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DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
STATISTICS DIVISION
UNITED NATIONS

10th London Group on Environmental Accounting
New York, 19-21 June 2006
United Nations Secretariat Building, Conference Room C

The German sectoral reporting module on transport and environment

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London Group Meeting – New York, 19-21 June 2006

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Overview

Summary

1 Mobility, transport and sustainability

2 Goals of the project

3 Database: Methodology and results

3.1 As to the methodology

3.2 The data base

4 Transport-relevant shares of selected environmental burdens

5 The environmental efficiency of transport

6 Analysis of the influence of environmental efficiency, of the structure of transport and of transport volume on the transport-related environmental burdens

7 Transport performance, economic growth and intertwining of production

8 Econometric modelling of environmental-economic effects of transport

9 Conclusions

List of references

The German sectoral reporting module on transport and environment*

Summary

In this paper the German sectoral reporting module on transport an environment is presented. The module is fully integrated into the system of environmental-economic accounting (EEA). A wide range of subjects is covered by the module under an environmental-economic perspective, like the transport infrastructure, the production of transport vehicles, transport related taxes as well as the production and the use of transport services. This paper is confined to presenting the method, the data and some analysis with regard to the transport services. The project can be seen as a further methodological development of the SEEA with special stress on the transport related hybrid description of environmental economic flows. The general aim of sectoral modules is to enhance the standard data set of the EEA in order to provide more detailed integrated accounting data on issues that are especially policy relevant.

The transport activities can be depicted from two different views, the production perspective (who produces the transport services?) ore the use perspective ((who uses the transport services?). Data are provided for transport variables, like kilometres driven and transport performance as well as for a number of environmental variables, like transport related energy use, air emissions and land use.

For the use perspective so far only some general data are available. The calculation of data, which show the allocation of the goods transport to the using economic activities in a detailed breakdown are planned for the next time. However for the production perspective the data are provided in a detailed disaggregation by branches and final use activities according to the concepts and definitions of the environmental-economic accounting framework.

The analytical approaches applied presented in this paper range from just calculating intensity ratios by combining physical and monetary information, over decomposition and input-output analysis to econometric modelling.

* Acknowledgement: This paper is mainly based on a project report by Walther Adler: Integrated environmental economic analysis of the transport sector, including the most important sustainability dimensions, Federal Statistical Office Germany, Wiesbaden 2005. The project was co-financed by Eurostat.

1 Mobility, transport and sustainability

Mobility is of fundamental importance for an economy and society that are based on the division of labour and global networks. Efficient, affordable transport is a major factor in international competition, and serves to further the flexibility of the factor labour. Participation in mobility within society is a prerequisite for both economic and personal freedom of movement, and ultimately enhances quality of life. A measurable expression of mobility is *transport*, meaning the motorised transportation of people and freight over land and by air.

In addition to its high socio-economic status, transport however also has special environmental relevance. The burdens imposed on the environment by transport activities and the transport infrastructure include, firstly, the environmental burdens caused by transport activities, such as the consumption of non-renewable fuels and the emissions of various pollutants, as well as noise. Secondly, the manufacture of vehicles, as well as the construction and maintenance of the transport infrastructure, leads to considerable consumption of resources. Added to this is the refuse problem related to vehicle disposal. Finally, the burdens on area and on soil caused by land use and by the cutting up of the landscape that is required for transport infrastructure needs to be pointed out, as well as by toxic contamination with operating fluids.

Because of their significance for economic, environmental and social elements, an intensive debate is hence underway on trends in transport in terms of sustainability at both national and international level.

At the national level, as per the order of the Federal Government, and at the recommendation of the Sustainability Council, "21 indicators for the 21st century" have quantified the German Sustainability Strategy since April 2002. Topic No. 11, entitled "Mobility", includes the two indicators "Transport intensity" (sub-divided into passenger and freight transport) as well as "Share of freight transport capacity accounted for by railway"; both are provided with quantitative goals. In the meantime, trends in the share of inland water transport are also being observed. Furthermore, the topic "Securing mobility – protecting the environment" has been defined as one of seven priority fields of action within sustainable development.[1] In November 2004, the Federal Government submitted the first monitoring of its Sustainability Strategy in the shape of the Progress Report 2004. In addition to the results of the public consultation process implemented in spring and summer 2004, this report also took up the conclusions of the Council for Sustainable Development from the "Sustainability and Society" dialogue, published under the title "Taking aim at Sustainability".[2]

There is a need to provide an adequate integrated data basis for these indicators, providing not only "naked" figures, but also supporting and including more profound analyses. The following reasons support this:

1. The indicator systems mentioned are not exhaustive as to the subordinate goals, and gaps remain. If one takes seriously calls for reporting both on sustainable development and on integration of environmental concerns in the individual sectoral policies, a fundamental need arises for a description of the sector-specific contribution to all sustainability goals and indicators touched on by the sector. The transport sector for instance is of major significance not only in the topical area of transport/mobility, but for instance also in the areas of climate protection, protection of resources or land use. These contributions also need to be described.

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[1] More information is available on http://www.nachhaltigkeitsrat.de/n_strategy/strategy_2002/index.html.
[2] For details, see comprehensive report at http://www.nachhaltigkeitsrat.de/n_strategy/strategy_2004/index.html.

2. Sustainability policy must not satisfy itself with disconnected observation of the individual indicators. Sustainability policy demands integration of the various policy areas, meaning the interdependencies of the indicators, and special attention must be attached to the so-called "interlinkages".
3. In essence, indicators primarily serve the purpose of communication and progress monitoring. The formulation of political measures, by contrast, requires more detailed analyses, the data requirements of which are much more comprehensive and detailed than those to ascertain comparatively global indicators. In addition to these dry benchmarks, therefore, further, interlinked analyses are indispensable, which are subject not only to degrees of goal achievement and change over time, but also reveal cause-and-effect relationships and where possible permit future trends to be estimated.

2 Goals of the project

The sectoral reporting module on transport an environment presented in this paper is fully integrated into the German system of environmental-economic accounting (EEA). A wide range of subjects is covered by the module under an environmental-economic perspective, like the transport infrastructure, the production of transport vehicles, transport related taxes as well as the production and the use of transport services. This paper is confined to presenting the method, the data and some analysis with regard to the transport services.

The project can be seen as a further methodological development of the SEEA with special stress on the transport related hybrid description of environmental economic flows. Other EEA sectoral reporting modules that have been prepared or are under preparation in the German Federal Statistical Office are modules on agriculture and environment, forestry and environment as well as private households and environment. The general aim of those modules is to enhance the standard data set of the EEA in order to provide more detailed integrated accounting data on issues that are especially policy relevant. The main reference point is to support the policy on sustainable development (SD) by an integrated data set, as policy on SD by definition requires a holistic approach that tries to balance the conflicting goals of different topics.

The transport related headline indicators of the German Sustainability Strategy are “transport intensity” (measured as the ratio between goods transport or passenger transport performance to Gross Domestic Product) and the share of railway transport to total goods transport performance.

