weight of freight transport is used as a general indicator of the volume aspect of production. Nearly all kinds of transport are accompanied by environmental impacts. For our purpose, we use data for road and rail transport only.

The empirical investigation covers the period from 1970 to 1985 and considers thirty-one industrial countries of the Eastern Council for Mutual Economic

**Table 1**  
**Data Sources**

<i>Cement Production</i>	Statistical Office of the United Nations: Statistical Yearbook; <i>ibid.</i> : Monthly Bulletin of Statistics.
<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>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>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> <sup>1</sup>	United States Statistical Yearbook: Comparative International Statistics; Statistical Bureau of the United States: Statistical Abstracts of the United States; Organisation for Economic Cooperation and Development (OECD): Main Economic Indicators; <i>ibid.</i> : National Accounts of OECD Countries.

<sup>6</sup> W. Leontief: Environmental Repercussions and the Economic Structure. An Input-Output Approach, in: The Review of Economics and Statistics, Vol. 52, 1972; C. Leipert, U. E. Simonis: Environmental Damage – Environmental Protection. Empirical Evidence on the Federal Republic of Germany, in: International Journal of Social Economics, Vol. 15, No. 7, 1988.

<sup>7</sup> OECD: Measuring Social Well-being. A Progress Report on the Development of Social Indicators, Paris 1976; *idem*: Living Conditions in OECD Countries, Paris 1986; H. Simonis and U. E. Simonis: Quality of Life. Methods and Measurement, Kiel 1976.

<sup>8</sup> F. Furger and C. Jaeger: Input-Output-Analyse für Umweltwissenschaftler, Zürich 1986.

<sup>1</sup> The economic performance of the Eastern European countries is expressed in GNP terms as published in the “Comparative International Statistics” of the US Statistical Yearbook. For calculating the GNP in US-Dollars, the constant GNP values were determined and then adjusted according to the existing 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 results in a somewhat smaller growth-rate than that given in their respective national statistics; nevertheless, the method of calculation employed here seems to be fairly realistic.

Assistance (CMEA) and the Western Organization for Economic Cooperation and Development (OECD).

As is well known, certain problems arise when comparing the data on the domestic (national) product of Eastern and Western economies.<sup>9</sup> For the purpose of this survey, we relied on the respective data in the "Comparative International Statistics" of the United States Statistical Yearbook, the "National Accounts of OECD Countries", and on structural data from the Statistical Office of the United Nations. The factors studied and their data base are presented in Table 1.

### Positive Effects of Change

The potentially beneficial environmental effects of technological and structural change and the significance of a structurally oriented environmental policy have been cited in recent literature.<sup>10</sup> The message of such a policy, however, has so far hardly been implemented. Structural change as a strategy of environmental protection is virtually non-existent. Rather, politicians merely react to the effects of structural change on the environment, be they positive or negative.

Positive effects of structural change are to be expected by actively de-linking economic growth from the consumption of ecologically significant resources. Such de-linking, achievable in particular by decreasing the input coefficients of these resources or by increasing their effectiveness through better use,

- ☐ would result in a decrease of resource consumption and, probably, a decrease in production costs;
- ☐ would mean *ex ante* environmental protection, cheaper than the *ex post* installation of pollution abatement equipment (*end-of-pipe technology*);

☐ would be more effective, since end-of-pipe technologies are designed to treat single, "outstanding" pollutants, whereas *integrated technologies* usually touch upon several environmental effects;

☐ would open up a full range of options for technological innovation or would itself be the result of it.

For individual types of pollution, the effectiveness of structural policy can be demonstrated empirically. For example, structural change in several industrialized countries with respect to energy consumption has had greater positive environmental effects than end-of-pipe protection measures, especially regarding such critical emissions as SO<sub>2</sub> and NO<sub>x</sub>.

The 1985 OECD report on the state of the environment reflects this fact well for several countries.<sup>11</sup> In the United States, France, and the United Kingdom, for instance, energy conservation has led to greater environmental protection effects than the installation of desulphurization plants. In Japan, where remedial environmental protection measures had remarkable effects during the 1970s, energy conservation was similarly successful.<sup>12</sup> In this case, conventional environmental protection has, so to say, been overhauled by technological and structural change. This

<sup>9</sup> F. L. Pryor: Growth and Fluctuations of Production in OECD and East European Countries, in: World Politics, Vol. 2, 1985.

<sup>10</sup> M. Karsch, H. Mönch and T. Ranneberg: Strukturpolitischer Umweltschutz in Berlin. Defizite und Möglichkeiten, in: USUS Reports 2/1983, Berlin (West) 1983; T. Ranneberg: Wirtschaftsstrukturelle Analyse von Umweltbelastungen und Ansatzpunkte eines strukturpolitischen Umweltschutzes, in: Zeitschrift für Umweltpolitik, Vol. 6, No. 2, 1984; M. Jänicke: Staatsversagen, Munich 1986; H. H. Härtel, K. Matthies and M. Mously: Zusammenhang zwischen Strukturwandel und Umwelt, Hamburg 1987; Rheinisch-Westfälisches Institut für Wirtschaftsforschung: Strukturwandel und Umweltschutz, Essen 1987; U. E. Simonis (ed.): Präventive Umweltpolitik, Frankfurt, New York 1988.

<sup>11</sup> OECD: The State of the Environment, Paris 1985.

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same effect can also be seen in other areas of environmental stress. For example, data from the Japanese Environmental Agency show that the effects of technological and structural change in water usage were equivalent to those of end-of-pipe purification equipment (see Figure 1).

Examples like these may support the suggestion for introducing resource taxes and effluent charges, a policy which would have economic as well as environmental advantages.

## Process of De-linking

Before dealing with the options for managing structural change of the economy, it is necessary to consider the ways to describe such processes, especially in the framework of international and intertemporal comparison of economies. Using the examples of the Federal Republic of Germany (FRG) and the German Democratic Republic (GDR), we would

first like to demonstrate the possibilities and limitations connected with such a description.

