Comparison of Environmental Economic Performance In South Korea and Germany

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Abstract

This paper compares the environmental economic performance of the South Korean and the German economy during the last decade. The analysis is based on comparable data from the Environmental Economic Accounts (EEA). The EEA is a satellite account to the National Accounts which enhances the conventional economic accounts by a description of the interactions between the economy and the environment. The data from the EEA and the national accounts are fully compatible.

In absolute terms the environmental pressures caused by economic activities were with regards to the environmental factors used for the analysis generally lower in South Korea than in Germany. If the use of environmental factors is related to each country's gross domestic product (environmental productivities) a lower level of environmental productivity can be observed for most of the environmental factors in South Korea compared to Germany. For example in 1999 energy and CO_2 productivity were about two fifths of the German level. This corresponds to the relation regarding labour productivity (Gross domestic product per employment).

Keywords : EEA, Eco-efficiency, Environmental factors, Environmental productivity

Ⅰ. Introduction

The aim of this paper was to compare the environmental economic performance in the Republic of Korea and in the Federal Republic of Germany on the basis of comparable Environmental Economic Accounting (EEA) data for both countries. The EEA is a satellite account to the National Accounts which enhances the conventional economic accounts by a description of interactions between economy and environment. This paper's intention was threefold: To give answers to some interesting research questions, to support further development of Korean EEA towards a user orientated data supply and to demonstrate the analytical benefits EEA data can offer to potential users.

Lots of environmental problems have a global dimension. Therefore it seems to be useful to compare the interaction between environment and economy between different countries. Especially a comparison between Germany as an "mature economy" and Korea as a "young economy" seems promising. In Germany as well as in South Korea during the last years a number of efforts have been made to reduce environmental pressures and at least to de-couple economic growth and pressure on the environment. But there is much concern that even stronger efforts to protect the environment may be overcompensated by increasing environmental pressures caused by economic growth, especially in the dynamic young economies. Comparing environmental economic performance of South Korea on the one hand and Germany on the other may provide new insights.

The System of Environmental Economic Accounts (SEEA) of the United Nations (UN) is the principal international framework for Environmental Economic Accounting (UN, 2003). This framework describes a highly sophisticated accounting system. For a statistical office entering this field it is not easy to decide what to begin with. Not to start with just filling the system with some data but to put priority on such data that are required for dealing with politically highly relevant issues may be a conducive approach. The question of eco-efficiency selected for this paper is a very important topic in the context of the sustainability debate (Schoer, 2003).

As demonstrated by the recently completed SEEA 2000, most of the basic methodological questions of Environmental Accounting are now solved and world-wide there are already quite rich experiences in compiling environmental accounts. But lots of potential users are still not aware of the analytical benefits these data can offer. In such a situation it may be a good policy for statistical offices not only to publish the data, but also to carry out analyses with the new type of information to demonstrate their practical usefulness.

For the purpose of the paper comparable statistical figures on eco-efficiency had to be calculated on the basis of the concepts recommended in the SEEA. The Federal Statistical Office of Germany already publishes a wide range of annual EEA (Environmental Economic Accounts) data on a regular basis. These publications cover a number of physical indicators on environmental pressures regarding consumption of natural resources, emission of residuals and land use that are related to gross domestic product. Therefore German data for this paper was taken from the regular publications.

The data for South Korea were partly specially compiled by the Korean National Statistical Office for the purpose of this paper with the aim to continue this work in future as a first step to establish EEA in South Korea. Hence, the compilation of this data in an accounting framework was an essential part of this paper. Parallel to the approach applied in national accounting, the results of environmental production factors for South Korea were not only obtained directly through primary environmental statistics but also by utilising all available environmental statistical sources. The main sources were as follows:

The data sources of green house gases, acidification gases and CO were calculated for the economic sectors and households by means of energy consumption from a database of energy balance by the Korean Energy Economic Institute (KEEI) and specific emission coefficients by the Korean Environmental Agency (KEA). The data sources for build-up and traffic area were provided by Ministry of Construction & Transport (MOCT), and coverage of build-up and traffic area was composed of data concerning area on building and adjacent, plant used for industrial, recreation used for sport, recreation and leisure, traffic used for road and rail and cemetery. The data of total use of water are compiled by the Ministry of Construction & Transport every two years, and are composed of numbers on used domestic water (urban water), industrial water, agriculture water and maintenance water. The data of waste water were taken from a survey of industry water and environmental statistics yearbook by the Ministry of Environment.

In the first section of this paper the relation between economic development and selected important environmental pressure factors will be investigated on a national level. The second section deals with the relation between the pressure factor CO_2 emissions and the emitting economic activities in a breakdown by industries.

Ⅱ. National economy and environmental factors

2.1 Population and gross domestic product

South Korea as well as Germany are densely populated countries with a highly developed economy. The population density was 477 people per square kilometre in South Korea in 2001. In Germany the density was about half the value of South Korea (231 people per square kilometres). The absolute number of population in South Korea was 47.3 millions against 82.4 millions in Germany in the year 2001 (Table 1).

<Table 1> Population and gross domestic product

Parameter	Unit	Germany			South Korea		
		1991	1993	2001	1991	1993	2001
Gross domestic product (at 1995 prices and exchange rates)	Bil.US-$	2,237.7	2,263.0	2,589.3	373.2	415.1	639.4
Population	Mo.	80.0	81.2	82.4	43.3	44.2	47.3
Gross domestic product per capita	1,000US-$/capita	28.0	27.9	31.4	8.6	9.4	13.5

The economic performance measured by the gross domestic product (GDP) at 1995 prices and exchange rates amounted to 639.4 Bil. US-$ in South Korea. In Germany the gross domestic product was with 2,589.3 Bil. US-$ about four times higher. In per capita terms South Korea achieved about 43 % of Germany's GDP level in the year 2001 measured at 1995 prices and exchange rates. A purchasing power parities-based comparison[1] shows a different situation. The gap between Germany's (26,600 US-$) and South Korea's per capita GDP (15,900 US-$) narrows up to 60 % in this case because of South Korea's lower price level.

1) Purchasing power parities(PPPs) are the rates of currency conversion that eliminate the differences in price levels between countries. Per capita volume indices based on PPP converted data reflect only differences in the volume of goods and services produced. Comparative price levels are defined as the ratios of PPPs to exchange rates. They provide measures of the differences in price levels between countries. The PPPs are given in national currency units per US-$ (Source: OECD: Main economic indicators, p.244, April 2003.).

