Environmental-Economic Accounting (EEA)

Environmental pressures from German imports and exports
Results of EEA on embodied energy, carbon dioxide and transport of goods

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Abstract

In this paper first preliminary results of the German System of Environmental-Economic Accounting (SEEA) on the development of embodied environmental pressures of imports and exports in the period 1995 to 2004 are presented for the variables energy, carbon dioxide emissions and goods transport performance.

The results on energy and carbon dioxide presented in this report are based on a methodologically improved IOT approach. Among others a so called expanded hybrid IOT was applied, which was tailor-made for the energy calculations.

The causes of the development of embodied pressures are studied on basis of detailed results of the German SEEA by homogeneous branches of production. It is a main purpose of the study to investigate whether the variables included show a significant difference in the development between the production and the consumption perspective. And subsequently it is asked whether the hypothesis is supported for Germany that there is a tendency of relocating environmentally intensive production activities to the rest of the world.

It is suggested to establish an EU-wide system of monitoring the embodied environmental pressures of external trade flows on basis of a systematic and harmonised statistical approach.

1. Introduction

Globalisation is at first hand an economic phenomenon which is above all characterized by an increasing integration of national economies to the world market. That comes along with a growing mobility of the production factors labour and capital and an increasing division of labour between the national economies. The increasing division of labour comes along with a disproportionate expansion of international trade flows.

From an environmental point of view, beside the use of the production factors labour and capital, the pressure on the natural capital is of specific interest. Economic production and consumption activities are the driving forces for the use of natural capital and for the development of environmental pressures. Depletion of subsoil resources, structural pressures, like the use of area for settlement and traffic purposes or for intensive agricultural practices as well as the disposal of residuals like waste and air emissions to the environment belong to the environmental pressures.

Environmental pressures in principal can be viewed from two perspectives. One can look at their direct generation by domestic producers and households. This is the so-called production perspective. On the other hand pressures can be measured for the domestic use (consumption) of goods and services. That is the so-called use perspective. Both perspectives are relevant for policy making. A policy that is aimed at influencing the extent of environmental pressures can either tackle the level or the environmental efficiency of certain production or the level and the pattern of consumption. Therefore, information from both perspectives is basically of interest at the national as well at the international level.

The statistical indicators which are used for environmental policy or for policy on sustainable development – for instance the indicator on green house gas emissions that is applied in the framework of the Kyoto-protocol – as a rule refer to the production perspective. That is: to the observation of direct environmental pressures on the national territory predominantly caused by domestic production activities. Examples for that type of indicator can be found in the European indicator system on sustainable development as well as in the indicator set of the German national strategy on sustainable development. The respective environment related indicators of the German national strategy on sustainable development

1 Paper presented at the 93rd Conference of the Directors-General of the National Statistical Institutes (Conference des directeurs generaux des institutes nationaux de statistique).

refer to the use of energy and raw materials and their efficient use in relation to the GDP, emissions of green house gases, other harmful air emissions, land use as well as goods transport performance, which is used as a yardstick for different transport related environmental impacts.

In contrast to that the use perspective enables to show the amount of environmental pressures embodied in the goods and services consumed within the domestic economy. The embodied pressures are equal to the total amount of pressures that were generated by the production of a product over the whole production chain.

Due to the increasing international relationships of national economies the proportion of goods and services is growing that are not consumed in the country where they were produced. Insofar it becomes increasingly important to regard not only the production but also the consumption perspective for analysing the development of environmental pressures.

The user perspective is more in line with the concept of global responsibility. According to that concept the environmental pressures of imports have to be assigned to the domestic economy. On the other hand pressures that are related to the production of exports are attributed to the economies importing these goods.

Monitoring the development according to both concepts may be of special importance if the pressures related to imports and exports do not balance each other. A special study on embodied carbon dioxide of imports and exports was undertaken by the OECD[2] which refers to the situation in the mid ninetieth and which covers the OECD member states as well as important threshold countries. The study arrived at the conclusion that most industrialised countries have an excess of imports over exports in terms of embodied CO_2-emissions. In contrast to that mainly threshold countries like China, Russian and India had a considerable excess of embodied exports over embodied imports. That might be a hint that industrialised countries had already relocated a part of the carbon dioxide emissions to the rest of the world until the mid nineties.

Moreover in the OECD study the hypothesis was put forward that the trend of shifting direct CO_2-emissions from industrialised countries to developing countries may have continued for the signatory countries of the Kyoto-protocol in order to observe limits of the treaty (carbon leakage).

With growing globalization a demand for a systematic statistical monitoring of environmental pressures has emerged, especially for the measurement of embodied energy and carbon dioxide emissions of import and exports. The aim should be to supplement the production related indicators that have predominantly been used so far. The methodological approach and the data used within the System of Environmental-Economic Accounting (SEEA) offer the opportunity to generate data on these embodied environmental pressures.

In this paper first preliminary results of the German SEEA on the development of embodied energy and carbon dioxide of imports and exports for the period 1995 to 2004 are presented. In a second section results on transport of imported and exported goods are shown.

The causes that lie behind the observed results are analysed on basis of data for homogeneous branches of production respectively for the commodities which they produce. It is a main purpose of this study to investigate whether the variables included show a significant difference in the development between the production and the consumption perspective. Subsequently it is scrutinised whether the hypothesis is supported for Germany that there is a tendency of relocating environmentally intensive production activities to the rest of the world.

After a short description of the methodological approach for estimating embodied environmental pressures (indirect effects) of the imports and exports in a following chapter the results of the calculation are presented and commented. Finally it is suggested to establish an EU-wide system of monitoring the embodied environmental pressures of external trade flows on basis of a systematic and harmonised statistical approach.

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2 OECD: Carbon dioxide emissions embodied in international trade of goods, OECD, Paris 2003.

2. The methodological approach of the System of Environmental-Economic Accountings for the estimation of embodied environmental pressures of exports and imports

In the System of National Accounts (SNA) the economic process is described from the generation or production perspective (Gross Domestic Product) as well as from the use perspective (especially Final Domestic Use). The Gross Domestic Product (GDP) differs from the Final Domestic Use by the balance of export against imports. The generation perspective deals with the question what goods and services were produced in the domestic economy and how much value added was created by that production. The use perspective shows what products were consumed in the domestic economy or by resident economic units.

The SEEA follows both concepts of the SNA. That is, the environmental pressures caused by economic production activities are reported in principal from the production as well as from the consumption perspective. Of course, a crucial precondition for showing both perspectives is that the difference can be quantified reliably.