Structural change as a continuous shift of labour, capital, and skills to more intelligent uses can also be conceived as a process of successive de-linking. The contribution of traditional factors to the national product decreases, i.e. they tend to change or lose their function in the process of development. This paper is concerned with some environmentally significant factors in this process.

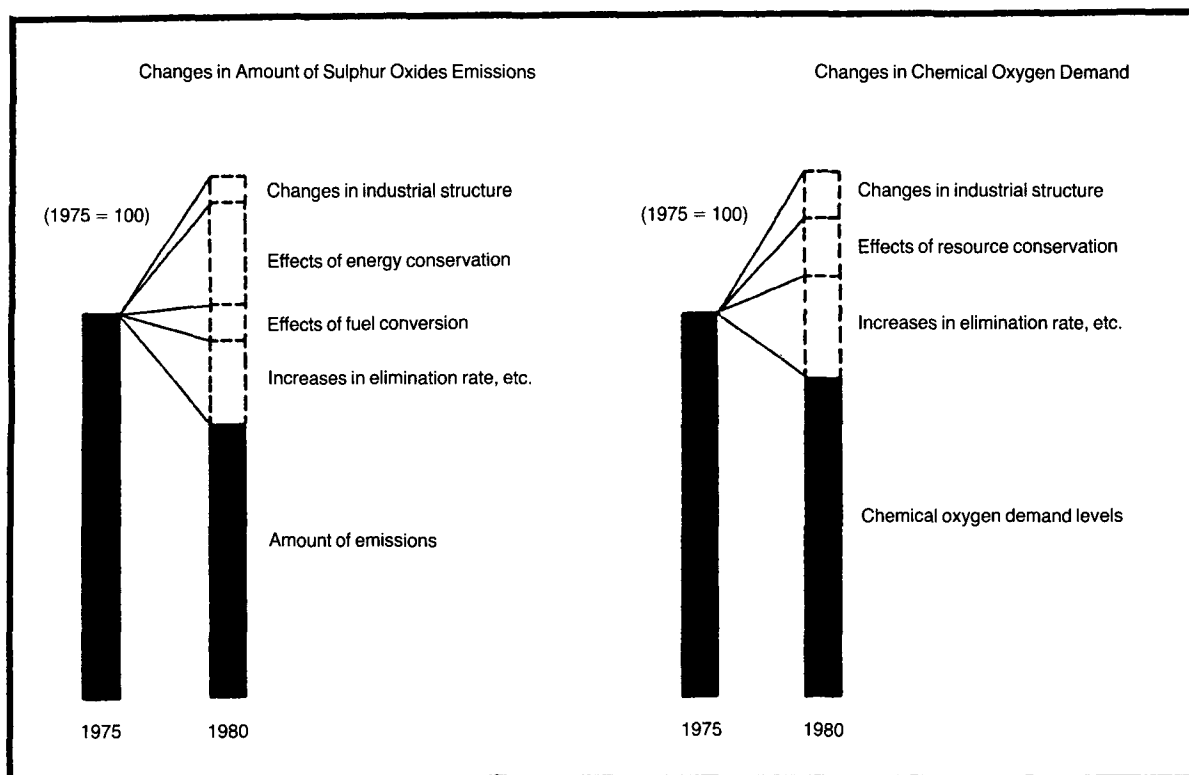
Figure 2 illustrates such de-linking from the growth of the Gross Domestic Product (GDP), taking the Federal Republic of Germany as an example. The de-linking of energy and cement consumption and the weight of freight transport from the GDP became apparent during the 1970s and had fully manifested itself by the end of that decade. Regarding steel consumption, the de-linking process began already in the 1960s.

## Environmental Gratis Effects

In the Federal Republic of Germany, structural change generated environmental gratis effects in various ways:

<sup>12</sup> Environment Agency, Government of Japan: Quality of the Environment in Japan 1985, Tokyo 1986.

**Figure 1**  
**Causes of Change in Sulphur Oxides Emissions and Chemical Oxygen Demand Levels in Japan**



Source: Environment Agency: Quality of the Environment in Japan 1982, Tokyo 1983, pp. 52-53.

□ The stagnating consumption of primary energy made a reduction in emissions possible despite a comparatively sluggish clean air policy in this period. (The effect of energy saving could have been more impressive if there had not been an increase in the consumption of electricity).

□ From the moderate decline in the weight of freight transport it can be concluded that the volume of materials and raw materials employed was reduced rather than increased, i.e. that the respective productivity has risen.

□ The fall in cement consumption represents a direct environmental gratis effect as far as the emissions from cement factories are concerned. With regard to the construction industry, this decrease points to the fact that "qualitative" trends are gaining in significance (e.g. modernization of housing stock versus new construction).