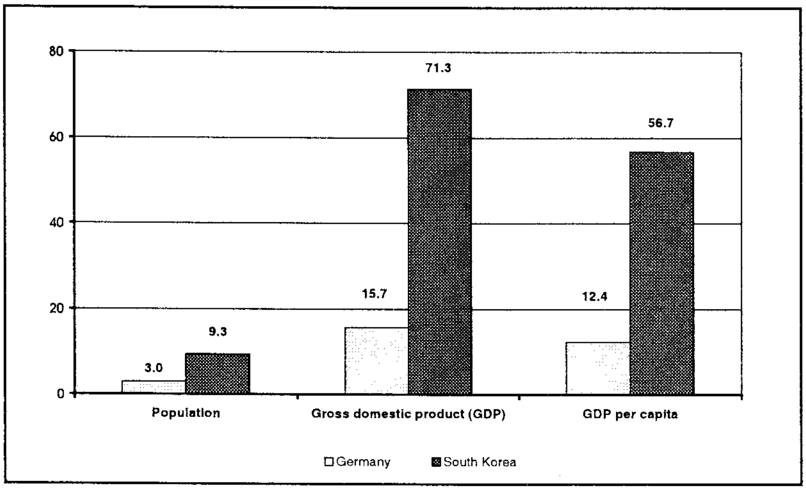
The growth rates of population and gross domestic product were considerably higher in South Korea than in Germany. In the last decades South Korea has shown a high population growth. Contrary to this, in Germany natural population growth had come to a halt, but there was a continuous inflow of immigrants.

Between 1991 and 2001 population in South Korea increased by 9.3 % (Figure 1). But in the last years clear signs can be found that the so called demographic transitions i.e. a decrease in population growth in the course of increasing economic wellbeing, is coming into effect in South Korea as well. In Germany the population figure rose by 3.0 %. Whereas the increase of population in Germany is exclusively caused by immigration, in South Korea the increase still goes back to natural population growth (surplus of births over deaths).

The pace of economic development was rather different in South Korea and Germany in the last decade. Gross domestic product in South Korea rose by 71.3 % between 1991 and 2001 and so remarkably higher than in Germany (15.7 %). Gross domestic product per capita rose by 56.7 % in South Korea compared to 12.4 % in Germany during the same period.

<Figure 1> Population and gross domestic product 2001

(% change : 2001 versus 1991)



2.2 Environmental factors

Any economic activity involves using nature. In the terminology of the EEA the natural environment is treated as a non-produced natural asset. This asset is, in analogy to produced assets, considered to be a primary factor that contributes to the production process. The environment provides natural resources as material inputs that are withdrawn from nature as raw materials, it provides areas for the production process and nature renders services like the absorption of air emissions, waste and waste water, i.e. substances are taken up by nature.[2] The services can only be measured indirectly by referring respectively to the material flows respectively emissions connected to those services. These input factors provided by the non-produced natural assets can be called environmental factors. In addition, unlike in the conventional national accounts where the inputs into the consumption process consist exclusively of products and not of primary inputs (production factors), in the EEA environmental factors also can be a direct input into the consumption process., e.g. the use of the environment for various types of emissions.

By being used by economic activities (production and consumption) the natural assets usually are depleted or degraded to some extent. That means the natural assets may not be available at the present quantity and quality for future generations. Doing business in line with the principle of sustainable development requires dealing with nature as carefully as possible, so that future generations may enjoy an intact environment, as well. This means that the quantitative use of nature should be as small as possible and/or should respect natural assimilation capacities.

In this paper the use of the environment in South Korea and Germany is measured by the quantities of important environmental factors for which comparable data could be generated (see Table 2). Beside the development of the absolute quantities, as will be looked at in this chapter, it is also useful to establish a relation between various quantities measured in physical units and the economic performance, i.e. to measure eco-efficiency by looking at environmental productivity. That issue will be taken up in chapter 2.3. The quantity and productivity trends for individual environmental factors however show only whether, and to what extent, these relevant factors are being used more carefully than in

2) In addition to its function as a sink, other services provided by nature should be mentioned such as buffer, recreation and production functions.

the past. The indicator does not provide information on the extent to which the goal of sustainability has been reached.

Table 2 shows a lower use of almost all natural factors in absolute terms in South Korea than in Germany in the year 1999. This corresponds to South Korea's lower number of population and lower gross domestic product. The amount of primary energy consumption in South Korea was with 7,592 Petajoule about half of Germany's consumption (14,329 Petajoule). A comparable relation can be observed for most of the air emissions. The water use in South Korea amounts with 33,100 Mio. cubic metres to about 73 % of the German level (45,502 Mio. cubic metres). A remarkable difference can be found regarding built-up and traffic area. While built-up and traffic area covers 42,976 square kilometres in Germany, in South Korea it covers only 6,611 square kilometres (16 %).

<Table 2> Use of environmental factors for economic purposes[3)]

Parameter	Unit	Germany			South Korea		
		1991	1993	1999	1991	1993	1999
Environmental factors							
Primary energy consumption	Petajoule	14,611	14,311	14,329	4,338	5,311	7,592
Total use of water[1)]	Mio. m^3	51,344	48,150	45,502	28,200	-	33,100
Built-up and traffic area	km^2	-	40,305	42,976	5,330	5,643	6,611
Greenhouse gas emissions	Mio. t	1,160.5	1,084.3	983.7	357.1	403.8	448.0
CO_2 emissions	Mio. t	976.5	917.7	859.6	287.7	346.2	443.6
N_2O emissions	Mio. t (CO_2 equiv.)	84.4	82.2	60.3	4.4	7.4	10.7
CH_4 emissions	Mio. t (CO_2 equiv.)	99.6	84.4	63.9	65.0	50.2	33.7
Acidification gas emissions	Mio. t	5.7	4.5	2.0	2.2	2.4	1.7
SO_2 emissions	Mio. t	4.0	2.9	0.8	1.6	1.6	1.0
NO_x emissions	Mio. t (SO_2 equiv.)	1.8	1.5	1.2	0.6	0.8	0.8
CO emissions	Mio. t	9.5	7.7	5.1	1.8	1.3	1.0
Waster water[1)]	Mio. m^3	43,971	40,758	38,557	15,190	-	18,468