Due to the type of available primary data the existing environmental reporting systems, like the air emission inventories of the environment agencies or the energy balance, provide data referring to the production perspective. Accordingly the SEEA, which uses those data as a starting point, at first provides results following the production perspective. That is, the direct environmental pressures that are generated in connection with the production activities are shown in a breakdown by homogeneous branches of production. Additionally also direct pressures related to consumption activities – above all the energy consumption of private households for heating, electric appliances, lighting and private cars - is included.

However, the use perspective does not require an activity but a product view. That is, the embodied environmental pressures of the consumed goods and services have to be calculated by accounting for all pressures that accrued with the production of these products over the whole production chain. The embodied or indirect pressures can be estimated on the basis of different methodological approaches. The most accepted are the life-cycle analysis and the input-output analysis.

The life-cycle analysis, which represents a bottom up approach, is suitable for investigating environmental pressures for certain individual products, which preferably belong to the early steps of the production chain, with a rather high degree of accuracy. On the other side the input-output analysis, which is a top-down approach, may offer less accurate results in detail. But this approach has the advantage of being a systematic and comprehensive method which covers the total economy and the results are coherent with the other figures of the accounting system. The input-output analysis enables to combine the monetary input-output tables (IOT) with figures of the SEEA in physical units. The method utilizes the information of the IOT on the intertwining of the production branches on basis of the so-called Leontief-inversis[3]. The utilization of monetary IOT for that type of physical/monetary (hybrid) analysis can be viewed as an important area for application of IOT.

However, the results of that type of calculation model depend on the concrete methodological approach and on the degree of detail of the available data. In order to increase the degree of accuracy the German Federal Statistical Office has taken considerable efforts for refining the methodological approach and to enhance the data base for that type of calculation during the last years. Among others the efforts were focussed on improving the method of estimating embodied energy use and embodied air emissions[4]. The work on that was concentrated on two points:

- Construction of an expanded hybrid IOT (HIOTexp)
- Modification of the standard approach for calculating embodied imports.

3 As an early example for calculating embodied energy in the Federal Statistical Office Germany refer to: Schoer, Karl:Energy use of private households by purposes of final consumption, paper submitted to the Joint ECE/Eurostat Work Session on Methodological Issues of Environment Statistics, Jerusalem, 11-14 October 1999. Online-Veröffentlichung, Statistisches Bundesamt Wiesbaden 1999 http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Publikationen/Fachveroeffentlichungen/UmweltoekonomischeGesamtrechnungen/Energyuse,property=file.pdf.

4 See: Mayer, Helmut: Calculation and analysis of a hybrid energy input-output table for Germany within the Environmental-Economic Accounts (EEA), Paper for the 16-th International Input-Output Conference, Istanbul Turkey, 2-6 July 2007, Online publication, Statistisches Bundesamt, Wiesbaden 2007 http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/EN/Content/Publikationen/SpecializedPublications/EnvironmentEconomicAccounting/HybridEnergy,property=file.pdf.

A hybrid IOT comprises mixed information either in monetary or in physical terms. Starting point is the monetary IOT. For the construction of a specific HIOT on energy monetary data on the use of the different energy carriers were replaced by more adequate physical use data. The approach of an energy related HIOTexp is to disaggregate production processes that are specifically relevant to energy use. For that purpose a number of homogeneous production branches of the IOT were subdivided further: branches related to the extraction or transformation of energy carriers, like coal mining, cookeries and refineries, electricity, gas and water supply as well as some energetically important branches, like chemical industry, manufacturing of non-ferrous metals. The chemical industry was further subdivided in pharmaceutical industry, basic chemical industry and other chemical industry. In a special project that is carried out at present an even more detailed disaggregation of the chemical industry will be provided. Moreover, a further project conducted for calculating indirect imports and exports of raw materials (raw material equivalents), which among others will make available detailed physical supply and use tables for the production and primary processing of raw materials[5]. Another project of the SEEA of the Federal Statistical Office deals with the detailed disaggregation of agriculture branch in IOT[6]. These projects will further improve the calculations in future.

The second point of methodological improvement refers to the calculation of embodied emissions of imports. The input-output approach at the first hand is suitable for the estimation of embodied environmental pressures of products which are manufactured in the domestic economy. That also covers exported goods and services. As imported products are concerned such an estimation – as far it is not based on calculations with the IOT relationships of the country of their origin – can be in principle only carried on the assumption that the domestic production relationships hold also for imported products. As the foreign production techniques can differ significantly from the domestic ones, the results on embodied pressures of a specific imported product can properly only be interpreted as the pressures that were avoided in the domestic economy by the import.

In order to depict the energy use and the carbon dioxide emissions related to the production of imported goods and services more adequately certain entries of the German HIOTexp were substituted by specific information on production processes abroad. The modification refers to a number of energetically highly relevant production processes, like electricity generation and the production of steel, aluminium and celluloses. For that purpose different external information like data from the energy balances for countries with significant exports to Germany was collected on the respective production techniques. Especially electric power and steel play an important role as intermediate goods in the production chain of many imported goods. That is, especially differences in the production techniques of those two product groups tend to have a broad and considerable impact on the energy and emission intensity of many imported goods and services. Moreover a tuning of the results was made with respect to the trade flows in physical terms of the external trade statistic.

The carbon dioxide emission intensity of electricity generation in Germany is higher than for the most important trade partners, due to a comparatively high proportion of brown coal and hard coal as well as a comparatively low share of renewable sources and nuclear fuels. Against that the efficiency factor of power plants as well as the proportion of less carbon intensive fuels developed more favourable in Germany than abroad in the last decade, which tended to result in a stronger de-burdening effect on carbon dioxide emissions for exported than for imported products. However, differences in the development of the energy efficiency of steel production tended to result in a diametrical effect. The energy intensity of steel production of the trade partners started with a higher level, but showed a stronger decrease than in Germany.

The described methodological improvements enhanced the quality of the results presented below considerably compared to earlier calculations.

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5 See: Schoer, Karl: Calculation of direct and indirect material inputs by type of raw material and economic activities, Paper presented at the London Group Meeting, New York, 19 – 21 June 2006, Online-Veröffentlichung, Statistisches Bundesamt, Wiesbaden, 2006
http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Publikationen/Fachveroeffentlichungen/UmweltoekonomischeGesamtrechnungen/CalculationEconomicActivities,property=file.pdf.