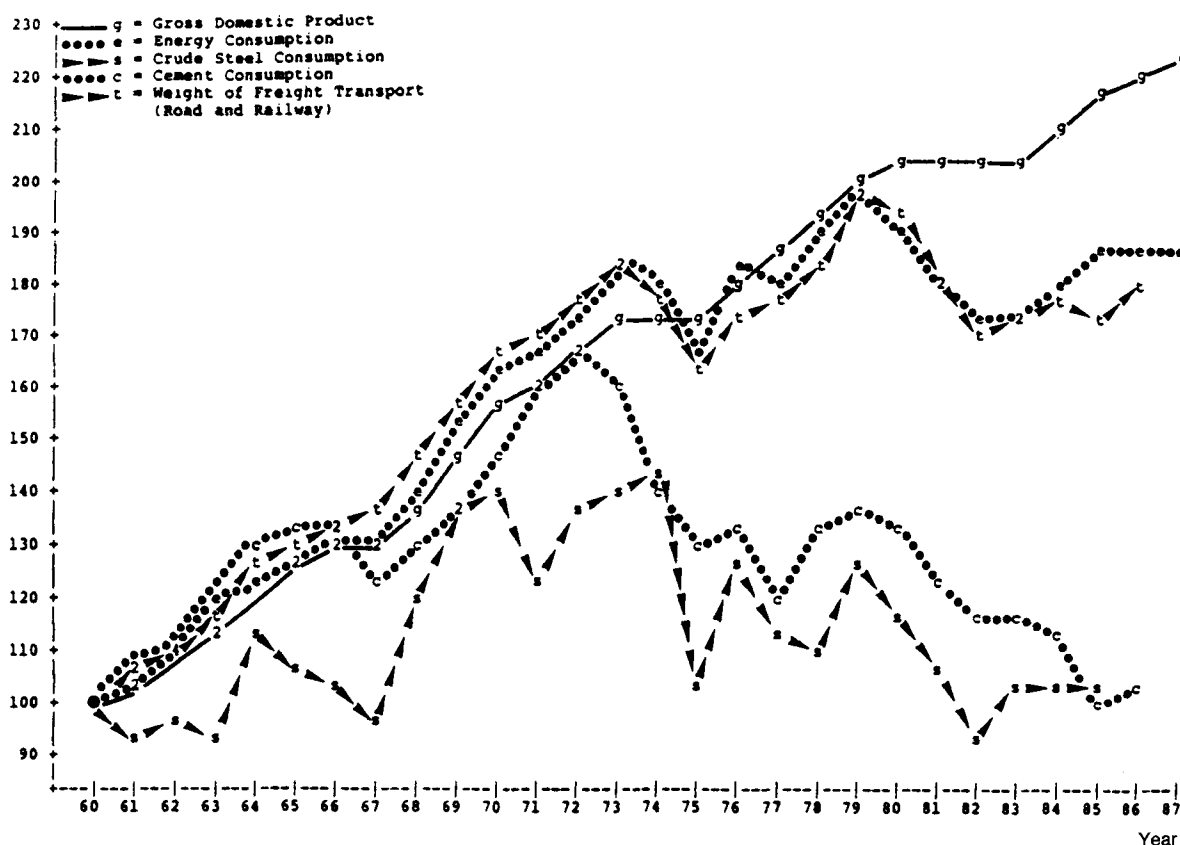
□ The decrease in steel consumption accounts for a considerable reduction in emissions as far as

production and processing are concerned. The drop is especially noticeable and is partly due to increased recycling activities. However, such positive environmental effects may have to be compared with the effects of increasingly used steel-substitutes such as plastics and their inherent environmental risks. The chemical risks in particular have increased since the 1970s.

Each of the factors discussed thus far would need to be examined in greater detail, a step that cannot be taken in this general survey. One of the methodological questions is whether or not a different set of factors might be better suited to offer an understanding of the environmentally significant structural changes of the economy.<sup>13</sup> The breadth of the international comparison of thirty-one industrialized nations as well as the intention to establish a particular typology, however, justifies concentrating on the four factors chosen for this study.

<sup>13</sup> A. Lijphart: Comparative Politics and Comparative Method, in: American Political Science Review, No. 3, 1971.

**Figure 2**  
**Structural Economic Change in the Federal Republic of Germany, 1960-1987**  
(1960 = 100)



### Protection through Resource Economy

Figure 3 shows that de-linking is also significant in the case of the German Democratic Republic (GDR), though it began later than in the Federal Republic of Germany (FRG). Unlike the FRG, the GDR has continued to rely on the industrial sector as the main source of economic growth. From the environmental point of view, then, structural change is more relevant within the industrial sector than between the industrial and service sectors (i.e. intra-industry versus inter-sectoral change).

The GDR provides an example of structural change in the sense of "material economy". Material or resource economy is officially treated as a form of environmental protection. Moreover, it is considered the decisive form of environmental protection, for it is also the more economic one. According to K. Steinitz, an economist from the GDR, an increased energy and materials productivity has a significant effect on environmental conditions: "This is the most important way of reducing the burden on the environment."<sup>14</sup>

It might be suggested that a country like the GDR, with its high level of pollution, should view remedial environmental protection measures as first priority. In addition, a genuine relief for the environment may be

registered only if an *absolute* reduction of the relevant material and energy inputs has been reached. The reduction was only relative for primary energy consumption which is so important ecologically, while it was marked for cement and steel. Particularly noticeable was the 16% reduction in the weight of freight transport from 1980 to 1985.<sup>15</sup>

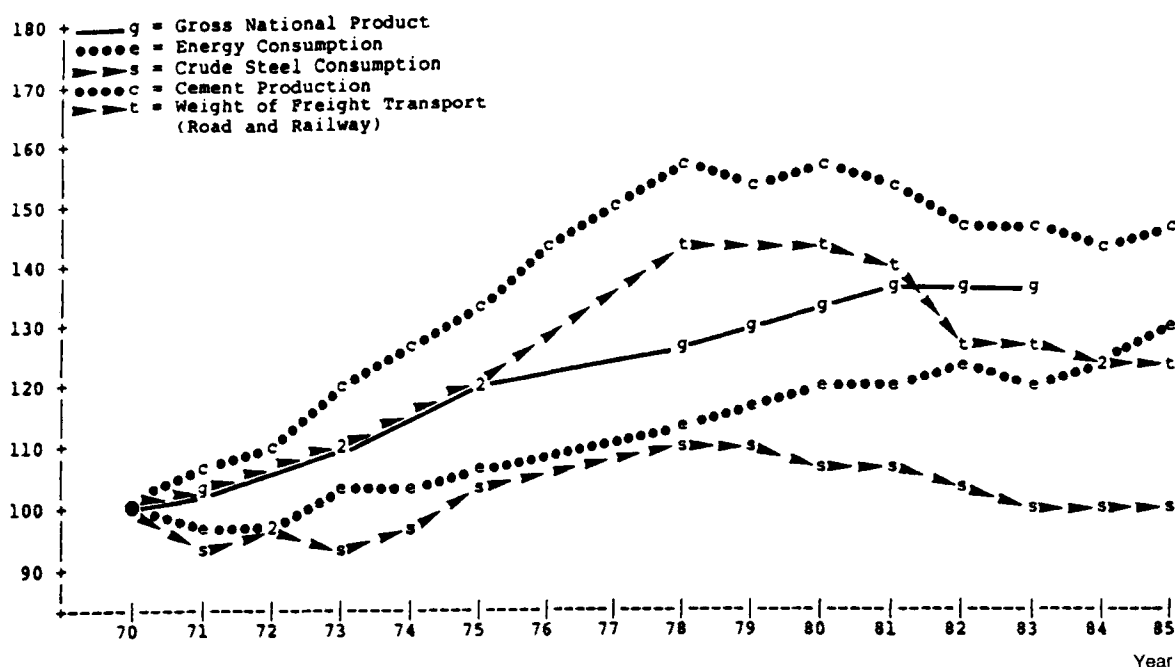
The example of the GDR points to the need for more detailed analysis which might reveal that the chosen *set* of indicators gives a better answer to this chapter's initial question than individual indicators do. In the case of primary energy consumption in the GDR, the substitution of lignite for oil, with its adverse effects on the environment, has not been considered. At the same time, the figure on the weight of freight transport does not reveal enough information about the parallel, environmentally positive shift of transportation from road to rail, which resulted from measures to rationalize the transport system.