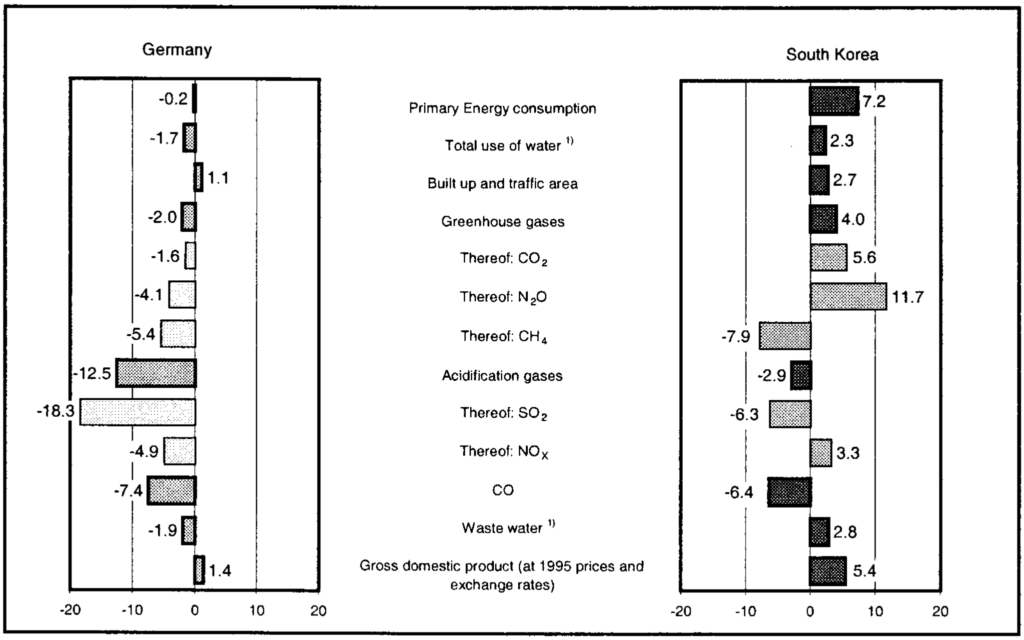
1) 1999 refers to 1998

3) German data for primary energy consumption and greenhouse gas emissions are based on the concepts of National Accounts. In this publication greenhouse gas emissions are defined as the sum of CO_2, and N_2O and CH_4 emissions. N_2O and CH_4 emissions are quoted as CO_2 equivalents with respect to their individual greenhouse effect. Acidification gas emissions are defined as the sum of SO_2 and NO_X emissions. NO_X emissions are quoted as SO_2 equivalents.

Regarding carbon dioxide (CO_2) emissions, in South Korea a rapid increase can be observed opposite to a moderate decrease in Germany. While in 1991 the level of CO_2 emissions was almost 3.5 times higher in Germany, in 1999 it was merely 2 times higher. For Methane (CH_4) emissions the level in South Korea was about half of the German, whereas for acidification gases the amounts in absolute terms were quite similar in both countries.

Regarding the development of environmental factors between 1991 and 1999 different tendencies are visible (Figure 2). In South Korea for most of the examined environmental factors an increase can be observed. For example Primary energy consumption rose with an average annual change rate by 7.2 % between 1991 and 1999. CO_2 emissions attained 5.6 % and the use of built-up and traffic area rose with an average annual change rate of 2.7 %. On the other hand remarkable decreases can be observed regarding CH_4 (-7.9 % p.a.), SO_2 (-6.3 % p.a.) and CO emissions (-6.4 % p.a.).

<Figure 2> Use of environmental factors for economic purposes and gross domestic product (Average annual change in % : 1991-1999)



1) 1999 refers to 1998

In Germany a decline of the use of almost all examined environmental indicators can be found. Primary energy consumption decreased with an average annual change rate of

- 0.2 %, CO_2 emissions decreased by - 1.6 %. The reduction of SO_2 emissions (-18.3 % p.a.) and CO emissions (-7.4 % p.a.) was higher than in South Korea while in Germany lower reduction rates regarding CH_4 (-5.4 % p.a.) were achieved.

Opposite to the other analysed environmental indicators in Germany built-up and traffic area rose with an average annual change rate of 1.1 % compared, as already mentioned, to 2.7 % p.a. in South Korea.

It is obvious that the substantially higher rate of economic growth in South Korea goes a long way in explaining the general differences between the two countries regarding the development of the use of environmental factors. Especially for CO_2 emission the development in South Korea, with a high increase in the last decade, and Germany, with a remarkable decrease, is rather different.

2.3 Environmental productivities

Environmental productivity indicators can measure to what extent a de-coupling of the use of a environmental factor and economic growth has taken place. The productivity of environmental factors is calculated according to the measurement of capital or labour productivity. It is defined in the following way:

$$\text{Productivity} = \frac{\text{Gross domestic product (at constant prices)}}{\text{environmental factor (in physical terms)}}$$

It has to be noted that environmental productivity cannot be measured by one single number but merely consists of a vector of various productivities according to the different inputs from nature to economy. For the calculation of each of these productivities the entire real yield of the economic activity is referred only to the production factor concerned, although the product is created through the combination of all production factors. Therefore these partial productivities as calculated can serve only for rough orientation.