However there are strong interlinkages between the transport activities and other indicators of the strategy.. It is the aim of the reporting module to underlay especially those indicators by detailed and integrated accounting data. The reporting module covers data on land use (traffic area) transport-related energy consumption and transport-related air emissions by modes of transport, kilometres covered, passenger kilometres, tonne kilometres, vehicle stocks, transport-related environmental taxes, gross added value. One central classification for all these data is a detailed NAMEA-type breakdown by economic activities. The NAMEA structure is a central classification of the national accounting system. The sub-division of production activities was originally developed for the monetary input-output tables.

The goals and contents of the project as portrayed are dealt with in the following five chapters: Chapter 3 explains the bases for calculation of the current transport database of the EEA and puts forward selected time series on the environmental burdens and transport performances by causes. The first analysis step is implicit in this, while the splitting of the indicator quotients in enumerator and denominator values and the commentary on their development over time is already completed. Chapter 4 discusses the shares of transport in the above environmental burdens and their changes over time. Chapter 5 is devoted to the efficiency analysis of transport activities, that is, the calculation of the amount and development of transport intensities. In Chapters 6 and 7, determinants for the development of the transport-related environmental burdens (Chapter 6) and the transport performance (Chapter 7) are defined, and their significance estimated using decomposition analyses. The final observation contained in Chapter 8 critically summarises the fundamental concepts of the present project.

3 Database: Methodology and results

In this chapter, we will start by explaining the delimitations and calculations of the data used in the project (3.1). Then selected parts of the resulting database will be presented and interpreted in overview tables for the time series of the observed characteristics, and in detail for a selected year under report.[3]

3.1 As to the methodology

Delimitations:

In the framework of Environmental Economic Accounting, *transport* is understood to mean the motorised transportation of people and freight over land and water, and in the air. Mobile work vehicles (e.g. tractors), military vehicles and high seas shipping are not included. This corresponds both to the proposals of the Task Force on NAMEA-Air, and to the definition contained in the energy balance of the Federal Republic of Germany.

A variety of concepts tend to be used to specifically delimitate transport activities: According to the territorial concept that is customary in technically-orientated reporting systems, a country's transport includes all transport activities which occur on its state territory, regardless of who provides them. Hence, for instance, transit of foreign motor vehicles on domestic territory is included, whilst transport by domestic motor vehicles abroad is not. This delimitation for instance is customary in the general reporting system on transport of the German Institute for Economic Research (DIW), as well as in the environmental system of the Federal Environmental Agency on transport (TREMOD). The sub-divisions follow largely technically-orientated concepts which are incompatible with the sub-divisions and classifications of the economic information in the national accounts. The macroeconomic transport indicators of the National Sustainability Strategy also follow the territorial concept.

The central concern of the EEA is, by contrast, to combine environmental and economic data to create a consistent environmental economic dataset. This is to guarantee that environmental data – and here specifically transport-related information (for instance on transport performances, transport-related environmental burdens) – can be combined in a detailed sub-division with the monetary information from the national accounts on economic activities. To this end, it is absolutely necessary for the EEA to follow the delimitation concepts of the national accounts in portraying the environmental facts.

[3] Much more detailed information is available for download as Excel tables at http://www.destatis.de/download/d/ugr/tabugr04.xls.

The delimitation of transport in the context of the so-called national accounts concept borrows from the portrayal form of the economic process in the national accounts. Particular relevance in this context is attached to the production and the use perspective of transport services. The production perspective describes in the national accounts the production activities of the national economy, i.e. the resident units. The subject of the portrayal of "Transport from the **production perspective**" is as a consequence the production of transport services by resident units. Since transport performance is not accounted for by producing units alone, but also by private households, as so-called individual transport, the transport performances of the resident private households are correspondingly to be included in accordance with the delimitation of the consumption of private households in accordance with the territorial concept.

The **use perspective** in the context of national accounts is concerned with allocating the volume of freight in the national economy - consisting of the goods produced on and imported to domestic territory - to the economic activities used (intermediary use of goods in the context of production and final use). The role of transport in this context is related to the transportation of the goods to the respective users. This means that in the use perspective, the portrayal of the transport activities is to allocate the transport services rendered to transport the goods, as well as the concomitant environmental impact, to the economic activities using them.

Extensive data have already been compiled in the project on transport from the production perspective. For the use perspective only some general data are available so far. The calculation of data which show the allocation of the goods transport to the using economic activities in a detailed breakdown are planned for the next time. The analyses presented below hence focus on data related to the production perspective. The user perspective is covered in chapter 7 only.

In contrast to the territorial concept, according to the national accounts concept from the production perspective the transport activities of all resident units are included, regardless of the place of their activity. Hence, according to this concept for instance journeys by domestic motor vehicles abroad are included, but not those of foreign vehicles on domestic territory.

That conceptual difference is virtually negligible from a quantitative point of view in observing macroeconomic energy consumption. But it is certainly relevant to air and road traffic activities, since all domestic enterprises' aeroplanes and very many road vehicles registered on domestic territory are also used abroad, and conversely a major share of the German transport volume originates from foreign road users. Therefore in the project the relevant transport characteristics are demarcated according to the national accounts concept (producer perspective). The relationship to the territory concept that is used for the SD indicators is shown in a bridge table.

Calculations:

Data about transport-related energy use, transport-related air emissions, kilometres covered and transport performance in a detailed NAMEA-type breakdown by economic production and final use activities are the core of the project. Though most of the freight transport services are produced by some few homogeneous branches which are specialised in transport, a considerable part of those services is generated in the other production branches as an auxiliary activity for supporting the main production activity (own account transport). With regard to passenger transport, the private households have a high share by generating transport services by private motor vehicles. The rest of the passenger transports is also divided between specialised transport providers and other branches which produce transport services as an auxiliary activity.

Those data, except for transport performance, in a NAMEA-type breakdown existed already before the project was launched as a step in the internal calculation procedures for compiling the data for total energy use and air emissions by economic activities. However, for this project the calculation procedures had to be improved and refined considerably in order to obtain sufficiently accurate data by branches for the subcategory transport for these variables.

The calculation of the transport performance, energy and emissions data can be sub-divided into two areas: Data on road transport were ascertained in a laborious procedure. Starting point for the calculations are data from the Federal Bureau of Motor Vehicles and Drivers about the stock of vehicles in a rather detailed breakdown by type of vehicle, by detailed technical classes and by type of owner. The ownership classification is transformed into the classification of economic activities that is used in the national accounts by using various data which are available in the National Accounts on asset stocks and burden distributions of mineral oil tax.

Those stock data are the basis for assigning the flow information to the economic activities, like the information about kilometres covered and for freight and passenger transport performance from the Federal Bureau of Motor Vehicles and Drivers in cooperation with the Federal Office for Freight Transport, the data on energy, emissions and kilometres covered from the Federal Environmental Agency – in particular the Agency's TREMOD Transport Emission Estimation Model operated in cooperation with the Institute for Energy and Environmental Research (ifeu), Heidelberg.