The different levels of energy and resource transformation within the national economies under

<sup>14</sup> K. Steinitz: Veränderungen in den Reproduktionsbedingungen der Volkswirtschaft der DDR, in: W. Sydow (ed.): In die Zukunft gedacht, Berlin (East) 1983, p. 16. Our translation.

<sup>15</sup> Statistisches Jahrbuch der DDR 1987, Berlin (East) 1987, p. 215.

**Figure 3**  
Structural Economic Change in the German Democratic Republic, 1970-1985  
(1970 = 100)



investigation have not yet been considered in this paper. This, however, is important since the process of de-linking is generally more easily achieved where energy and raw materials consumption are at a high level. In such a case, remedial environmental protection measures also have high priority.

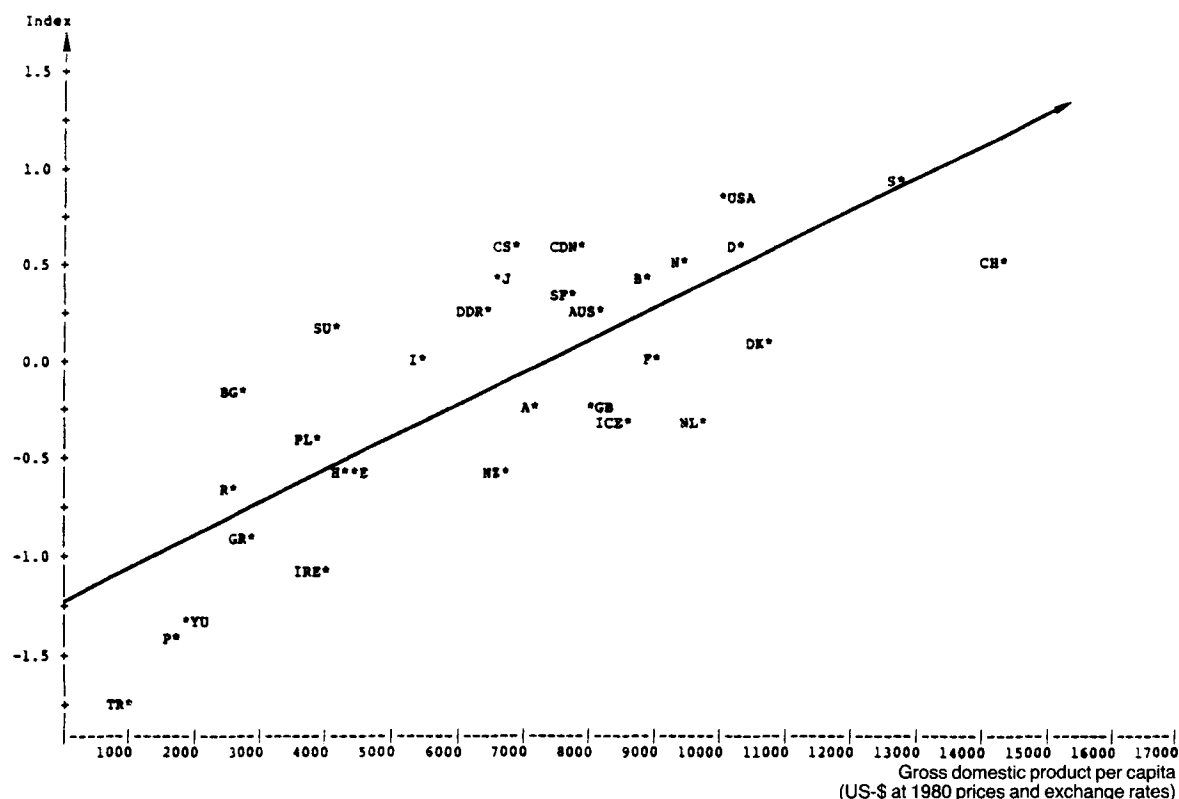
In considering the environmental impacts of production and consumption, one can discern three aspects: (a) absolute environmental impact; (b) impact per capita, and (c) impact per unit of the gross domestic product (GDP). With regard to the absolute impact, it is the change over time that is of interest. Without reference to the size of the country, its population and output, however, the absolute impact is unsuitable for international comparison. Such comparison becomes feasible by using the per capita impact and the impact per unit of GDP.

In a first round, we tested the level of structural environmental impact in thirty-one industrialized CMEA and OECD countries between 1970 and 1985. For this purpose we computed an aggregated environmental

impact index, consisting of the per capita impacts resulting from the consumption of primary energy and crude steel, weight of freight transport and cement production. The aggregated index gives equal weight to these four factors and marks 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 studied. The abbreviations used are the international signs for motor vehicles. The results of the computations are presented in Figures 4, 5 and 6.