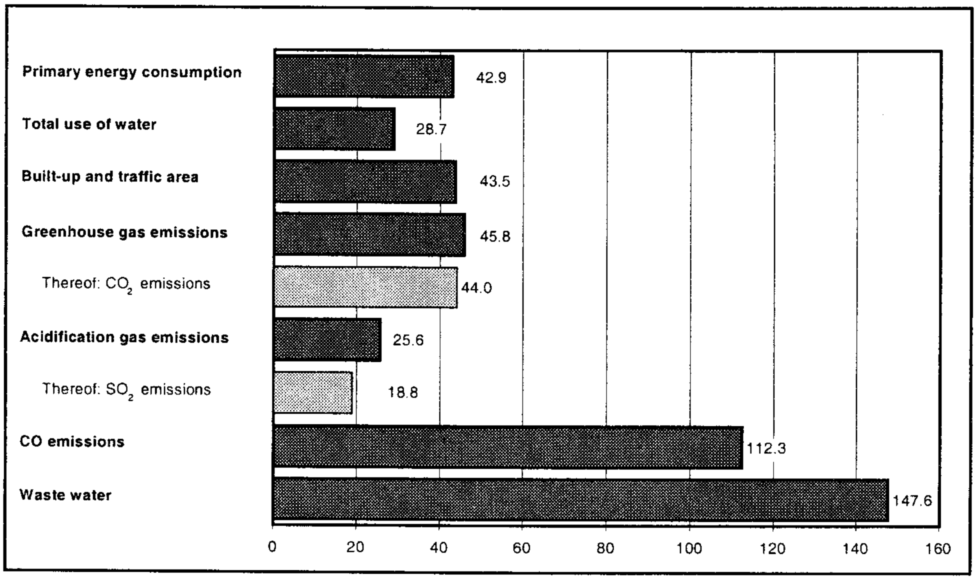
By using productivities an international comparison of the efficiency of the use of environmental factors for economic activities is possible. Due to their different qualities and functions, those factors (and the corresponding productivities respectively) cannot be compared directly with each other. However, by observing their development over long periods one may obtain information on how the relations between the factors have changed.

Table 3 and figure 3 show that regarding most environmental factors, the level of environmental productivities in South Korea was lower than in Germany. For example in 1999 energy and CO_2 productivity were about two fifths of the German level which corresponds to the relation regarding labour productivity (Gross domestic product per employment). This may indicate that there is still quite a lot of space for improving South Korean environmental productivities in the future.

<Table 3> Environmental productivities : per environmental factor

Parameter	Unit	Germany			South Korea		
		1991	1993	1999	1991	1993	1999
Primary energy consumption	US-$ per Gigajoule	153	158	174	86	78	75
Total use of water[1)]	US-$ per m^3	44	47	54	13	-	15
Built-up and traffic area	Mio.US-$ per km^2	-	56	58	70	74	86
Greenhouse gas emissions	US-$ per t	1,928	2,087	2,541	1,045	1,028	1,163
CO_2 emissions	US-$ per t	2,292	2,466	2,908	1,297	1,199	1,280
Acidification gas emissions	US-$ per t	389,612	505,392	1,271,291	168,662	172,814	325,099
SO_2 emissions	US-$ per t	562,365	772,923	3,172,550	233,530	264,215	596,937
CO emissions	US-$ per t	235,189	293,740	486,043	212,035	321,768	545,853
Waster water[1)]	US-$ per m^3	51	56	64	25	-	28
Employment	US-$ per capita	58,124	61,244	64,699	19,981	20,358	26,954

<Figure 3> Comparison of environmental productivities between South Korea and Germany 1999 (Ratio (%) of South Korea to Germany)

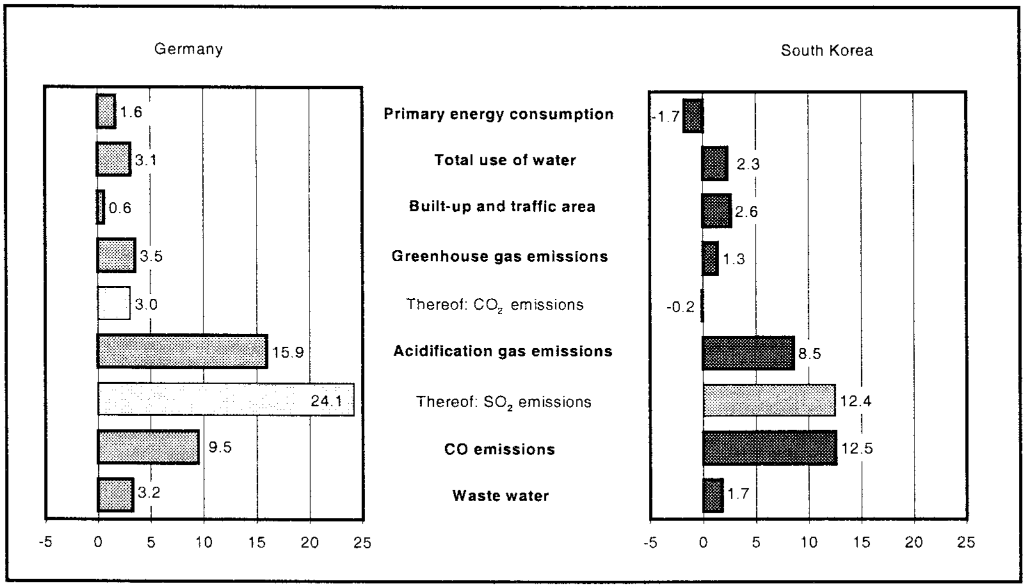


There are two exemptions from the general tendency. As already shown for the absolute figures, the productivity for built-up and traffic area was considerably higher in South Korea than in Germany. Furthermore the CO productivity was higher in South Korea also.

The comparison of the development of environmental productivities shows that productivities of all environmental factors in South Korea rose in between 1991 and 1999 except those for primary energy (-1.7 %) and CO_2 (-0.2 %) (Figure 4). In German average annual change rates of all environmental productivities were positive and in most cases higher than in South Korea. Higher annual change rates in South Korea compared to Germany were only achieved for productivity of built-up and traffic area (+2.6 % compared to +0.6 %) and for CO (12.5 % against 9.5 %).

<Figure 4> Change of environmental productivities

(Average annual change in % : 1991-1999)



By relating the figures on the development of use of environmental factors to the economic growth, as done by calculating productivities, the impact of economic growth on the development of one factor can be shown. Compared to the high differences in the absolute development of environmental factors the development of environmental productivities is rather similar in both countries. That indicates that the higher increase for most environmental factors in South Korea to a large extent can be explained simply by the considerably higher economic growth.

Ⅲ. Comparison of CO_2 emissions by economic activities

In this chapter economic driving forces for the development of CO_2 emissions will be analysed in detail in a breakdown by industries and consumption of private households. For CO_2 emissions comparable data is available for the time period 1995 to 2000.