Data from the transport statistics supplement these, as do those from the Federal Statistical Office's land accounts. Economic references come from the national accounts of the Federal Statistical Office.

The results put forward here are, moreover, coordinated to the respective benchmarks from the energy balances and the transport calculations ("Transport in Figures") from the German Institute for Economic Research, Berlin (DIW). The data presented in this paper refer to the state of calculations by the end of 2004. Revised data will be released by the end of this year.

The second data block referred to the non-road modes of transport rail, inland water transport and air. In contradiction to road traffic, these are always only to be attributed to a single homogeneous branch. Here, the benchmarks of the transport statistics and the energy balance can be used with slight modifications, but to adjust to the national accounts concept in inland water transport and in air. The bunkering balances between domestic economy and the rest of the world were included. To sub-divide the total energy consumption and emissions in rail and air transport, special tabulations were used based on the administrative statistics of Deutsche Bahn AG and the Lufthansa AG as standards.

The further calculation procedures of the subsequent sustainability analyses are discussed directly in the appropriate chapters.

3.2 The data base

The data base generated in the project can be shown in this paper for reasons of space only selectively. The chapter concentrates on displaying some data on transport related energy consumption, transport related green house gas emissions, traffic area and freight transport performance. All of the variables mentioned are differentiated for the year 2001 according to the four modes of transport, i.e. road, rail, inland water transport and air. Added to this are the kilometres covered of road transport. Here, in most cases the data for total traffic are shown as time series by aggregated homogeneous branches for 1994 to 2001. For the homogeneous branches of lines 1 to 7, transport activities are only auxiliary in nature (their main activities are by contrast for instance production of goods or construction work). Line 9 shows by contrast the data for transport service-providers.[4] A further table each shows the data for the year 2001 in a more detailed breakdown: The contribution of passenger and freight transport is shown individually for each mode of transport[5], and for all together; for freight transport by road, additionally, the energy consumption of those vehicles is shown separately which are included in the calculation of freight transport performance, i.e. heavy goods vehicles with one and more trailers with a permissible total weight of more than 3.5 tonnes.[6]

The total energy consumption of transport is stated for the years under report 1994 to 2001 by aggregated homogeneous branches in Table 1.

Table 1: Energy consumption of transport 1994 – 2001
Terajoules

No.	CPA 1)	Homogeneous branches and consumption of private households	1994	1995	1996	1997	1998	1999	2000	2001	No.
1	A-B	**Agriculture, hunting and forestry, fishing**	15 424	14 363	12 856	12 004	11 506	11 183	10 134	9 883	1
2	C	**Mining and quarrying**	2 564	2 468	2 311	2 058	1 955	1 838	1 790	1 982	2
3	D	**Manufacturing**	113 836	111 898	104 738	100 800	101 073	103 722	105 749	102 701	3
4	E	**Electricity, gas and water supply**	5 504	5 483	5 444	5 243	5 376	5 348	5 310	5 335	4
5	F	**Construction**	74 126	74 922	70 731	68 227	67 372	69 012	65 524	63 787	5
6	G	**Wholesale and retail trade, repair of mot. vehicles + cycles, pers. + household good**	132 802	133 966	128 553	123 720	131 007	141 633	146 357	143 134	6
7	H, J-Q	**Other services (not incl. transport services)**	280 060	303 694	316 059	315 957	331 962	355 494	376 150	377 122	7
8		**Total homogeneous branches not incl. transport services (lines 1-7)**	624 315	646 794	640 693	628 009	650 252	688 230	711 013	703 943	8
9	I	**Transport, storage and communication**	656 463	665 283	665 761	671 795	692 157	736 455	764 449	744 468	9
10	A-Q	**All homogeneous branches**	1 280 777	1 312 077	1 306 453	1 299 804	1 342 409	1 424 685	1 475 462	1 448 412	10
11		Domestic consumption of private households	1 241 251	1 264 016	1 276 018	1 287 484	1 285 873	1 282 195	1 202 789	1 173 700	11
12		**All homogeneous branches and domestic cons. of private households (NA concept)**	2 522 029	2 576 092	2 582 471	2 587 288	2 628 282	2 706 880	2 678 252	2 622 111	12

1) European Community statistical classification of products by activity.

The figures include the fuel consumption of domestic road, rail, water and air vehicles[7], as well as the consumption of electrical energy for rail traction. The conversion losses for energy incurred in electricity generation for the railways were not included (according to the national accounts system, these conversion losses are included in homogeneous branch 40.1 Electricity generation). The energy consumption of all modes of transport in 2001 was 2,622 petajoule (= PJ). This figure was 100 PJ (or 4.0%) higher than in 1994, but 85 PJ lower than in 1999, the peak year of this time series. The fall since 1999 is due above all to the drop in energy consumption by private households.

Table 2 shows energy consumption for 2001 in detail. In 2001, road passenger transport had a share of almost 58% in the overall energy consumption of transport, at 1,514 PJ, of which 1,166 PJ, or almost 45 percentage points, were accounted for by private households and 348 PJ, or 13 percentage points, by the homogeneous branches. Road freight transport of the homogeneous branches accounted for 731 PJ, or 28% of total consumption. In total, the energy consumption of road transport was 2,253 PJ, or 86% of total consumption. Air passenger transport is prominent among total other energy consumption, at 269 PJ, accounting for a about 10%.

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[4] These are the homogeneous branches 60.1 Transport via railways, 60.2-60.3 Other land transport, transport via pipelines, 61 Water transport, 62 Air transport, 63 Supporting and auxiliary transport activities; activities of travel agencies as well as 64 Post and telecommunications.

[5] With the exception of inland water transport. That was not included because of its negligible passenger transportation output in Germany.

[6] Whilst freight was also transported with lighter HGVs – so-called light commercial vehicles – the official statistical surveys of the Federal Bureau of Motor Vehicles and Drivers and of the Federal Office for Freight Transport are restricted to the heavier vehicle classes from 3.5 t pay load upwards. Transport performance of HGVs with less than 3.5 t pay load, but more than 3.5 t permissible total weight were added in the EEA by estimating.

[7] Petrol in road traffic (and to a slight degree in air transport), diesel oil in road, rail and ship transport, heavy heating oil to a slight degree in inland water transport, as well as kerosene in air transport.