As Figure 4 shows, there was a significant connection between a country's per capita GDP in 1970 and the structural impacts on its environment regarding the four selected factors. The correlation coefficient for the aggregated environmental impact index and the per capita GDP was 0.76 for all thirty-one countries. This means that around 1970 the domestic product of the industrial countries was based strongly on "hard" production factors (high volume production). In the Federal Republic of Germany, for example, this emphasis on "hard" factors came at the expense of the

**Figure 4**  
**Index of Structural Environmental Impacts per Capita<sup>1</sup> and Economic Performance Level 1970, and Regression Line ( $Y = 0.000170x - 1.23615$ ,  $R = 0.756$ )**



Note: <sup>1</sup> Aggregated per capita indices of cement production, energy consumption, crude steel consumption and weight of freight transport (Mean 1970/85 = 0)



"blue skies over the Ruhr valley" – to mention just one aspect of the reverse side of the prosperity "coin".

Countries with high environmental impacts per capita (see Figure 4) were Sweden, the United States, the Federal Republic of Germany, Czechoslovakia, Canada, Norway, Switzerland, Japan, Belgium and Finland. In the lowest third of the scale were Hungary, Spain, New Zealand, Romania, Greece, Ireland, Yugoslavia, Portugal, and Turkey.

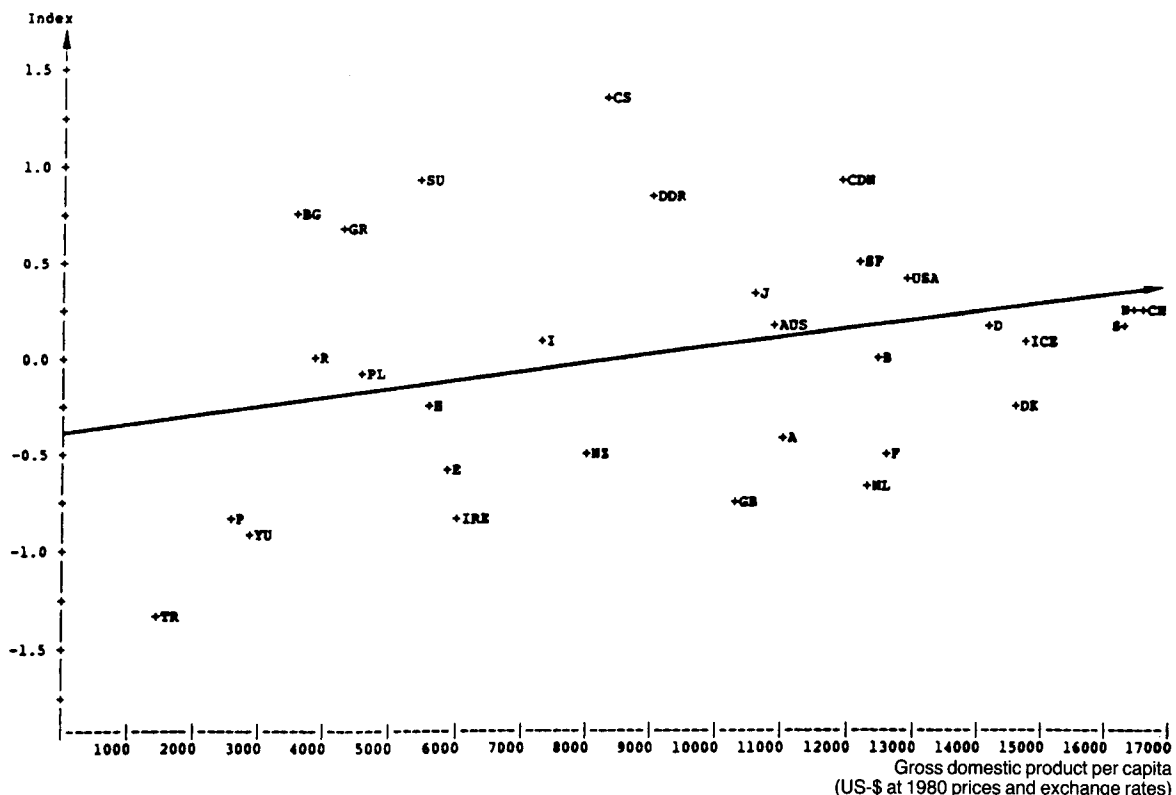
During the 1970s this relationship between economic performance (GDP) and structural impacts changed to a considerable extent. The correlation coefficient in 1985 was only 0.31, significantly below that of 1970. Figure 5 shows the diversified picture. The process of structural change in several countries pushed back the "hard" factors (high volume production) in the economy. Accordingly, the position of the countries has changed over time. Several countries were able by 1985 to improve their international placing considerably. This is especially true of Sweden, but also of the Federal Republic of Germany, France, the United Kingdom, and

the United States. It should be added that in Sweden and the United States (and partly also in Norway) the structural change of the economy was accompanied by an improved employment situation. Instead the United Kingdom, but also the Federal Republic of Germany and France, was plagued with rising unemployment.

In contrast, the placing of several countries had deteriorated by 1985. This is especially true of Greece but also of Bulgaria, Romania, the USSR and Czechoslovakia. The group with the highest structural environmental impacts is now led by member states of the CMEA, namely Czechoslovakia, the USSR, the German Democratic Republic and Bulgaria; Western industrialized countries show up in the second (Canada), sixth (Greece), seventh (Finland), and eighth (USA) positions. Japan, despite its improved position is still in the top half of the scale.

The dynamics and the international pattern of structural change from 1970 to 1985 is shown in Figure 6, which is a combination of Figures 4 and 5. The main message here is the variation as to the direction of

**Figure 5**  
**Index of Structural Environmental Impacts per Capita<sup>1</sup> and Economic Performance Level 1985,**  
**and Regression Line ( $Y = 0.000046x - 0.39506$ ,  $R = 0.312$ )**



Note: <sup>1</sup> Aggregated per capita indices of cement production, energy consumption, crude steel consumption and weight of freight transport (Mean 1970/85 = 0)

change. In the group of the medium-income countries two different patterns emerged, i.e. increasing environmental impacts on the one hand and decreasing environmental impacts on the other.