Generally spoken, pressure on the environment by economic activities can be traced back to a number of different causes. Economic growth (volume effect) is certainly very important in this context. Environmental factors are mainly used in the production process, but they can also be used directly in the consumption process of private households, for example the use of energy sources for housing purposes (mainly heating and cooking) or as fuel for private vehicles. When looking at the economy by individual industries with different products and different technical conditions, development of productivity at the national level is influenced by the development of productivities in individual branches, which can be labelled as the efficiency or intensity effect, as well as by the change in the composition of the economy by branches, which can be labelled as the structural effect.

In this chapter in a first step the mathematical instrument of a decomposition analysis is used to quantify the effect of these influence factors on CO_2 emissions at the national level. In the next step the factors are investigated more in detail by looking at individual branches which are important regarding CO_2 emissions.

3.1 Decomposition of CO_2 emissions

The following decomposition analysis deals only with direct emissions in production. For CO_2 emissions comparable data in a breakdown by industries are available for the years 1995 to 2000. In both countries the share of total direct CO_2 emissions caused by production is about three fourths of the total CO_2 emissions. One fourth of the emissions goes back to private households, mainly for housing purposes and use of private vehicles.

The following factors influencing the development of CO_2 emissions in production between 1995 and 2000 were taken into account:

- economic output (gross value added at 1995 prices)

- economic structure (shares of industries in the gross value added)
- CO_2 intensity of the production (total CO_2-emissions per gross value added (GVA)).

The overall CO_2 intensity of production can be traced back to the development of the CO_2 intensity in the individual industries and the development of the economic structure. With other conditions remaining constant, CO_2 emissions would increase or decrease along with the development of production. Decreases in emissions along with rising production may be achieved by a more efficient use of energy i.e. if individual enterprises succeed in producing the same amount while using less energy. The CO_2 emissions are mainly caused by burning fossil energy carriers. The process of decreasing CO_2 intensity is supported both by general technological progress and by the relative rise of prices of the production factor of energy. An other potential factor that might contribute to reduce CO_2 intensity is the changeover to using energy sources containing less carbon per energy unit - e.g. replacing coal by natural gas or renewable energy sources.

The change of the economic structure has an impact on the overall CO_2 intensity, if there is a change in the share of products whose production is related to lower CO_2 emissions per unit against products with higher specific emissions. Structural change is mainly the result of changed demand structures. The overall result is composed by a variety of developments, some of which can be countervailing with regards to CO_2 emissions.

For separating the influence of the structural and of the intensity effect it is essential to have data on CO_2 emissions and GVA in a subdivision by industries. For determining the impact of the above mentioned three components of economic growth, change of economic structure and change of CO_2 intensity in the individual industries on the overall development of CO_2 emissions, the actual development of emissions between the years 1995 to 2000 was compared with a hypothetical development which would have occurred under the assumption that the factor under examination remained constant over time while for the other factors the actual development was assumed. The effects thus obtained can be considered only as a rough indication for the contribution of the individual factors to the overall development of CO_2 emissions. This is because the level of any effect is also influenced by the level of the other three effects and, in strictly mathematical terms, cannot be added up. It should also be noted that the shares of the structural and of the intensity effect may be influenced by the level of aggregation of the subdivision by industries, because with a higher level of aggregation structural effects within an aggregated position appear as intensity effect.

Table 4 shows the influence of the three effects for South Korea and Germany for the period 1995 to 2000. The direct CO_2 emissions of production were reduced by 4.0 % in Germany between 1995 and 2000, whereas the emissions increased by 17.2 % in South Korea. With gross value added remaining the same as in 1995 and other conditions unchanged, hypothetical CO_2 emissions in 2000 would have been lower by about 11.5 % in Germany and by 27.2 % in South Korea (growth effect).

<Table 4> Change of total CO_2 emissions and the impact of growth, intensity and structural effect

(% change : 1995 versus 2000)

	Germany	South Korea
Total CO_2 emissions	-4.0	17.2
Growth effect	11.5	27.2
CO_2 intensity effect	-10.3	-15.3
Structural effect	-6.1	3.9

The other two factors partly contribute to an increase and partly to an increase of actual CO_2 emissions. The intensity effect moved towards the same direction for both countries. In Germany contribution of the intensity effect for decreasing the emissions was 10.3 %, in South Korea the impact of this effect was considerably stronger with 15.3 %. Structural change, i.e. the change in the demand structure of the overall economy towards types of goods that are less CO_2 intensive (structural effect), in Germany accounted for a decrease in emissions by 6.1 %, whereas this effect moved in the opposite direction in South Korea accounting for an increase of emissions by 3.9 %.

3.2 Direct CO_2 emissions by economic activities

In table 5 distribution and development of CO_2 emissions by economic activities (industries and private households) for South Korea and Germany are shown.

In 2000 the share of direct CO_2 emissions by consumption of private households to total CO_2 emissions was nearly identical in both countries with 23.5 % in South Korea and

23.1 % in Germany. Regarding production activities, "Manufacturing and construction" and "Electricity, gas and water supply" accounted most of emissions. From total CO_2 emissions (including emissions of private households) "Manufacturing and construction" accounted for 34.5 % and "Electricity" for 25.5 % in South Korea in 2000. In Germany the proportion of "Manufacturing and construction" was 24.3 % against 35.2 % for "Electricity, gas and water supply". The high proportion of "Electricity, gas and water supply" in both countries results from this industry's primary function, that is the transformation of (mainly) fossil energy sources such as coal, mineral oil and natural gas into electricity and electricity supply to other industries. The service sector had a share of 13.6 % of CO_2 emissions in Germany and 14.6 % in South Korea. The emissions of "Manufacturing of basic metals" were more than two times higher in South Korea (18.4 %) than in Germany (7.3 %).

Regarding the development of CO_2 emissions between 1995 and 2000 table 5 shows a growth of total CO_2 emissions in production in South Korea of 17.2 %. In Germany a decrease of 4.0 % can be observed. In South Korea the emissions of almost all industries, except "Mining and quarrying", increased between 1995 and 2000. High increases can especially be observed for those industries relevant for CO_2 emissions, like "Manufacturing of chemicals and chemical products" and "Electricity, gas and water supply". In Germany almost all important emitters of CO_2 achieved considerable reductions over the last decade or showed, compared with South Korea, rather small increases (e.g. "Services": +4.9 %).