Table 2: Energy consumption of transport 2001
Terajoules

No.	CPA [1]	Homogeneous branches and consumption of private households	Road			Rail		Inland waterways [3]	Air		All modes of transport		Total	No.
			Passenger transport	Freight transport	of which tp relev. [2]	Passenger transport	Freight transport		Passenger transport	Freight transport	Passenger transport	Freight transport		
1	**A-B**	**Agriculture, hunting and forestry, fishing....**	3 009	6 874	3 920	-	-	-	-	-	3 009	6 874	9 883	1
2	**C**	**Mining and quarrying....**	287	1 695	1 188	-	-	-	-	-	287	1 695	1 982	2
3	**D**	**Manufacturing....**	50 851	51 850	35 726	-	-	-	-	-	50 851	51 850	102 701	3
4	**E**	**Electricity, gas and water supply....**	2 086	3 249	1 211	-	-	-	-	-	2 086	3 249	5 335	4
5	**F**	**Construction....**	16 377	47 410	25 141	-	-	-	-	-	16 377	47 410	63 787	5
6	**G**	**Wholesale and retail trade, repair of mot. vehicles + cycles, pers. + household good**	60 831	82 304	66 524	-	-	-	-	-	60 831	82 304	143 134	6
7	**H, J-Q**	**Other services (not incl. transport services)....**	170 525	206 596	132 278	-	-	-	-	-	170 525	206 596	377 122	7
8		**Total homogeneous branches not incl. transport services (lines 1-7)....**	303 965	399 978	265 988	-	-	-	-	-	303 965	399 978	703 943	8
9	**I**	**Transport, storage and communication....**	44 061	331 085	316 184	42 698	16 983	12 786	269 375	27 480	356 134	388 334	744 468	9
10	**A-Q**	**All homogeneous branches....**	348 026	731 063	582 172	42 698	16 983	12 786	269 375	27 480	660 100	788 312	1 448 412	10
11		Domestic consumption of private households....	1 165 788	7 912	-	-	-	-	-	-	1 165 788	7 912	1 173 700	11
12		**All homogeneous branches and domestic cons. of private households (NA concept)**	1 513 814	738 975	582 172	42 698	16 983	12 786	269 375	27 480	1 825 888	796 224	2 622 111	12

1) European Community statistical classification of products by activity.
2) Energy consumption of vehicles relevant to transport performance (HGVs with a total permissible weight of more than 3.5 tonnes).
3) Only freight transport.

The energy consumption of all freight transport (in which the role of private households is virtually negligible) amounts to 796 PJ. Half of this is accounted for by own-account road freight transport (400 PJ), plus transport service-providers in road traffic, whose share of consumption, at 331 PJ, is about 42%. Therefore, the modes of transport rail, inland water and air only contribute a good 7% to the total energy consumption of freight transport.

Allocation of the transport activities and their environmental consequences to the actual transport players, i.e. according to the production perspective, can as a consequence answer the question of by whom transport activities are implemented, but not for what. In order to achieve this, it would be necessary to assign the transport services and transport-related environmental burdens to the economic activities according to the use perspective.

Tables 3 and 4 present the greenhouse gasses emitted by transport activities.

Table 3: Greenhouse gas emissions of transport 1994 – 2001
1,000 t CO_2 equivalents

No.	CPA [1]	Homogeneous branches and consumption of private households	1994	1995	1996	1997	1998	1999	2000	2001	No.
1	**A-B**	**Agriculture, hunting and forestry, fishing....**	1 161	1 082	968	904	867	841	760	741	1
2	**C**	**Mining and quarrying....**	193	186	174	155	147	138	134	149	2
3	**D**	**Manufacturing....**	8 566	8 425	7 887	7 595	7 615	7 798	7 934	7 706	3
4	**E**	**Electricity, gas and water supply....**	414	413	410	395	405	402	398	400	4
5	**F**	**Construction....**	5 574	5 637	5 323	5 138	5 075	5 186	4 911	4 783	5
6	**G**	**Wholesale and retail trade, repair of mot. vehicles + cycles, pers. + household good**	9 992	10 085	9 678	9 321	9 870	10 647	10 980	10 739	6
7	**H, J-Q**	**Other services (not incl. transport services)....**	21 074	22 865	23 797	23 807	25 011	26 724	28 217	28 293	7
8		**Total homogeneous branches not incl. transport services (lines 1-7)....**	46 973	48 692	48 237	47 316	48 991	51 736	53 335	52 811	8
9	**I**	**Transport, storage and communication....**	31 911	31 800	31 408	30 789	32 049	34 152	34 508	33 678	9
10	**A-Q**	**All homogeneous branches....**	78 885	80 492	79 645	78 105	81 040	85 888	87 842	86 488	10
11		Domestic consumption of private households....	93 722	95 479	96 373	97 265	96 981	96 625	90 679	88 292	11
12		**All homogeneous branches and domestic cons. of private households (NA concept)**	172 606	175 971	176 018	175 370	178 021	182 513	178 521	174 780	12

1) European Community statistical classification of products by activity.

The greenhouse gas (GHG) emissions shown in the EEA include carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4); the emission quantities of the last two gases are converted into CO_2 equivalents via their greenhouse potential for the purpose of aggregation. The GHD emissions occur in transport when fuel is burnt. The volume of carbon dioxide, by far the most important greenhouse gas, is exclusively dependent on the type and volume of fuel burned, and cannot be reduced by filters or alternative burning processes. The time development of total emissions is shown in Table 3 to be similar to that of energy consumption.

Table 4: Greenhouse gas emissions of transport 2001

1,000 t CO_2 equivalents

No.	CPA [1]	Homogeneous branches and consumption of private households	Road			Rail		Inland waterways [3]	Air		All modes of transport		Total	No.
			Passenger transport	Freight transport	of which tp relev. [2]	Passenger transport	Freight transport		Passenger transport	Freight transport	Passenger transport	Freight transport		
1	A-B	**Agriculture, hunting and forestry, fishing**	227	514	294	-	-	-	-	-	227	514	741	1
2	C	**Mining and quarrying**	22	127	89	-	-	-	-	-	22	127	149	2
3	D	**Manufacturing**	3 823	3 883	2 680	-	-	-	-	-	3 823	3 883	7 706	3
4	E	**Electricity, gas and water supply**	157	243	91	-	-	-	-	-	157	243	400	4
5	F	**Construction**	1 235	3 548	1 885	-	-	-	-	-	1 235	3 548	4 783	5
6	G	**Wholesale and retail trade, repair of mot. vehicles + cycles, pers. + household good**	4 572	6 167	4 990	-	-	-	-	-	4 572	6 167	10 739	6
7	H, J-Q	**Other services (not incl. transport services)**	12 812	15 481	9 935	-	-	-	-	-	12 812	15 481	28 293	7
8		**Total homogeneous branches not incl. transport services (lines 1-7)**	22 848	29 963	19 963	-	-	-	-	-	22 848	29 963	52 811	8
9	I	**Transport, storage and communication**	2 894	22 805	21 791	1 371	522	938	4 671	477	8 936	24 741	33 678	9
10	A-Q	**All homogeneous branches**	25 742	52 767	41 753	1 371	522	938	4 671	477	31 784	54 704	86 488	10
11		Domestic consumption of private households	87 708	584	-	-	-	-	-	-	87 708	584	88 292	11
12		**All homogeneous branches and domestic cons. of private households (NA concept)**	113 450	53 352	41 753	1 371	522	938	4 671	477	119 492	55 288	174 780	12

1) European Community statistical classification of products by activity.
2) Emissions of vehicles relevant to transport performance (HGVs with a total permissible weight of more than 3.5 tonnes).
3) Only freight transport.