The fact that economically advanced Western industrialized nations occupied leading positions regarding per capita impacts in 1970 is not surprising. At that time Sweden, the United States and Japan, being confronted with high pollution, had to recognize the need for sweeping environmental protection measures. The fact that Czechoslovakia was leading in 1985 indicates – by contrast – the problems of that country's economic structure. In 1984 one could read in the Czechoslovakian economic newspaper *Hospodarske Noviny* "... that energy consumption in the CSSR per unit of production is more than 50% higher than in other countries; similarly, specific steel consumption is practically twice that of countries with comparable levels of production".<sup>16</sup>

### Typology

It should be remembered that the shifts in the international position of countries listed in Figures 4-6 relate to structural per capita impacts only, i.e. without account being taken of the individual country's economic growth rate. For example, the shift in Norway's position coincided with a high economic growth (see Table 2) so that the effect of structural change was partly neutralized.

To be sure, the absolute environmental impacts are of utmost importance for the environmental debate. However, structural change in relation to the growth of the economy is also relevant to the environmental situation of a country. There may be no structural improvement in absolute terms because high growth rates neutralized the positive effect of structural change. But in this case the environmental situation of the country would be even worse if no structural change had taken place.

To differentiate such patterns of change we use the following typology:

(a) *absolute structural improvements*, i.e. the absolute decline of production factors causing high environmental impacts;

(b) *relative structural improvements*, i.e. the relative decline of production factors causing high environmental impacts compared to the growth of the economy;

(c) *structural deterioration* (which includes relative deterioration), i.e. a disproportionally high increase of production factors causing environmental impacts compared to the growth of the economy.

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

In Table 2 sixteen out of the thirty-one countries in our sample are grouped according to these three development patterns. (Again, we use here our set of indicators for a material-intensive and energy-intensive mode of production, i.e. consumption of primary energy and crude steel, cement production and weight of freight transport.)

Of all the industrialized nations in our sample, Sweden is the most interesting case. Although the growth rate of industrial production in Sweden was just about zero since 1973, it increased its economic performance (GDP) quite considerably, primarily

**Table 2**  
**Environmental Impacts Deriving from**  
**Structural Change**  
Percentage Changes 1970/1985

Country	Consumption of Primary Energy	Crude Steel	Cement Production	Weight of Freight Transport	GDP <sup>1</sup>
Group 1: Absolute Structural Improvement					
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
UK	-2.3	-43.5	-28.7	-18.2	32.4
Group 2: Relative Structural Improvement					
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
Group 3: Structural Deterioration					
Bulgaria	74.9	24.9	42.3	77.5	37.3
Czechoslovakia	31.5	22.5	37.3	62.9	33.9
Greece <sup>2</sup>	119.3	67.3	162.9	43.1	69.1
Portugal <sup>2</sup>	89.0	34.2	133.1	27.4	69.0
Soviet Union	76.3	33.5	35.9	70.2	47.7
Turkey	218.8	184.4	173.2	118.6	118.2

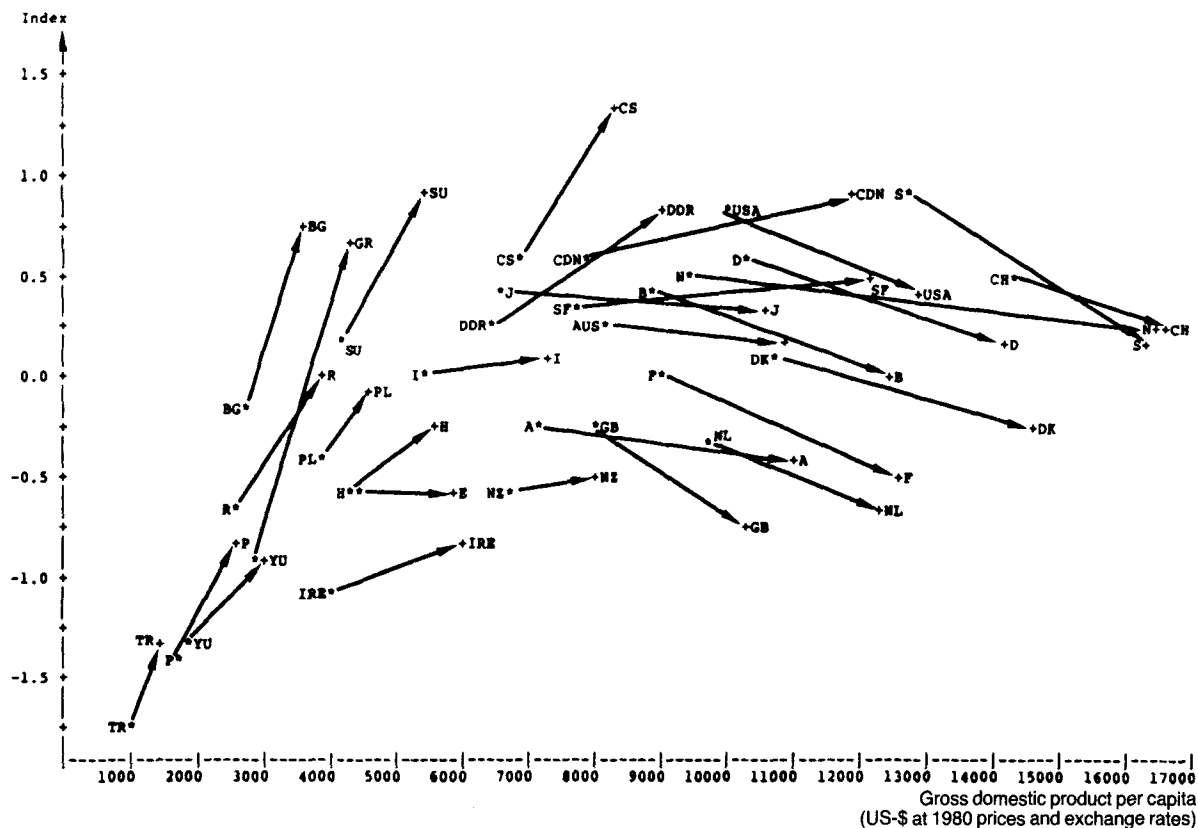
**Notes:**

<sup>1</sup> 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 domestic product.

<sup>2</sup> Transport data only take railway transport data into account.