The differences concerning the development of CO_2 emissions between the two countries in absolute terms are mainly caused by the higher general economic growth in South Korea (+27.4 %) compared to Germany (+11.5 %). The total amount of the growth effect is, as already mentioned, shown in table 4.

3.3 CO_2 intensities by industries

Regarding the level of CO_2 intensity (CO_2 emissions per GVA) of individual branches considerable differences between the branches within one country, but also of corresponding branches between the two countries can be found. For total production CO_2 intensity in South Korea (584 kg/1,000 US-$) was more than twice as high as in Germany (268 kg per 1,000 US-$) in the year 2000. Regarding the individual branches it generally can be detected that CO_2 intensity was higher in South Korea for almost all industries

<Table 5> Direct CO_2 emissions by industries and by consumption of private households

No.	Industries (ISIC classification)	Germany 1995	Germany 2000	South Korea 1995	South Korea 2000
		total emission [1,000 t]			
A+B	Agriculture, hunting, forestry and fishing	10,181	8,411	7,978	9,119
C	Mining and quarrying	38,704	24,510	219	108
D+F	Manufacturing and construction	229,556	208,313	138,054	165,174
D15	Manufacture of food products and beverages	14,075	12,744	3,53	3,688
D17+18	Manufacture of textiles, wearing apparel; dressing and dyeing of fur	1,664	1,303	3,586	4,811
D24	Manufacture of chemicals and chemical products	33,372	26,933	4,117	12,027
D26	Manufacture of other non-metallic mineral products	39,170	37,061	20,321	26,620
D27	Manufacture of basic metals	65,747	62,648	79,689	88,360
	Other Manufacturing and Construction	75,528	67,624	26,888	30,104
E	Electricity, gas and water supply	298,086	302,565	101,162	122,106
G−Q	Services	111,337	116,768	65,169	69,743
A−Q	Total industries	687,865	660,566	312,582	366,250
	Domestic consumption of private households (including Non-profit institutions serving households)	215,497	197,994	96,438	112,785
	Total industries and domestic consumption of private households (including Non-profit institutions serving households)	903,361	858,561	409,020	479,034
		1995 = 100			
A+B	Agriculture, hunting, forestry and fishing	100	82.6	100	114.3
C	Mining and quarrying	100	63.3	100	49.4
D+F	Manufacturing and construction	100	90.7	100	119.6
D15	Manufacture of food products and beverages	100	90.5	100	106.8
D17+18	Manufacture of textiles, wearing apparel; dressing and dyeing of fur	100	78.3	100	134.2
D24	Manufacture of chemicals and chemical products	100	80.7	100	292.1
D26	Manufacture of other non-metallic mineral products	100	94.6	100	131.0
D27	Manufacture of basic metals	100	95.3	100	110.9
	Other Manufacturing and Construction	100	89.5	100	112.0
E	Electricity, gas and water supply	100	101.5	100	120.7
G−Q	Services	100	104.9	100	107.0
A−Q	Total industries	100	96.0	100	117.2
	Domestic consumption of private households (including Non-profit institutions serving households)	100	91.9	100	117.0
	Total industries and domestic consumption of private households (including Non-profit institutions serving households)	100	95.0	100	117.1
		percentage			
A+B	Agriculture, hunting, forestry and fishing	1.1	1.0	2.0	1.9
C	Mining and quarrying	4.3	2.9	0.1	0.0
D+F	Manufacturing and construction	25.4	24.3	33.8	34.5
D15	Manufacture of food products and beverages	1.6	1.5	0.8	0.8
D17+18	Manufacture of textiles, wearing apparel; dressing and dyeing of fur	0.2	0.2	0.9	1.0
D24	Manufacture of chemicals and chemical products	3.7	3.1	1.0	2.5
D26	Manufacture of other non-metallic mineral products	4.3	4.3	5.0	5.6
D27	Manufacture of basic metals	7.3	7.3	19.5	18.4
	Other Manufacturing and Construction	8.4	7.9	6.6	6.6
E	Electricity, gas and water supply	33.0	35.2	24.7	25.5
G−Q	Services	12.3	13.6	15.9	14.6
A−Q	Total industries	76.1	76.9	76.4	76.5
	Domestic consumption of private households (including Non-profit institutions serving households)	23.9	23.1	23.6	23.5
	Total industries and domestic consumption of private households (including Non-profit institutions serving households)	100	100	100	100

shown in the table. In South Korea as well as in Germany "Electricity, gas, and water supply" achieved the highest CO_2 intensity (7,577 kg per 1,000 US-$ resp. 5,855 kg per 1,000 US-$) followed by "Manufacturing of basic metals" (5,968 kg per 1,000 US-$ resp. 3,020 kg per 1,000 US-$). "Manufacturing of other non-metallic products" showed also a comparatively high level of CO_2 intensity. Regarding "Services" in both countries CO_2 intensity was comparatively low (Table 6).