6 Thomas Schmidt, Bernhard Osterburg: Aufbau des Berichtsmoduls ´Landwirtschaft und Umwelt´in den Umweltökonomischen Gesamtrechnungen, Abschlussbericht 2005. Bundesforschungsanstalt für Landwirtschaft und Statistisches Bundesamt, Braunschweig und Wiesbaden
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3. Results

3.1 Embodied energy and carbon dioxide emissions of imports and exports

3.1.1 Macroeconomic development

Between 1995 and 2004 the international integration of the German economy increased considerably. Whereas the Gross Domestic Product (GDP) grew price adjusted by 13 % during that period of time the exports (without re-exports) showed an increase of 83 % and the imports (without re-exports) grew by 55 % (see table 1). That development continued also in 2005. Such the globalization process is reflected by a considerable intensification of the German external trade in the last decade.

The exports accounted for 25 % of the total final use in 2004. The imports had a share of 20 %. The external trade surplus in current prices increased from 33 billion EUR in 1995 to 141 billion EUR in 2004. As a result of the substantial increase of the trade surplus the consumption of goods and services – measured as the final domestic use of products – increased by only 7 % (price adjusted), which was appreciable lower than the growth of the production (GDP)

Table 1

Gross Domestic Product, Imports and Exports in monetary and physical units

		Values			Change		
		1995	2000	2004	1995	2000	2004
	Monetary values						
		billion EUR (at current prices)			1995 = 100 (deflated, chain index, ref. year 2000)		
	Gross Domestic Product,	1,848.5	2,062.5	2,207.2	100.0	110.4	113.0
-	Balance: exports - imports	33.0	37.9	141.3	x	x	x
	Exports	428.7	669.8	822.5	100.0	154.9	193.9
	of which.:exports without re-exports	374.6	576.6	696.6	100.0	149.8	182.7
	Imports	395.7	631.9	681.3	100.0	151.8	172.2
	of which: imports without re-exports	340.2	537.9	554.8	100.0	144.5	154.7
=	**Final domestic use**	1,815.5	2,024.6	2,065.9	100.0	109.4	107.4
	Energy consumption						
		PJ			1995 = 100		
	Primary (direct) domestic energy consumption (SNA concept)	14,156	14,213	14,278	100.0	100.4	100.9
	Production	10,245	10,373	10,373	100.0	101.3	101.3
	Private households	3,911	3,839	3,905	100.0	98.2	99.9
-	Balance: embodies energy of exports - embodied energy of imports	-35	293	1,261	x	x	x
	Embodied energy of exports[1)]	5,348	6,865	7,449	100.0	128.4	139.3
	Embodied energy of imports[1)]	5,383	6,572	6,188	100.0	122.1	115.0
=	**Cumulated energy of final domestic use**	14,191	13,920	13,018	100.0	98.1	91.7
	Embodied energy of goods for final domestic use	10,280	10,080	9,113	100.0	98.1	88.6
	Direct energiy consumption of private households	3,911	3,839	3,905	100.0	98.2	99.9
	Memorandum item:						
	Direct exports	1,165	1,715	1,795	100.0	147.3	154.1
	Direct imports	11,007	12,119	12,463	100.0	110.1	113.2
	Balance: direct exports - direct imports	-9,843	-10,404	-10,668	100.0	105.7	108.4
	Balance: direct and embodied energy of exports - direct and embodied energy of imports	-9,878	-10,111	-9,407	100.0	102.4	95.2
	CO_2-emissions						
		million tonnes			1995 = 100		
	Direct domestic CO_2-emissions (SNA-concept)	938.0	901.4	903.2	100.0	96.1	96.3
	Production	718.2	693.0	699.7	100.0	96.5	97.4
	Private households	219.8	208.4	203.5	100.0	94.8	92.6
-	Balance: embodied CO_2-emission of exports - embodied CO_2-emission of imports	24.3	46.6	103.8	x	x	x
	Embodied CO_2-emission of exports[1)]	333.7	402.7	441.2	100.0	120.7	132.2
	Embodied CO_2-emission of imports[1)]	309.5	356.1	337.4	100.0	115.1	109.0
=	**Cumulated CO_2-emissions of final domestic use**	913.7	854.8	799.4	100.0	93.5	87.5
	Embodied CO_2-emissions of final domestic use	693.9	646.4	595.9	100.0	93.1	85.9
	Direct CO_2-emissions of private households	219.8	208.4	203.5	100.0	94.8	92.6

1) Without re-exports.

The domestic direct energy use (primary energy use) increased in the period 1995 to 2004 by rather 1 % up to 14,300 Petajoules (PJ). Such the growth of energy consumption was below the growth of GDP. That lead to an increase of the energy productivity by 10 %. The direct domestic energy use (consumption of primary energy) shows how much energy was consumed by the production activities and additionally by the (direct) energy consumption of private household.

Due to the strong increase of external trade the growth of the embodied energy consumption of imported and exported products was considerably higher than the domestic energy use. In 2004 energy embodied in exports accounted for 7,400 PJ. The energy content of exports exceeded the embodied energy of imports by nearly 1,300 PJ. The embodied energy of exports increased by 39 % since 1995 and the embodied energy of imports grew by 15 %. As a result of the growing export surplus of embodied energy the embodied energy of domestic consumption, which is measured by the cumulated energy use of the final domestic use of products, fell by a little more than 8 % between 1995 and 2004.

Such the development of energy use shows a considerable different tendency for the consumption perspective compared to the production perspective. The use of energy for the production of the goods and services that where consumed domestically decreased, whereas the energy consumption for manufacturing the exported products increased substantially. Therewith it can be stated that a considerable and growing proportion of the direct domestic energy consumption was used for the production of exported products which benefited the final use in the rest of the world.

The difference in the change of primary energy use and embodied energy of domestic consumption is to a certain extent simply mirroring the difference between GDP and domestic final use.

When looking at the external trade balance of embodied energy of German imports and exports it has to be regarded, that Germany is strongly dependant on direct energy imports. The share of direct imports of energy carriers in the total primary energy consumption increased from 78 % in 1995 to 87 % in 2004. The balance of direct energy imports over exports increased during the period of observation from 9,800 PJ to 10,700 PJ. However, if one also includes the international trade flows of embodied energy still a considerable access of the imports over the exports of 9,400 PJ is obtained for 2004, but it is remarkable that in that perspective the deficit decreased by nearly 500 PJ since 1995.

In the OECD study that was mentioned at the outset of this paper the expectation was put forward that after 1995 there would rather be a tendency of relocating energy and emission intensive production activities from industrialized countries to threshold countries. For energy that presumption is clearly refuted by the data presented for in Germany referring to the period 1995 to 2004.