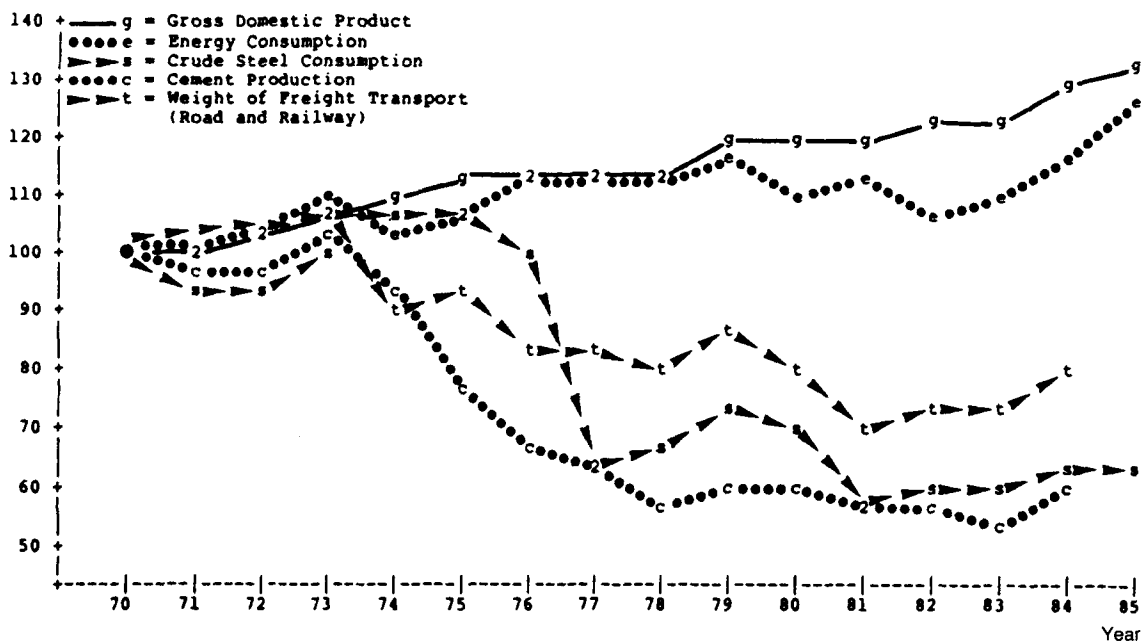
<sup>16</sup> Quoted from: *Natur*, No. 1, 1986, p. 35. Our translation.

**Figure 6**  
**Index of Structural Environmental Impacts per Capita<sup>1</sup> and Economic Performance Level**  
**(1970 = \*, 1985 = +) and Change (→)**

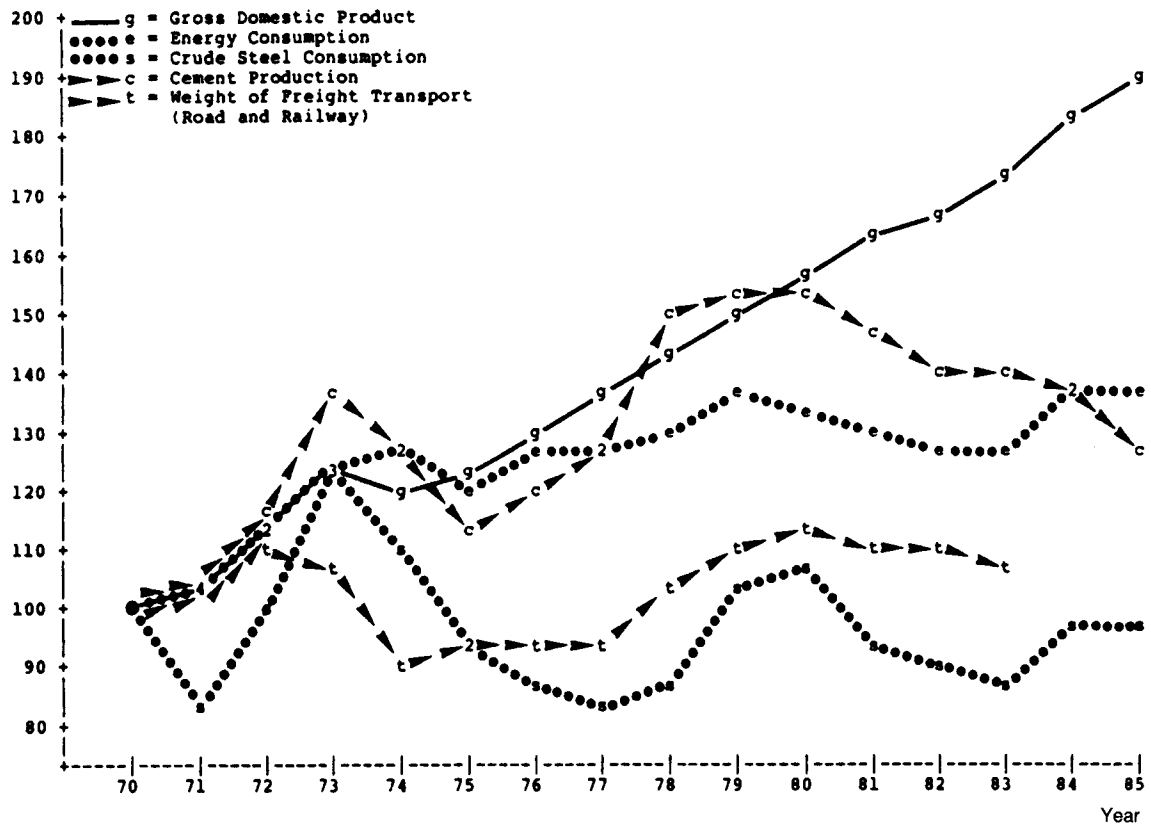


Note: <sup>1</sup> Aggregated per capita indices of cement production, energy consumption, crude steel consumption and weight of freight transport (Mean 1970/85 = 0)