The freight transport performance as the most important measure of freight transport activity is portrayed in Tables 5 and 6:

Table 5: Freight transport performance 1995 – 2001

millions tkm

No.	CPA [1]	Homogeneous branches and consumption of private households	1995	1996	1997	1998	1999	2000	2001	No.
1	A-B	**Agriculture, hunting and forestry, fishing**	1 964	1 633	1 710	1 884	1 808	1 820	1 937	1
2	C	**Mining and quarrying**	590	561	497	465	428	424	488	2
3	D	**Manufacturing**	18 868	17 763	17 421	16 657	16 366	16 211	15 653	3
4	E	**Electricity, gas and water supply**	276	324	269	291	322	297	497	4
5	F	**Construction**	12 635	11 243	11 204	10 467	11 383	10 479	10 277	5
6	G	**Wholesale and retail trade, repair of mot. vehicles + cycles, pers. + household good**	29 049	29 078	29 549	30 559	32 506	32 090	32 609	6
7	H, J-Q	**Other services (not incl. transport services)**	51 031	54 257	56 239	59 315	63 929	65 711	67 128	7
8		**Total homogeneous branches not incl. transport services (lines 1-7)**	114 414	114 860	116 889	119 638	126 742	127 032	128 588	8
9	I	**Transport, storage and communication**	270 365	265 283	279 104	291 110	302 095	312 567	316 559	9
10	A-Q	**All homogeneous branches**	384 779	380 143	395 993	410 747	428 838	439 599	445 148	10
11		Domestic consumption of private households	-	-	-	-	-	-	-	11
12		**All homogeneous branches and domestic cons. of private households (NA concept)**	384 779	380 143	395 993	410 747	428 838	439 599	445 148	12

1) European Community statistical classification of products by activity.

Table 6: Freight transport performance 2001

millions tkm

No.	CPA [1]	Homogeneous branches and consumption of private households	Road	Rail	Inland waterways	Air	**Total**	No.
1	A-B	**Agriculture, hunting and forestry, fishing**	1 937	-	-	-	1 937	1
2	C	**Mining and quarrying**	488	-	-	-	488	2
3	D	**Manufacturing**	15 653	-	-	-	15 653	3
4	E	**Electricity, gas and water supply**	497	-	-	-	497	4
5	F	**Construction**	10 277	-	-	-	10 277	5
6	G	**Wholesale and retail trade, repair of mot. vehicles + cycles, pers. + household good**	32 609	-	-	-	32 609	6
7	H, J-Q	**Other services (not incl. transport services)**	67 128	-	-	-	67 128	7
8		**Total homogeneous branches not incl. transport services (lines 1-7)**	128 588	-	-	-	128 588	8
9	I	**Transport, storage and communication**	168 301	76 360	64 818	7 080	316 559	9
10	A-Q	**All homogeneous branches**	296 890	76 360	64 818	7 080	445 148	10
11		Domestic consumption of private households	-	-	-	-	-	11
12		**All homogeneous branches and domestic cons. of private households (NA concept)**	296 890	76 360	64 818	7 080	445 148	12

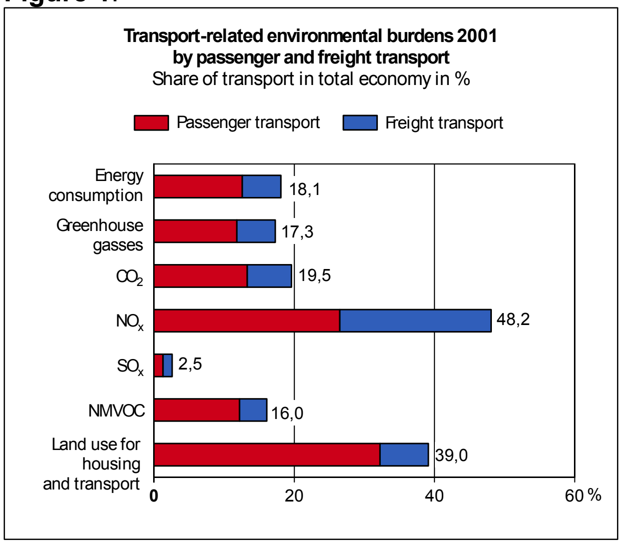
1) European Community statistical classification of products by activity.

The freight transport performance has increased by a total of almost one-sixth between 1995 and 2001.

4 Transport-related shares of selected environmental burdens

In order to be able to recognise the relevance of the transport sector for a Sustainability Strategy in the macroeconomic framework, it is necessary to work out its relative quantitative significance. This is the purpose of the following chapter. Figure 1 shows the shares of transport among selected environmental burdens which are relevant in the framework of the Sustainability Strategy:

Figure 1:



The results summarised in Figure 1 show that the transport-related share of the environmental burdens is greatest as to the emissions of NO_x (almost one-half of the total NO_x burden is accounted for by transport). This is followed by the transport area, which accounts for one-third of the total land use for housing and transport (i.e. two thirds are used for housing). In the area of roughly 15% to 20% of the respective total burden, we see transport-related NMVOC emissions, transport-related greenhouse gas emissions, transport-related energy consumption and transport-related carbon dioxide emissions.

For all the environmental burdens mentioned, the role of passenger transport is more significant than that of freight transport.

5 The environmental efficiency of transport

If one starts by taking the amount of transport performance as a given, the amount and the development of the total transport-related environmental burdens is determined by two parameters, namely on the one hand by the economic structure (composition by branches, including the mode of transport) and on the other by the environmental intensity in the individual branches:

- Relevance attaches, firstly, to the shares of the individual modes of transport road, rail, water and air transport among the total transport volume. This is a result of the fact that the modes of transport clearly differ in their environmental efficiency, depending on the type of environmental burden they cause. Environmental efficiency is measured via environmental intensities, meaning by the relative environmental burdens of a mode of transport per unit of transport performance. With constant total transport volume, the total burden falls if the transport share of an environmentally-intensive mode of transport is reduced, favouring a less environmentally-intensive alternative.

- The second major element is the development of the respective environmental intensities of the modes of transport over time. With constant total transport volume and constant modes of transport shares, the total burden falls if the environmental intensity of at least one mode of transport falls.