That result for energy is widely confirmed by looking at the CO_2 related balance between embodied imports and exports. That is not surprising as the CO_2-emissions predominantly result from combustion of fossil energy carriers. Differences between the development of energy consumption and CO_2-emissions can mainly be explained by a change in the mix of energy carriers, like an increase of emission free renewable energy sources.

In 2004 the share of embodied CO_2-emissions of exports on the total final use (1,037 million tonnes) in Germany was 43 %. The share of the embodied imports amounted to 33 %.

The direct domestic CO_2-emissions decreased between 1995 and 2004 by nearly 4 %. The embodied emissions of exports rose by 32 %. The embodied emissions of imports grew by 9 %. The growing export surplus resulted in a decline of the cumulated CO_2-emissions of the final domestic use by 12.5 %. That is, the CO_2-emissions according to the consumption perspective showed a decrease that was nearly 9 percent points higher than of the emissions according to the production perspective.

The energy and emission intensities – measured as the relationship between energy consumption or CO_2-emissions and the respective price adjusted monetary reference figures – generally decreased in the period 1995 to 2004 (table 2). The direct domestic energy use (primary energy use) per GDP went down by 11 %. The respective CO_2-intensity decreased by -15 %. Compared to that the CO_2-intensities of imports (-28 %) and exports (-29 %) decreased even stronger.

Table 2

Intensity of primary energy consumption and CO_2-emissions

	Values			Change		
	1995	2000	2004	1995	2000	2004
Energy						
	PJ / billion EUR			1995 = 100 (deflated, chain index, ref. year 2000)		
Primary domestic energy consumption per GDP	7.7	6.9	6.5	100.0	90.9	89.3
Embodied energy of exports per value unit	14.3	11.9	10.7	100.0	85.7	76.3
Embodied energy of imports per value unit	15.8	12.2	11.2	100.0	84.5	74.3
Cumulated energy of final domestic use per value unit	7.8	6.9	6.3	100.0	89.7	85.4
Of which: embodied energy of final domestic use per value unit	5.7	5.0	4.4	100.0	89.7	82.5
CO_2-emissions						
	Tonnes / 1,000 EUR			1995 = 100 (deflated, chain index, ref. year 2000)		
Direct domestic CO_2-emissions per GDP	0.51	0.44	0.41	100.0	87.0	85.2
Embodied CO_2-emission of exports per value unit	0.89	0.70	0.63	100.0	80.5	72.4
Embodied CO_2-emission of imports per value unit	0.91	0.66	0.61	100.0	79.6	70.5
Cumulated CO_2-emissions of final domestic use per value unit	0.50	0.42	0.39	100.0	85.5	81.5
Of which: embodied CO_2-emissions of final domestic use per valu unit	0.38	0.32	0.29	100.0	85.2	80.0

The change in the macroeconomic emission intensity goes back to changes in the intensities of the individual product groups as well as to structural changes (change of the share of emission intensive product groups compared to the share of less emission intensive product groups). A decrease of the emission intensity of individual product groups can have different reasons:

- Improvement of the direct intensity of the production branch which manufactures that product by introduction of energy or emission saving production techniques
- Improvement of the direct intensity of the respective production branch by a shift in the composition and quality of the products within that product group
- Diminishing the intensity of intermediary products used as an input in the product group either by substituting them by less emission intensive intermediary products or by a decrease of the emission intensity in earlier steps of the production chain.

The following description in the next section concentrates on analysing the background for the reasons for the change of embodied CO_2-emissions of imports and exports.

3.1.2 Decomposition analysis of embodied carbon dioxide emissions for imports and exports

The embodied CO_2-emissions of exports increased in the period 1995 to 2004 by 107 million tonnes. The rise of the import related emissions was considerably lower with only 28 million tonnes. In the following the substantial influencing factors for the development for both variables are quantified by using the mathematical tool of decomposition analysis. That tool can be applied for decomposing the change of a variable, like the embodied exports of CO_2-emissions, arithmetically into influencing factors. Each of the effects isolated by that approach shows how the emissions would have changed, if only that individual factor had changed. The individual effects may have a positive or negative sign and negative effects may be compensated by positive effects. For the interpretation of the results some limitations that are inherent to this type of analysis should be regarded. Especially the influencing factors are defined externally and it is assumed that the individual factors are independent from each other.

The decomposition analysis carried out for embodied CO_2-emissions of imports and exports considers the following influencing factors:

- **Scale effect**: price adjusted development of the total value of imports or exports
- **Structural effect**: change of the product structure (price adjusted)
- **Intensity effect**: change of the emission intensity (CO_2-emissions per value unit (price adjusted) of the individual product groups

The availability of integrated data on the value of the imports and exports as well as the related embodied CO_2-emissions in a detailed breakdown by product groups is a precondition for carrying out those calculations by including a structural effect. Those data are provided by the SEEA.

Figure 1 shows that the total increase of the embodied CO_2-emissions of exports by 107 million tonnes in the period 1995 to 2004 is the result of burdening and de-burdening influences. The scale effect amounted to +233 million tonnes. Therewith this factor had a considerable burdening influence. The effect of the increased level of exports was partly compensated by the de-burdening influence of the structural effect (36 million tonnes) and of the intensity effect amounting to 89 million tonnes.