<Table 6> CO_2 intensity by industries and by consumption of private households

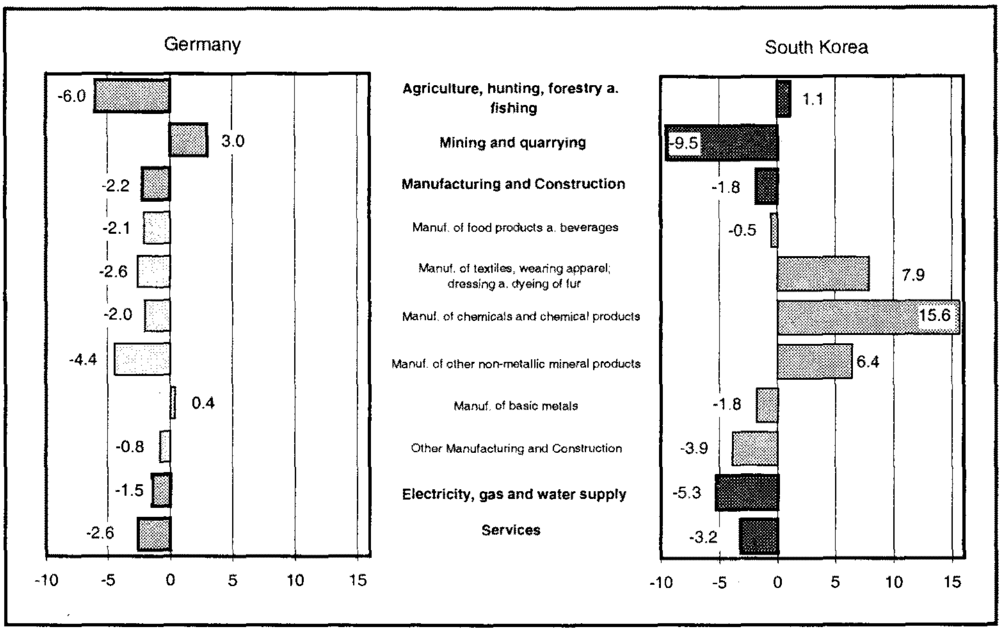
No.	Industries (ISIC classification)	Germany 1995	Germany 2000	South Korea 1995	South Korea 2000
	kg Co_2/1,000 US-$ gross value added (1995 prices and exchange rates)				
A+B	Agriculture, hunting, forestry and fishing	361	265	263	278
C	Mining and quarrying	2,989	3,457	95	58
D+F	Manufacturing and construction	511	316	694	634
D15	Manufacture of food products and beverages	313	274	291	284
D17+18	Manufacture of textiles, wearing apparel; dressing and dyeing of fur	132	119	419	612
D24	Manufacture of chemicals and chemical products	633	505	292	603
D26	Manufacture of other non-metallic mineral products	1,664	1,694	3,260	4,455
D27	Manufacture of basic metals	3,147	3,020	6,530	5,968
	Other Manufacturing and Construction	153	134	184	151
E	Electricity, gas and water supply	6,302	5,855	9,928	7,577
G−Q	Services	76	68	259	221
A−Q	Total industries	311	268	634	584
	kg Co_2 per 1,000 US-$ consumption expenditure (1995 prices and exchange rates)				
	Domestic consumption of private households (including Non-profit institutions serving households)	161	137	360	359
	1995 = 100				
A+B	Agriculture, hunting, forestry and fishing	100	73.43	100	105.43
C	Mining and quarrying	100	115.67	100	60.73
D+F	Manufacturing and construction	100	89.49	100	91.37
D15	Manufacture of food products and beverages	100	87.64	100	97.35
D17+18	Manufacture of textiles, wearing apparel; dressing and dyeing of fur	100	90.21	100	146.06
D24	Manufacture of chemicals and chemical products	100	79.73	100	206.70
D26	Manufacture of other non-metallic mineral products	100	101.80	100	136.63
D27	Manufacture of basic metals	100	95.95	100	91.39
	Other Manufacturing and Construction	100	87.68	100	82.17
E	Electricity, gas and water supply	100	92.90	100	76.32
G−Q	Services	100	89.99	100	84.98
A−Q	Total industries	100	86.10	100	92.02
	kg Co_2 per 1,000 US-$ consumption expenditure (1995 prices and exchange rates)				
	Domestic consumption of private households (including Non-profit institutions serving households)	100	84.96	100	99.78

The change of CO_2 intensity in 2000 compared to 1995 shows different developments in the two countries (see figure 5). While most industries in Germany reduced their CO_2 intensity over time, in South Korea the general development was non-uniform. Among the industries with a high weight in terms of CO_2 emissions the CO_2 intensity of "Manufacturing of non-metallic and mineral products" and of "Manufacturing of chemicals and chemical products" increased considerably whereas CO_2 intensity of "Electricity, gas, and water supply", "Manufacturing of basis metals" and "Other manufacturing" decreased much stronger than in Germany. The compound effect of these different tendencies is, as was shown in the decomposition analysis, a higher CO_2 intensity effect than in Germany.

Such that the intensity effect supported the reduction of direct CO_2 emissions from production at the level of national economy in both countries. But this effect was stronger in South Korea than in Germany.

<Figure 5> Change of specific CO_2 emissions by industries

(Average annual change in % : 1995 - 2000)



3.4 Economic structure (distribution of Gross value added) by industries

As was shown in the previous chapter CO_2 intensities differ considerably between branches. That means, economic structure measured by the distribution of gross value added by industries can have a substantial influence on the amount and the development of CO_2 emissions at the level of the national economy.

Regarding the economic structure significant differences between both countries can be observed. In South Korea the share of the emission intensive branch "Manufacturing and construction" was with 41.6 % considerably higher than in Germany (26.7 %) in 2000 (Table 7). This holds also for "Electricity" with a share of 2.6 % in Korea and 2.1 % in Germany. Against this, the service sector, which is characterised by a low emission intensity, had a share in South Korea of only 50.3 % compared to 69.6 % in Germany. This indicates that the economic structure in South Korea is more emission intensive than in Germany.

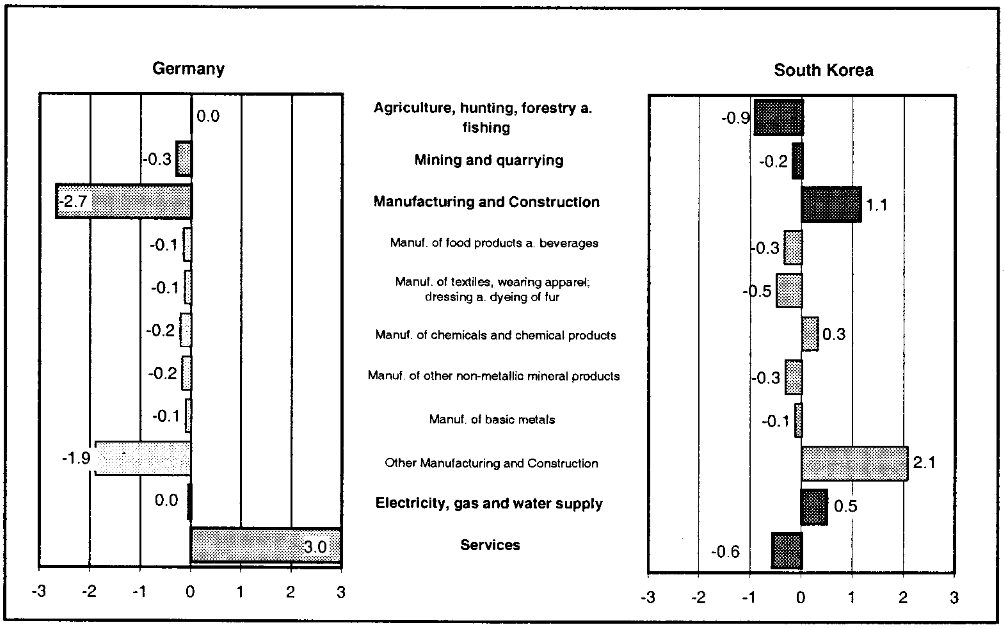
<Table 7> Gross value added by industries (1995 prices and exchange rates)