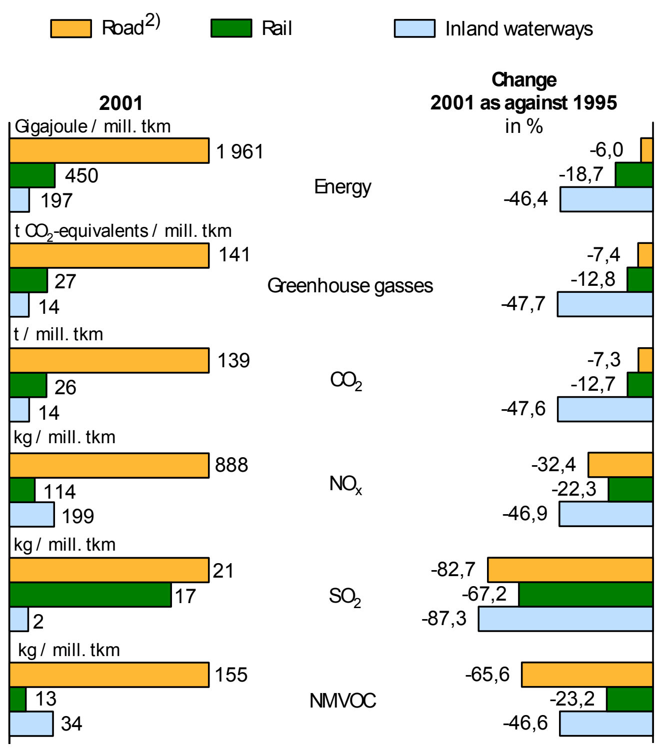
The shares of the modes of transport among freight transport volume for the year under report 2001 can be seen from Table 6. The following chapter is therefore devoted to the analysis of the environmental intensities and their development.

Firstly, the environmental intensities of freight transport are viewed in a breakdown by modes of transport. Since however the environmental intensities fluctuate considerably, not only between the modes of transport, but also between the homogeneous branches, the energy intensity of freight transport is broken down by homogeneous branches in energy consumption as an example of the environmental indicators observed.

Figure 2 shows how the environmental intensity of freight transport (unit environmental burden per unit of freight transport performance, meaning per tonne kilometre) differs for the various modes of transport and how it has changed over time.

Figure 2:

Environmental intensity of freight transport by modes of transport, including electricity generation for rail [1]
Environmental burdens per freight traffic output



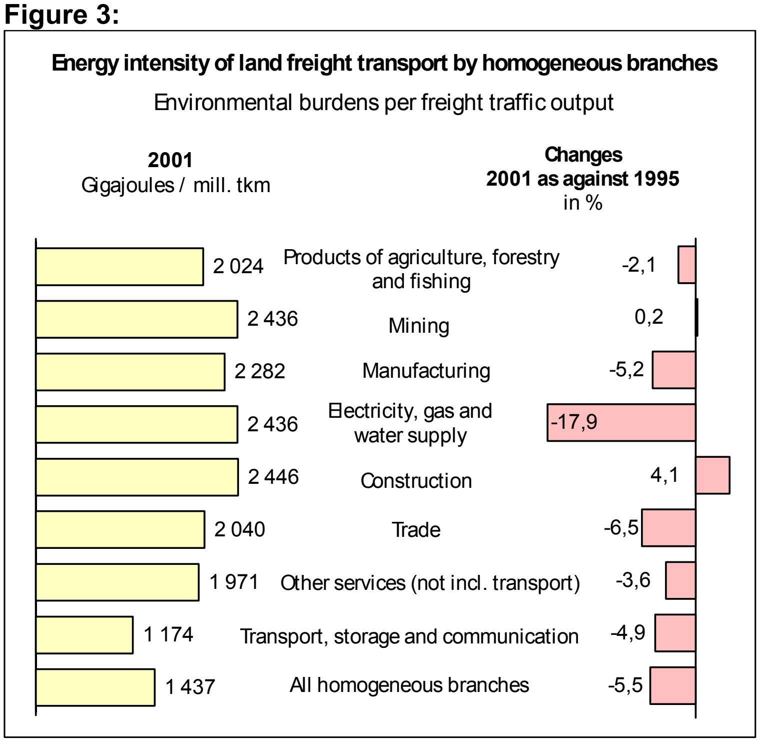
1) Conversion losses and emissions in electricity generation for traction of rail engines - 2) not incl. light commercial vehicles up to 3.5 tonnes permissible total weight and not incl. special vehicles.

It becomes obvious that road transport road is the most environmentally intensive mode of transport observed. Each environmental burden studied is much greater per tonne kilometre covered on the road than by rail and inland water transport. For instance, the energy intensities of road transport were roughly 2,000 kilojoules per tonne kilometre in 2001, whilst on rail and waterways they were only about 450 and 200 kilojoules per tonne kilometre.

The view of the time development reveals a pronounced improvement for all values included meaning that it was possible to decouple the transport-related environmental burden from transport volume with all modes of transport.

The previous differentiation of freight transport by the modes of transport can be supplemented by being broken down by branches. This makes sense because whilst rail and waterways transport only take place using specialised transport service-providers, road traffic is however implemented both by these, as well as by the other homogeneous branches (in the shape of own-account transport). For this reason, for the purposes of the following study own-account transport by road was attributed to the implementing homogeneous branches, and commercial road traffic, as well as rail and inland water transport, were attributed to the homogeneous branch "Transport, storage and communication". Figure 3 reflects the results for the energy intensities of the year under report 2001:

Figure 3:



Own-account transport can be found in lines 1 to 7, commercial freight transport in line 8.[8] It becomes clear that commercial freight transport is much more environmentally efficient than own-account transport: Whilst the energy intensities of own-account transport are between 1,971 and 2,446 kilojoules per tonne kilometre, the intensity of the transport area is only

8 The designation "land transport" as a summary of road, rail and inland waterway transport makes clear the lack of air transport.

1,174 kJ/tkm, i.e. roughly half. Hence, the average intensity of all homogeneous branches is reduced to 1,437 kJ/tkm. It should be taken into account that the efficiency advance of transport service-providers is caused only slightly by their more efficient HGV fleet and their higher occupancy levels, but to a primary extent by more energy-efficient rail and inland water transport.

The percentage changes in energy intensities on the right-hand side of Figure 3 show a fall of roughly 5% for the quantitatively-significant homogeneous branches (manufacturing and all services), and hence a gain in efficiency. The derogating trends of some other areas are partly based on very small basic totals, and should therefore not be over-emphasised.

6 Analysis of the influence of environmental efficiency, of the structure of transport and of transport volume on the transport-related environmental burdens

In Chapters 4 and 5, the situation of transport-related environmental burdens was observed first of all using the absolute extent of the burdens, the shares of the types of transport, as well as their trends, and secondly using the intensities and their changes. It was seen that the absolute transport-related environmental burdens had changed, in some cases considerably, between 1995 and 2001. There are three possible reasons for this: Firstly, environmental burdens increase or fall if ceteris paribus[9] the transport activities causing them increase or fall in their extent (transport volume-related burden changes). Secondly, environmental burdens may increase or fall if ceteris paribus the environmental burden intensities of the transport activities increase or decrease (intensity-related burden changes). Thirdly, environmental burdens may increase or fall if the modes of transport involved show different intensities, and ceteris paribus the structure of modes of transport, meaning that the modal split shifts towards more or less environmentally-intensive modes of transport or sectors (structural burden changes). In reality, all three causes of change work simultaneously, so that the resulting overall change of an environmental burden emerges as an expression of the changes in the transport volume (scale), in the individual environmental intensities (intensity) and in the modal split (structure).