Figure 1

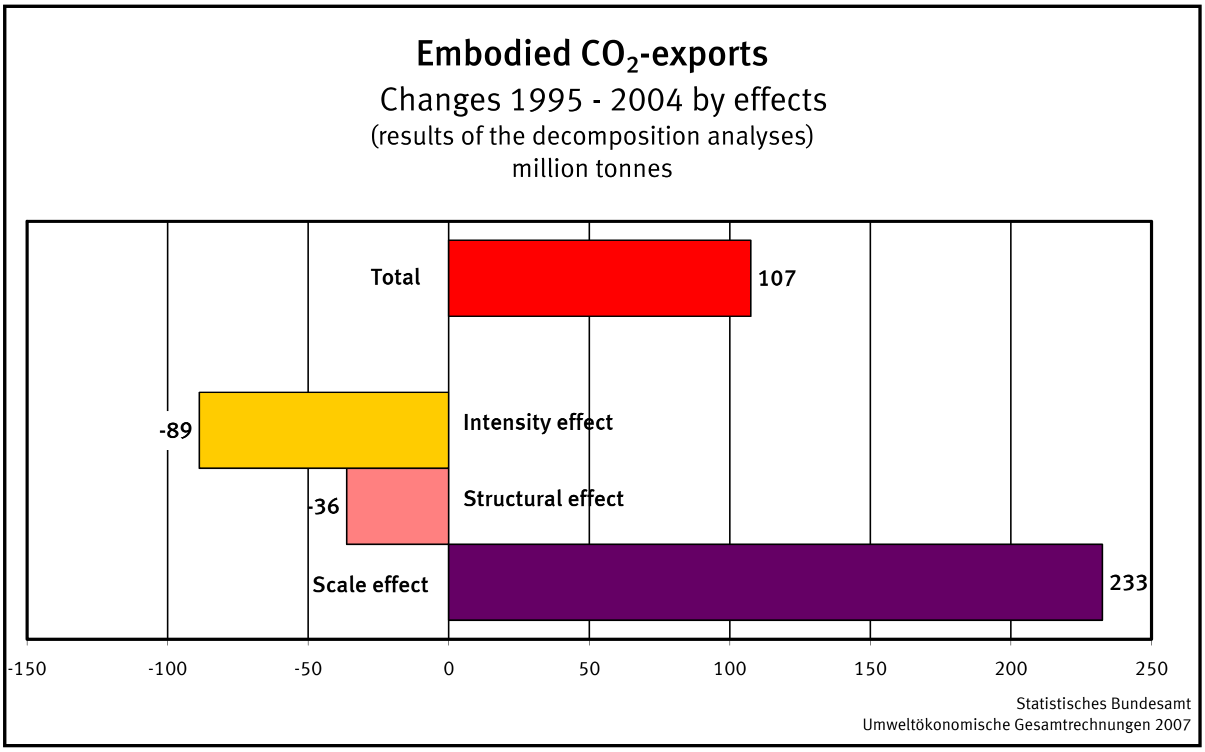


Figure 2 shows for comparison the components for the rise of the import related CO_2-emissions by 28 million tonnes. The price adjusted increase of the total value of imports (scale effect) had a burdening influence of 146 million tonnes. That effect was considerably alleviated by an antagonizing structural effect (-35 million tonnes) and a de-burdening intensity effect of 83 million tonnes.

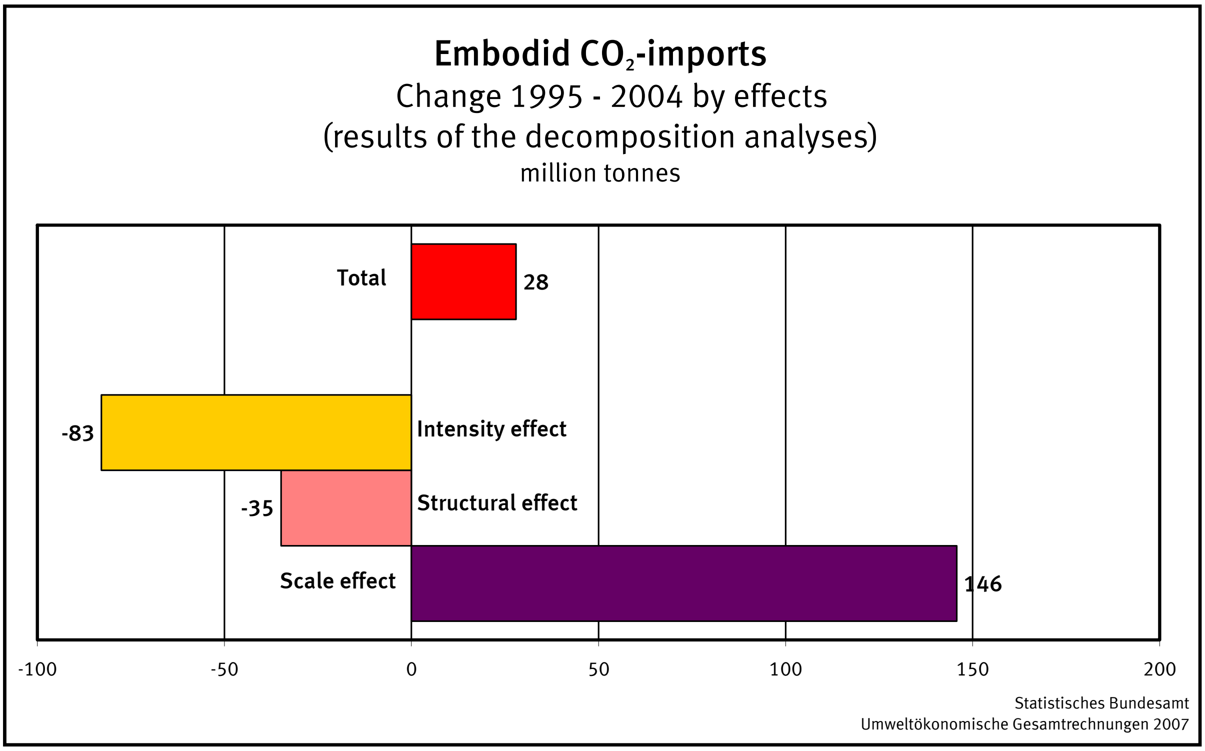
A comparison of the magnitude of the respective influencing factors for imports and exports shows the following picture:

- The burdening scale effect for exports exceeded the scale effect for imports by 87 million tonnes.
- The de-burdening structural effect was nearly equal for imports and exports.
- The de-burdening intensity effect was about 6 million tonnes higher for exports than for import.

Therefore the results for the scale effect show that the growth of the export surplus for embodied CO_2-emissions can be explained nearly completely by the increase of the monetary export surplus.

The negative sign of the structural effect for embodied imports and exports shows that the share of emission intensive products decreased. As far as the exports are concerned that would be in accordance with the above mentioned “relocating hypothesis” of shifting emission intensive production activities to the rest of the world. However, in return according to that hypothesis for the imports there should be expected rather a burdening effect, i.e. a growing emission intensity of the imports. At least the intensity effect should be significantly less de-burdening for imports than for exports. The actual development with rather equal de-burdening structural effects for imports and exports therefore clearly contradicts the “relocation hypothesis”.

Figure 2



The emission intensities went down considerably for imports and exports, but slightly more pronounced for exports. Insofar the increase of the export surplus was somewhat retarded.

Both, the decrease of the emission intensities as well as the shift to less emission intensive demand structures might have been boosted by the world wide strong increase of the energy prices during the period of observation. With regard to the German imports the price for crude oil rose by 136 % between 1995 and 2004 against an increase of the total price index for imports by only 5 %.

3.1.3 Embodied CO_2-emissions of imports and exports by product groups

The summary results of the decomposition analysis elucidate the most important influencing factors that where behind the development of the export surplus for CO_2. In this section the contribution of the individual product groups to the change of the export surplus will be analysed for further illustration of the results of the decomposition analysis.