No.	Industries (ISIC classification)	Germany 1995	Germany 2000	South Korea 1995	South Korea 2000
		Bil. US-$			
A+B	Agriculture, hunting, forestry and fishing	28	32	30	33
C	Mining and quarrying	13	7	2	2
D+F	Manufacturing and construction	649	658	199	261
D15	Manufacture of food products and beverages	45	46	12	13
D17+18	Manufacture of textiles, wearing apparel; dressing and dyeing of fur	13	11	9	8
D24	Manufacture of chemicals and chemical products	53	53	14	20
D26	Manufacture of other non-metallic mineral products	24	22	6	6
D27	Manufacture of basic metals	21	21	12	15
	Other Manufacturing and Construction	494	505	146	199
E	Electricity, gas and water supply	47	52	10	16
G−Q	Services	1,473	1,717	251	316
A−Q	Total industries	2,211	2,466	493	628
	Memorandum item : Household final consumption (including Non-profit institutions serving households)	1,340	1,450	268	314
		1995 = 100			
A+B	Agriculture, hunting, forestry and fishing	100	112.51	100	108.41
C	Mining and quarrying	100	54.75	100	81.28
D+F	Manufacturing and construction	100	101.40	100	130.95
D15	Manufacture of food products and beverages	100	103.31	100	109.72
D17+18	Manufacture of textiles, wearing apparel; dressing and dyeing of fur	100	86.80	100	91.85
D24	Manufacture of chemicals and chemical products	100	101.22	100	141.33
D26	Manufacture of other non-metallic mineral products	100	92.94	100	95.88
D27	Manufacture of basic metals	100	99.31	100	121.32
	Other Manufacturing and Construction	100	102.11	100	136.26
E	Electricity, gas and water supply	100	109.26	100	158.16
G−Q	Services	100	116.55	100	125.93
A−Q	Total industries	100	111.53	100	127.33
	Memorandum item : Household final consumption (including Non-profit institutions serving households)	161	108.14	360	116.20

Figure 6 shows that the changes of the economic structure moved in the opposite direction in South Korea and Germany between 1995 and 2000. In South Korea there was an increase of the share of emission intensive sectors. The share of "Manufacturing and construction" increased by 1.1 percent points and the share of "Electricity, gas and water supply" moved up by 0.5 percent points. Against this, in Germany the relative importance of "Manufacturing and construction" (-2.7 percent points) went down while the share of "Electricity, gas and water supply" stayed unchanged (-0.0 percent points). The share of the service sector decreased in South Korea by 0.6 percent points, but went up in Germany by 3.0 percent points. That means, whereas the economic structure in Germany became less emission intensive during the last five years, for South Korea a development towards a more emission intensive economic structure could be identified.

These results confirm the outcome of the decomposition analysis regarding the structural effect of the decomposition analysis presented above (Table 4). That means, part of the emission increase in South Korea can be explained by the development towards a more emission intensive economic structure. Against this, in Germany the structural change contributed to a decrease of the CO_2 emissions.

<Figure 6> Change of the share of gross value added by industries Change from 2000 to 1995 in percent points



Ⅳ. Conclusion

This paper compares the environmental economic performance of the South Korean and the German economy during the last decade. The analysis is based on comparable data from the Environmental Economic Accounts (EEA). The EEA is a satellite account to the National Accounts which enhances the conventional economic accounts by a description of the interactions between the economy and the environment. The data from the EEA and the national accounts are fully compatible.

The Federal Statistical Office of Germany already publishes annual EEA data on a regular basis. The South Korean data were partly specially compiled by the Korean National Statistical Office for the purpose of this paper with the aim to continue this work in future as a first step to establish EEA in South Korea.

In the first section of the paper the relation between economic development and important environmental pressure factors, like energy, water, area coverage and several air emissions, was investigated on a national level. In the second section the relation between the pressure factor CO_2 emissions and the emitting economic activities in a breakdown by industries was analysed.

In absolute terms the environmental pressures caused by economic activities were with regards to the environmental factors used for the analysis generally lower in South Korea than in Germany. If the use of environmental factors is related to each country's gross domestic product (environmental productivities) a lower level of environmental productivity can be observed for most of the environmental factors in South Korea compared to Germany. For example in 1999 energy and CO_2 productivity were about two fifths of the German level. This corresponds to the relation regarding labour productivity (Gross domestic product per employment).

In the second part of the paper the differences in the development of CO_2 emissions in the two countries were investigated in detail. Especially the influence of the factors economic growth, structural change and change of CO_2 intensity in the individual branches were analysed for the period from 1995 to 2000. It was found that the direct CO_2 emissions caused by production were reduced in Germany by 4.0 % between 1995 and 2000, whereas the emissions increased in Korea by 17.2 %. With gross value added remaining the same as in 1995 and other conditions being unchanged, hypothetical CO_2 emissions in 2000 would have been smaller by about 11.5 % in Germany and by 27.2 % in Korea (growth effect). That is, a considerable part of the differences of the development of CO_2 emissions between the two countries can be explained by the higher economic growth in South Korea. However the other two factors partly contributed to a decrease and partly to an increase of actual CO_2 emissions. The CO_2 intensity effect moved in the same direction for both countries. In Germany the contribution of decreasing CO_2 intensity on the overall development of the CO_2 emissions was 10.3 %. In South Korea the impact of this effect was considerably stronger with 15.3 %. Structural change, i.e. the change in the demand structure of the overall economy towards types of goods that are less CO_2 intensive (structural effect), in Germany contributed to a decrease in emissions by 6.1 %, whereas this effect moved in the opposite direction in Korea accounting for an increase of emissions by 3,9 %. The main difference behind this tendency is the rapidly growing share of the less CO_2 intensive service sector in Germany, whereas in Korea the share of the CO_2 intensive manufacturing sector is still moving up.

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