The interesting question now arises: which of the three factors that have been identified – scale, structure and intensity component – influence the development of the environmental burden of transport, to what degree, and in which direction? Such questions can be answered by calculations in which information from Environmental-Economic Accounting and the national accounts is combined. A mathematical procedure is applied that is described as decomposition analysis.[10] This method can be used to separate and compare the impacts of the individual influencing factors. The total of the scale, intensity and structural effect then gives the total impact.

In Figure 4 results of decomposition calculations are presented at the example of energy use for freight transport. As structural effect the composition by economic branches is regarded.

The burdening effect of the increased transport volumes on energy consumption came to +87.8 PJ, which was partly compensated by the decreasing influence of the structural (-11.3 PJ) and of the intensity effect (–45.0 PJ).

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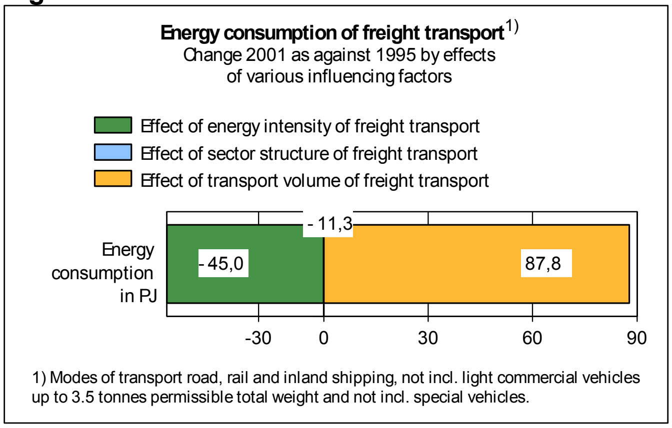
[9] Under the ceteris paribus presumption, all other influencing factors of a change in the resultant value which is to be studied are made constant (where appropriately only conceptually), and only the effects of a specific influencing factor are observed in isolation.
[10] A detailed description of the procedure is offered by Seibel (2003

Figure 4:



7 Transport performance, economic growth and intertwining of production

In the analyses described in Chapter 6, transport volume (meaning the freight transport performance measured in tonne kilometres) was interpreted as one of the three driving forces for the development of environmental burdens by transport. In analogy, it is possible to analyse how the transport volume itself is influenced in turn by various determinants. In the transport intensity indicator of the Sustainability Strategy the total freight transport performance (tonne kilometres) is related to the gross domestic product (GDP) at constant prices. Its functional interpretation is as follows: How much additional freight transport performance was needed to implement one percent of additional economic growth? The goal of the SD-strategy is to achieve a decrease of the intensity. Against that the figures show a considerable rise during the last years.

The reason behind that development could be analysed with a decomposition approach. For such an analysis the view must be changed. Whereas in the previous sections, transport activities were observed from the production perspective (→ who is the producer of the transport service?), in this case the user perspective has to be taken (→ who is the user of the transport service?). In the user perspective all freight transport activities on the economic territory which are related to production or final use activities of the economy have to be included. For estimating a proper structural effect, such an analysis ideally requires detailed figures about the use of freight transport services by economic production and final use activities. Those data will be made only available in the near future.

Therefore, for this paper a simplified interim approach was applied in order to demonstrate the potential of that type of environmental-economic analysis.

The following influencing factors were identified for the decomposition procedure[11] for development of the freight transport performance (FTP) of land transport between the years 1995 and 2001:

[11] As already explained, the decomposition procedure transforms the multiplicative relationship into an additive one. The total change of the variable under consideration is expressed as the sum of the individual effects

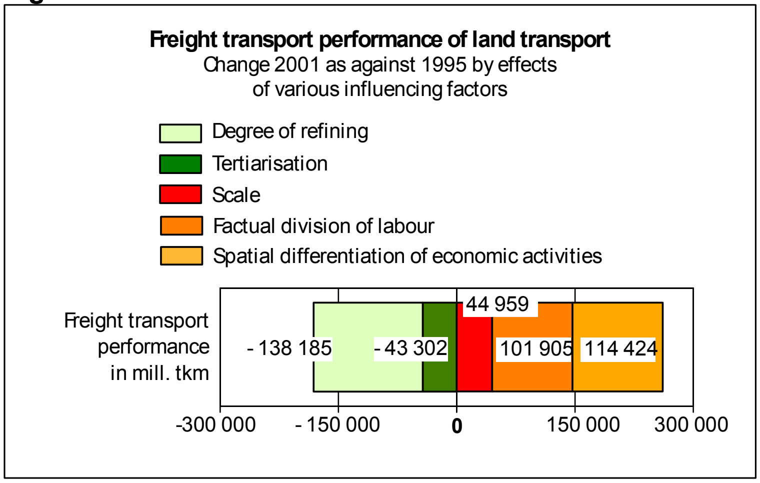
$$FTP = GDP \times \frac{VAM}{GDP} \times \frac{TSM}{VAM} \times \frac{TONS}{TSM} \times \frac{FTP}{TONS}$$

- Change of GDP at constant prices as the **scale effect**.
- The **degree of tertiarisation** (service sector share) was taken as a proxi for the influence of the change of the economic structure. The production of services usually requires only small material inputs, compared to material production activities. The tertiarisation effect is measured by the development of the ratio of the gross value added of material production to total production (VAM / GDP), so that increasing tertiarisation is expressed in a falling quotient.
- As a third influencing factor, the change in the degree of the **factual division of labour** in the material production was selected. That is approximately measured by the development of the relationship between total supply of material goods in monetary units to the gross value added of material goods production (TSM/VAM). The more differentiated the division of labour between the individual producing units is, the higher as a rule is the ratio of the intermediate consumption to the gross value added which inflates the total supply of goods in relation to the gross value added.
- As a fourth influencing factor the **degree of refining** of the transported goods was considered. That measure refers to the average weight of the transported goods in relation to their value. For that purpose the total weight of the transported goods is related to the total supply of material goods in monetary terms (TONS/TSM). A decrease of this ratio may reflect, if only in summarised form, a shift from material-intensive branches to less material and more value added-intensive branches within material production branches.
- Finally, the change in the average transport distance has also to be taken into account. The average transport distance is a result of the relationship between the freight transport performance and the total freight volume in tonnes (FTP/TONS). This ratio can be interpreted as a measurement of the **spatial differentiation of the economic activities**. An increase in the average transport distance can be caused both by an increase in the spatial spread of material production activities as well as by an extension of the average transport distances for the goods for final use

The freight transport performance itself can be depicted as a mathematical product of the five factors explained. The effects of the influencing factors described on the change in the freight transport performance of land transport on German territory between 1995 and 2001 are visualised in Figure 6.

The overall increase in the freight transport performance of land transport in this period was nearly 80 billion tonne kilometres [tkm], which corresponds to an increase of almost one-fifth as against 1995. Economic growth per se would have led to an increase in transport performance by 45 billion tkm. However the burdening effect resulting from an increase of the spatial differentiation of economic activities was at +114 billon tkm much higher than the influence of GDP growth (scale effect). The increase of the factual division of labour worked in the same direction and effected +102 billion tkm. Both influencing factors taken together correspond in their extent to more than 52% of the total transport performance of 1995. The three burdening effects were partly compensated by the following decreasing factors: Increasing tertiarisation had a dampening effect of -43 billion tkm. And the growing degree of refining, i.e. the increased share of highly processed freight, accounted for an effect of –138 tkm.