The average CO_2-intensity of exports – measured as embodied CO_2-emissions per value unit – was 0.63 tonnes per 1,000 EUR (imports: 0.61 tonnes per 1,000 EUR) in 2004. The average intensity of externally traded goods and services was considerably higher than the average for the products for final domestic use with 0.29 tonnes per 1,000 EUR (table 3). The difference is attributed to the fact that the basket of commodities for external trade is dominated by goods against a dominance of services for domestic consumption. For German exports the share of goods stood at 92 % in 2004. Thereof vehicles (18 %), machinery (13 %) and chemicals (8 %) alone accounted for about two fifths.

The increase of the export surplus of embodied CO_2-emissions by 79.5 million tonnes between 1995 and 2004 is closely related to the contribution of product groups with high or medium emission intensity. For table 3 the underlying 73 homogeneous product groups were assigned to the categories high, medium and low emission intensity according to the CO_2-intensity of the exports. The average intensity of final domestic use was taken as a yardstick for classifying the product groups.

In relation to the total value of exports in 2004 the products with high emission intensity had a share of 20 %. That is, this category of good played a quite important role for the German portfolio of exported goods and services. The portion of products with medium emission intensity came to 61 %. For products with low intensity the share amounted to 19 %.

In 2004 the German economy showed an export surplus of 53.8 million tonnes for products with high emission intensity. For products with medium intensity the surplus amounted to 66.3 million tonnes. Against that the goods and services with low intensity showed a deficit of 16.3 million tonnes. As a result here total export surplus was 103.8 million tonnes.

The products with high emission intensity contributed 40.0 million tonnes to the total increase of the export surplus of 79.5 million tonnes between 1995 and 2004. The highest contributions in this category of products was rendered by the product groups „iron and steel“ with 15.1 million tonnes, followed by „petroleum products” (8.0 million tonnes), „electricity“ (5.3 million tonnes), „construction materials“ (4.4 million tonnes), „air transport services“ (1.5 million tonnes), „basic chemicals“ (1.2 million tonnes) and „pulp and paper“ (1.1 million tonnes). The considerable increase of the CO_2-export surplus for iron and steel can mainly be explained by an increase of the monetary surplus (price adjusted). However that effect was intensified by a substantial convergence of the foreign emission intensities to the lower German level. This improvement of emission intensities was reached among others through the increasing implementation of the continuous casting method by many important trade partners during the last decade, whereas that approach had been implemented in Germany rather exhaustively already in the mid nineties. The development for construction materials was strongly influenced by a distinct increase of cement exports accompanied by a decrease of the imports. The downturn of the domestic construction activities should have played an important role for that development.

Table 3

Embodied CO_2-emissions by homogeneous product groups

million tonnes

CPA	Homogeneous product groups	Exports			Imports			Exports minus Imports			Memo.: CO_2-intensity of exports 2004 tons per 1,000 EUR
		1995	2004	Change 2004 to 1995	1995	2004	Change 2004 to 1995	1995	2004	Change 2004 to 1995	
	Products with high CO_2-intensity	**185.4**	**230.4**	**45.0**	**171.5**	**176.6**	**5.1**	**13.8**	**53.8**	**40.0**	
27.1-3	Basic iron, steel and tubes, semi-finished products made from steel	52.2	63.6	11.4	47.3	43.6	-3.7	4.9	20.0	15.1	3.16
23.2	Refined petroleum products	5.1	8.3	3.2	16.0	11.2	-4.8	-10.9	-2.9	8.0	0.84
40.1	Electricity	22.1	28.9	6.8	18.0	19.6	1.6	4.0	9.3	5.3	4.55
26.2-9	Non-refractory ceramic goods, treated stone and earths	5.8	9.5	3.7	7.6	6.9	-0.8	-1.8	2.6	4.4	1.97
62	Air transport services	7.7	9.0	1.4	6.1	6.0	-0.1	1.6	3.1	1.5	1.71
24.1	Basic chemicals	40.6	47.7	7.1	26.6	32.5	5.9	14.0	15.2	1.2	1.38
21.1/9	Pulp, paper and paper products	11.0	12.0	1.0	13.7	13.5	-0.1	-2.6	-1.5	1.1	1.44
	Other 1)	40.9	51.3	10.4	36.3	43.3	7.1	4.6	8.0	3.3	
	Products with medium CO_2-intensity	**133.2**	**187.4**	**54.2**	**102.2**	**121.1**	**18.9**	**31.0**	**66.3**	**35.3**	
34	Motor vehicles, trailers and semi-trailers	30.8	56.9	26.1	14.7	23.6	8.8	16.1	33.4	17.3	0.44
29	Machinery	28.4	33.8	5.4	9.3	11.2	1.8	19.1	22.7	3.6	0.37
25.2/9	Plastic products	7.3	11.9	4.6	4.3	5.6	1.3	2.9	6.3	3.4	0.69
28	Fabricated metal products	10.8	15.0	4.2	7.2	8.0	0.8	3.6	7.0	3.3	0.67
	Other 2)	55.8	69.7	13.9	66.6	72.7	6.1	-10.8	-3.0	7.8	
	Products with low CO_2-intensity	**15.2**	**23.5**	**8.2**	**35.7**	**39.7**	**4.0**	**-20.5**	**-16.3**	**4.2**	
11	Crude petroleum and natural gas;	0.1	0.1	0.0	22.4	19.8	-2.6	-22.3	-19.7	2.6	0.10
51	Wholesale trade and commission trade	4.1	6.6	2.5	0.4	0.5	0.1	3.7	6.1	2.4	0.16
33	Medical, precision and optical instruments, watches and clocks	3.6	5.8	2.2	2.1	2.8	0.7	1.4	3.0	1.5	0.26
22.1	Publishing, printed matter and record media	0.9	1.7	0.8	0.5	0.7	0.2	0.4	1.0	0.6	0.22
	Other 3)	6.6	9.3	2.6	10.3	15.9	5.6	-3.7	-6.7	-3.0	
	Total	**333.7**	**441.2**	**107.5**	**309.5**	**337.4**	**28.0**	**24.3**	**103.8**	**79.5**	**0.63**
	Memo item: final domestic use	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**0.29**

1) CPA 27.5, 27.4R, 24 R, 27.42, 12/13/14, 26.1, 60.1, 40.3, 23.3, 40.2, 23.1, 21.2
2) CPA 20, 15.1-8, 18, 01, 22.2+3, 17, 24.4, 19, 31, 36, 25.1, 45.1/2, 32, 05, 15.9, 63, 60.2/3, 61, 35
3) CPA 55, 74, 50, 75.1/2, 72, 10.2/3, 16, 66/67, 02, 45.3-5, 37, 41, 71, 75.3, 80, 85, 91, 52, 93/95, 64, 70, 73, 92, 65, 30, 10.1

The general increase of export surpluses for product groups with high energy and emission intensities shows that those industries widely succeeded in maintaining their international competitiveness during the last decade. Increased efforts for improving energy efficiency and high recycling rates for iron, glass, paper and the intensified energetic use of waste by incineration, e. g. in the cement industry, may have played a role.