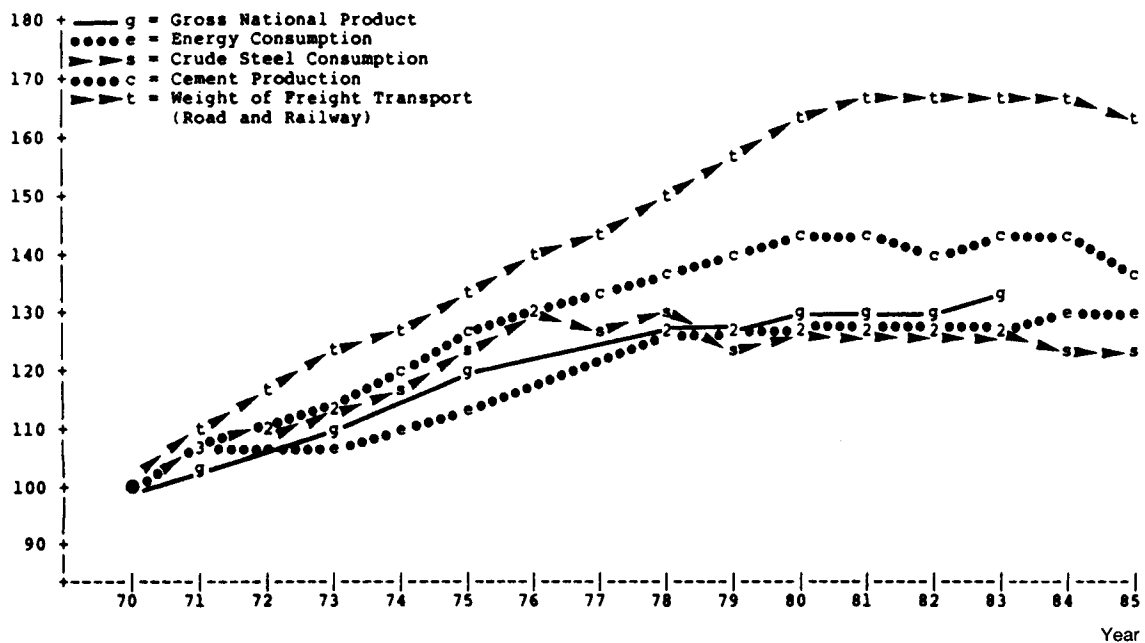
**Figure 7**  
**Structural Economic Change in Sweden, 1970-1985**  
(1970 = 100)



**Figure 8**  
**Structural Economic Change in Japan, 1970-1985**  
(1970 = 100)



**Figure 9:**  
**Structural Economic Change in the CSSR, 1970-1985**  
(1970 = 100)



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 environmental gratis effects.

Absolute improvements are also ascertainable in the United Kingdom, where the four structural impact factors decreased between 2.3% and 43.5%. In contrast to Sweden, however, these reductions were connected with high mass unemployment.

In Denmark, too, structural change in the economy decreased the pollution load of the environment. Between 1970 and 1985, Denmark's GDP grew by some 40.8%, while three of the four impact factors decreased by between 2.7% and 33.2%.

In Japan, the process of de-linking was partly neutralized by the rapid growth in industrial production and thus only resulted in relative structural improvement (see Group 2 in Table 2). The conclusion may be drawn that a forced rate of industrial growth collides with the ecological advantages of structural change away from traditional modes of production. In addition to the positive environmental effects of structural change, countries with high rates of economic growth must, therefore, strongly rely on remedial (reactive) environmental protection measures.

In Czechoslovakia, no real de-linking of economic growth from the four impact factors was discernible. Some of them even increased. After the second oil price hike, the economy entered a crisis. The development profile of Czechoslovakia, with sluggish or even no structural change, is to some extent representative of the national economies of Eastern Europe (with the exception of the German Democratic Republic).

Group 3 of our sample ("structural deterioration") consists for the most part of industrial late-comers, now in a relatively early stage of industrialization. But with Czechoslovakia, it is a relatively old industrial economy which (in 1985) took the lead in structural environmental impacts per capita.

Among the Western industrial nations, countries with a smaller GDP can be characterized by quantitative (high-volume) growth. This is true for Turkey and Portugal, which are still in an early stage of industrialization, and especially for Greece which suffered from high pollution caused by this type of economic growth.<sup>17</sup>

<sup>17</sup> OECD: Environmental Policies in Greece, Paris 1983.

<sup>18</sup> E. D. Larson, M. H. Ross and R. H. Williams: Beyond the Era of Materials, in: Scientific American, Vol. 254, No. 6, 1986.

## Conclusions

The method of selecting factors leading to environmental impacts, as used in this report, leaves room for refinement. The question of substitution processes (steel/plastics, for example) should be further investigated. Also, additional information is needed if, for instance, *industrial* consumption of energy, or the specific impacts of energy *production* (such as lignite) are taken into consideration. Certain problems are also posed by the different methods of computing the domestic (national) product in East and West.

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

□ Structural change in the sense of de-linking material inputs and economic growth was evident in most of the thirty-one industrialized countries studied. Fewer than half of these countries clung to the traditional modes of quantitative growth. This was true for the low-income Western countries and for most of the countries of Eastern Europe.

□ Structural change was not simply a question of the decreasing energy consumption observed after the oil price hikes of the 1970s; it was also demonstrated by the other factors.<sup>18</sup>

□ Certain Western countries enjoyed environmental gratis effects as a result of structural change. In some cases, especially in Sweden, these effects were quite considerable.

□ In other Western countries, the possibly beneficial environmental effects of structural change were cancelled out by the economic growth achieved. This was especially true in the case of Norway and Japan.

□ The relationship between economic performance and environmental impacts, still evident in 1970, had partly dissolved by 1985. The prosperous countries featured fairly rapid structural change.

□ In the medium-income countries, distinct development patterns emerged; there were cases of rapid quantitative growth and cases of qualitative growth, i.e. economic growth with constant or decreasing resource input. Therefore it is not possible to speak of one dominant development trend among the industrialized countries.

The differences between these development patterns are of particular interest for future environmental policy. The reasons for such differences and their consequences deserve further attention.