For products with medium emission intensity the CO_2-export surplus increased by 35.3 million tonnes to 66.3 million tonnes for products from 1995 to 2004. The highest contribution to the export surplus in that category of products was provided by the product group „Motor vehicles“ (+17.3 million tonnes), followed by „Machinery“ (+3.6 million tonnes), „Plastic products“ (+3.44 million tonnes) and „Fabricated metal products“ (+3.3 million tonnes).

For the product category with low emission intensity the export deficit decreased by 4.2 million tonnes.

3.2 Environmental pressures by the transport of imported and exported goods

Transport activities may cause considerable environmental pressures by using area and eco-systems, creating noise pollution and due to consumption of fossil energy carriers and different types of air emissions. Therefore the German national strategy on sustainable development has formulated among others the goal of decoupling economic growth and goods transport performance.

The statistical indicator of the strategy on goods transport intensity serves the purpose of performance controlling[7]. However, that indicator only refers to the goods transport performance on the national territory. That means the considerable activities for transporting the German import and export goods outside the national territory are excluded. As the existing indicator can reflect the growing transport requirements caused by the increasing integration of the German economy into the world market only in an insufficient manner, it has to be supplemented by appropriate data.

In response to that requirement a new module on goods transport was developed in the framework of the German SEEA in order to close the data gap in a systematic manner. The new module provides comprehensive information on the transport of German import and export goods outside the national territory. For the period 1995 to 2005 data are calculated for the variables transported goods (tonnes), goods transport performance (tonne kilometres), energy use and carbon dioxide emissions in a breakdown by mode of transport (and energy carriers), product groups and country groups. Most important data sources for the calculations are the foreign trade statistic on imports and exports in physical units and type of good, country and mode of transport. In addition results of the national transport statistic about cross-border transports by land, sea and air are used as well as information from various data banks on transport distances, energy coefficients by mode of transport and carbon dioxide emission coefficients by type of energy carrier.

Table 4 shows first preliminary aggregated results of the calculations. The direct goods transport performance outside the German national territory - which covers for imports the transport ex-factory to the German border and for exports the transport from the German border to the recipient - amounted for imports and exports together to 2,726 billion tonne kilometres in 2005. Thereof the imports accounted for 2,023 billion tonne kilometres. The exports contributed 703 billion tonne kilometres. Compared to the total transport performance on the national territory, which was 581 billion tonne kilometres in 2005, the performance outside the national territory was almost four and a half times higher. The results demonstrate that the major part of the transport activities that are caused by the German economy take place outside the national territory.

Under the perspective of global responsibility of the domestic consumers at least the transport performance used for transporting the imports ex-factory to the national border should be added to the domestic transport performance. For both together that would yield roughly a magnitude[8] of 2,600 billion tonne kilometres.

The freight tonne kilometres outside the territory for the transport of exported goods increased by 36 % in the period 1995 to 2005. The performance for imported goods rose by 25 %.

The direct energy use (including transformation losses by the manufacturing of fuels or by generating the electric power from primary energy carriers) for the transport of external trade goods outside the national territory amounted to 855 PJ in 2005. Thereof the exports accounted for 246 PJ and the imports for 610 PJ. In the period 1995 to 2005 the energy use for the transport of exported and imported goods increased by 44 %.

[7] See: Federal Statistical Offce: Sustainable Development in Germany, Indicator Report 2006S, Wiesbaden 2007, Chapter on mobility.
[8] It has to be noted, that the calculated figure does conceptually not fit fully to the term final domestic use of the SNA. Major differences result from the transit transport and the transport of exported goods from the factory to the border. At present the conceptual differences cannot be quantified exactly. But those figures will be calculated in the course of the planned project on “domestic goods transport from the use perspective”.

Table 4

Transport of imported and exported goods outside the national territory				
	1995	2004	2005	Change 2005 against 1995 %
Value billionn EUR (at current prices)				adjusted prices
Exports	428.7	822.5	890.8	107.8
Imports	395.7	681.3	745.6	84.9
Sum	824.4	1,503.8	1,636.3	96.6
Memo item: Tot. Supply of products	3,624.5	4,711.1	...	...
Transported goods[2] million tonnes				
Exports	245	381	390	59.1
Imports	491	595	599	22.1
Sum	736	976	989	34.4
Memo item: transport of goods on the national territory[1]	4,016	3,720	3731	-7.1
Material intensity of transported products[2] tonnes / 1,000 EUR				
Exports	0.57	0.46	0.44	-23.5
Imports	1.24	0.87	0.80	-34.0
Sum	0.89	0.65	0.60	-31.6
Memo item: transport of goods on the national territory[1]	1.11	0.79	...	...
Transport performance[2] billionn tonne kilometre				
Exports	535	686	728	36.1
Imports	1,623	2,064	2,046	26.1
Sum	2,158	2,750	2,774	28.6
Memo item: transport of goods on the national territory[1]	431	564	581	34.8
Memo item: transport of goods on and outside the national territory[1]	2,588	3,315	3,355	29.6
Average distance per unit of transported goods kilometer				
Exports	2,179	1,799	1,865	-14.4
Imports	3,306	3,470	3,415	3.3
Sum	2,931	2,817	2,804	-4.3
Memo item: transport of goods on the national territory[1]	107	152	156	45.1
Memo item: transport of goods on and outside the national territory[1]	644	891	899	39.5
Primary energy consumption[3] petajoule				
Exports	163	250	252	54.4
Imports	425	571	615	44.9
Sum	588	821	868	47.6
Energy intensity of transport kilojoule per tonne kilometres				
Exports	306	365	347	13.4
Imports	262	277	301	14.9
Sum	273	299	313	14.8
CO_2-emissions[3] million tonnes				
Exports	12.3	18.6	18.8	53.1
Imports	30.0	39.8	42.5	41.8
Sum	42.2	58.4	61.3	45.1
Memo item: transport of goods on the national territory[1)4)]	50.2	56.2	56.4	12.4

1) Incl. transit, ex pipelines within the territory.

2) Incl.carrying cases.

3) Incl. energy losses from transformation of energy.

4) Source: road transport, inland navigation, rail transport (Federal Environment Agency), air traffic, pipelines (estimation: Federal Statistical Office).

The direct carbon dioxide emissions (including transformation losses) for the transport of imported and exported goods outside the national territory amounted to 61 million tonnes in 2005. The emissions outside the territory for 2005 surpassed the respective value for domestic transport (56 million tonnes). Also the increase of the emissions during the period 1995 to 2005 was with 42 % outside the territory considerably higher than on the territory (12 %).

These results on the transport outside the territory make clear that the usually applied indicators that cover the transport activities on the territory only, depict the size and the development of transport activities that are caused by the domestic economy in an insufficient manner.

Table 5 shows results on goods transport by mode of transport. In 2005 maritime navigation accounted for 73 % of total goods transport performance for imports. Pipelines (oil and gas) had a share of nearly 15 %. The shares of road transport and rail transport came to about 5 % each. The energy consumption for the transport of imported goods shows a different picture: Due to considerably different energy intensities pipelines accounted 33 % of the energy consumption. Maritime navigation had a share of 30 % and road traffic stood at 16 %. Maritime navigation had the lowest energy intensity with 124 KJ per tonne kilometre. The intensity for road transport was about seven times higher than for sea transport. The intensity for air traffic exceeded the ratio for maritime navigation by 90 times.

For exports the goods transport performance of maritime navigation plays a dominant role with a share of nearly 80 %. For energy the rather high share of air traffic amounting to 31 % is remarkable compared to its rather low importance in terms of tonne kilometres (1%).

As far as emissions of carbon dioxide are concerned the relation between the modes of transport are very similar to energy.

Table 5

Transport of imported and exported goods outside the national territory by mode of transport 2005

Mode of transport	Transport performance	Energy consumption[1)]	CO_2 emissions[1)]	Memo item: energy consumption per transport performance
	Share %			Kilojoule per tonne kilometre
Exports				
Total	**100.0**	**100.0**	**100.0**	349
Rail transport	3.3	3.4	3.3	359
Road transport	13.5	34.0	33.7	879
Inland navigation	1.8	2.3	2.3	441
Maritime navigation	79.6	27.2	28.5	119
Air traffic	1.0	31.3	30.8	10,653
Pipelines	0.8	1.7	1.4	801
Imports				
Total	**100.0**	**100.0**	**100.0**	301
Rail transport	5.1	6.4	6.7	374
Road transport	5.3	15.8	16.7	888
Inland navigation	1.7	2.5	2.6	433
Maritime navigation	72.8	29.8	33.4	124
Air traffic	0.3	12.3	13.1	11,102
Pipelines	14.7	33.3	27.4	681

1) incl energy losses from transformation of energy

4. Summary of results and conclusions

Due to the increasing integration of national economies into the world market the proportion of goods and services not being consumed in the country of production is rising. That is, a growing spatial divergence of production and consumption can be observed. In terms of environmental pressures this increasing divergence may lead to a situation were the pressures linked with the production activities of a country differ considerably from the pressures that are embodied in the products consumed in that country.

At least for Germany the results on energy and carbon dioxide emissions presented in this report show considerably different trends for the results based on the production perspective on the one hand and the consumption perspective on the other. The embodied environmental pressures related to the imported and exported product do not balance. Above all the German export surplus of embodied carbon dioxide increased by nearly 80 million tonnes between 1995 and 2004. As a consequence the embodied CO_2-emissions of final domestic use (consumption perspective) decreased by 12.5 %. In contrast production related emissions dropped only by 4 % (production perspective).

A decomposition of the trends of embodied CO_2-emissions of imports and exports into the influencing factors namely scale, structure and intensity using the decomposition analysis shows that the increase of the German trade surplus of embodied CO_2-emissions is caused mainly by the rise of the German export surplus (scale effect). The relieving influence of the structural effect with a decrease of the share of emission intensive products was nearly equal for imports and exports. That is, there was no overall tendency of relocating emission intensive production activities from Germany to the rest of the world. The influence of a decrease of the emission intensity of products was rather equal for imports and exports.

Another important result refers to goods transport performance. It is shown that the major part of the transport activities caused by the German economy takes place outside the national territory. The freight tonne kilometres for transporting the German import and export goods outside the national territory amounted to 2,726 billion tonne kilometre in 2005. That is almost four and a half times higher than the total goods transport performance on the territory (581 billion tonne kilometre).

These results show that the development of embodied environmental pressures of external trade flows have to be monitored by a systematic statistical approach on a regular basis, with the aim of at least supplementing the currently used indicators.

The methodological frame and the data of the System of Environmental-Economic Accounting (SEEA) offer the opportunity of generating information on embodied environmental pressures preferably by an input-output approach.

The results on energy and carbon dioxide presented in this study are based on a methodologically improved input-output approach. Among other a so-called expanded hybrid input-output table (HIOTexp) was applied, which was tailor-made for the energy calculations.

Comparable EU-wide data on environmental pressures from the consumption perspective could be quite useful in the political context, e.g. for the discussion between the member countries on burden sharing of green house gas reduction.

As a precondition for launching those EU-wide calculations on energy and air emission in a co-ordinated and comparable manner all member states should strengthen the regular and frequent calculation of IOT and of SEEA results on energy and air emission in a detailed breakdown by branches (NAMEA format). In order to achieve a high quality of estimates the compilation of HIOTexp should be strived for.

Moreover, efforts should be made to carry out those calculations on a regular basis also for other industrialised and threshold countries. The calculations should be done preferably with a uniform method and by using harmonized classifications, as only that might guarantee that a coherent description of the environmental pressures from the consumption perspective is obtained.

The national calculations on embodied environmental pressures of imports are based at least partly on the assumption that the production relationships of the country of delivery are identical with the country of destination. The national calculations on imports could be improved and harmonised considerably by using results from input-output analysis from the countries of delivery. The mutual use of respective data could be supported by establishing a data bank for country and product specific coefficients on embodied environmental pressure of product groups.

The following measures are suggested for improving the statistical coverage of environmental effects of globalization at the EU-level:

- Regular compilation of monetary IOT in EU member countries
- Regular compilation of results on energy and air emissions in a detailed breakdown by economic branches in the framework of SEEA

- Regular compilation of specific expanded hybrid IOT as a basis for calculation of embodied environmental pressures
- Regular calculation of embodied environmental pressures from exports and imports in the EU member states and on EU level. Eurostat could take at least a coordinating function by establishing and operating a coefficient data bank
- Inclusion of further industrialised and threshold countries into the compilations. OECD or UNSD could play a role in that matter.