Figure 6:



It can be concluded that the increasing factual and spatial differentiation of material production and final use activities use led to a clear expansive effect on transport volume, which was much higher than the influence of the economic growth (scale effect) during the period of study. That was compensated partly by the reducing structural effects as the trend towards production of non-material products and the trend towards more refined material products.

This result makes it clear that economic growth itself, compared with the other factors, had only a comparatively slight influence on overall trend in transport performance. Merely observing the sustainability indicator "transport intensity" without analysing the influencing factors behind it is hence unlikely to be sufficient to take suitable political measures.

In light of advancing globalisation, one should anticipate that the expansive effects mentioned will continue to apply. Combined with anticipated economic recovery, one could rather expect an even stronger expansion of the transport volume for the future, in contradiction to the objective of the Federal Government's Sustainability Strategy. Political measures should aim to assess the conflicting goals inherent in the Sustainability Strategy to influence individual factors such as the increasing spatial differentiation of goods production and their use. Further measures could aim to increase the environmental efficiency of freight transport itself.

8 Econometric modelling of environmental-economic effects of transport

The task of official statistics lies in portraying and analysing facts lying in the past, and hence in providing descriptive ex-post analyses. The present project report demonstrates that by these means many interlinkages can already be shown between economic and environmental variables.

As indispensable as such information is for recognising the present and its origins, sustainability strategies are future-related. Hence additional future prognoses are required to portray not only the most probable, but also alternative development paths in the shape of model scenarios.

In Germany such instruments for environmental-economic modelling have been developed parallel to the implementation of the German system of environmental-economic accounting

(GEEA). The scientific advisory committee of the ministry of environment for GEEA played a leading role in promoting the development and the use of that instrument.

The starting points were already existing modelling instruments for the economy, which are widely based on data from the national accounts. Those models were extended by including important environmental-economic interactions at the basis of the EEA data. Meanwhile the "Panta Rhei" model of the GWS Osnabrück[12] turned out to be the most widely used model for that purpose. That model is a multi-sectoral approach which can make maximum use of the disaggregated data base of the EEA.

Such models relate the integrated data of the expanded accounting system to each other by a complex system of empirically based mathematical behaviour equations. The model-relationships which are based on those equations can be of economic, environmental-economic or socio-economic nature. The models can be used for forecasting and scenario simulations. Those simulations are indispensable for an SD policy approach, as they can quantify the effects of political measures on the target variables but at the same time the side effects on other economic, environmental and social variables which are relevant for the SD policy. That type of information supports the process of finding cost-efficient solutions and balancing conflicting goals.

The examples for the application of environmental-economic models in Germany range from modelling scenarios of rather comprehensive SD policy approaches to more specialised exercises[13].

The data provided by the new sectoral reporting module on transport and environment have already been integrated into the Panta Rhei model and were used for the simulation of transport related measures which were formulated by the Federal Environment Agency. The proposed measures were aimed at improving the performance of transport indicators of the national SD strategy. In addition to the direct effects on the transport indicator values, the trends of a number of other environment-related, economic and social indicators of the national SD strategy were simulated with the model.

Table 7 shows the forecast for the basis scenario for a number of SD indicators up to the year 2020.

Table 7:

German sustainability indicators: business-as-usual forecast

Indicator	Unit	1991	2000	2010	2020
Intensity of passenger transport	1999=100	102.9	94.7	84.9	77.1
Intensity of goods transport	1999=100	90.6	99.8	102.8	106.4
Share of rail transport to total goods transport performance	in %	20.0	15.1	13.3	11.6
Energy productivity	1990=100	104.6	122.5	137.7	170.5
Green house gas emissions	1990=100	95.6	81.2	78.8	78.1
Air pollution	1990=100	85.7	50.2	44.5	38.9
Increase of the settlement and traffic area	hectare per day	119.7	129.2	93.4	81.5
Gross domestic product per capita	Euro	21312	23943	27034	32010
Employment ratio	in %	65.8	65.5	67.2	73.2
Increase of budget deficit	in % of GDP	3.0	-1.3	3.3	2.7
Capital formation ratio	in % of GDP	23.8	21.7	17.3	15.6

Source: Gesellschaft für wirtschaftliche Strukturforschung

[12] See: Meyer, B. (1998)
[13] See for example Mayer, B. (2004).

As one example of the results of the project the effect of doubling the existing road toll for heavy goods vehicles is shown in table 8.

Table 8:

Simulation of the effect of doubling the road toll for heavy goods vehicles

	2010	2020
Intensity of goods transport (1999=100)	-3.3	-3.6
Share of rail transport to total goods transport performance (%)	1.6	1.8
CO_2-emissions (million tons)	-2.7	-2.9
GDP per capita (Euro 1995)	16.0	34.0
Employment (1000)	10.0	28.0

Source: Gesellschaft für wirtschahftliche Strukturforschung

The table describes the differences between the results of the “measurement scenario” compared to the “basis scenario” for a selected number of variables. According to the modelling results it can be expected that the measure will yield an improvement for the indicators values related to freight transport. The intensity of freight transport will go down by 3.6 percent points and the share of rail transport will rise by 1.8 percent points. However, compared to the target values of the strategy the proposed measure alone will not be sufficient. For reaching the target it is necessary to achieve a decrease of the transport intensity by more than 11 percent points and an increase of the share of rail transport by nearly 13 percent points compared to the business-as-usual scenario. The side effects of the measure on other SD variables are positive. CO_2 emissions will go down – but only by 2.9 million tonnes against a current level of total CO_2 emissions of more than 800 million tonnes – and there will be no negative effects on GDP and employment, but, maybe surprisingly, a slight increase.

9 Conclusions

The time series of Chapter 3 and the analyses of Chapters 4 to 8 of this paper demonstrate the potential of the accounting data on transport and environment for supporting a policy for achieving the goals of the National Sustainability Strategy. The diversity of influences condensed in the quantitative objectives of the Sustainability Strategy to become a small number of ratios can be layered comprehensively in the framework of the national accounts system.

The absolute data on transport performance and the added value from Chapter 3 already lead to new knowledge in the comparison to the highly-aggregated sustainability **indicators** by separating the **components** – enumerator and denominator – of indicators and at the same time making clear the respective composition. The additional information on the environmental **burdens** of transport in the same delimitation also provides information on the consequences of transport for the environment. What is more, they show up interlinkages by revealing the influence of transport on other sustainability indicators, which do not explicitly deal with the transport sector, but are influenced by it. One should mention here the indicators " productivity of energy ", "greenhouse gas emissions", "emissions of air pollutants" as well as "increase in land use for housing and transport". With the share data of Chapter 4 and their visualisation, the view of the **causer** structure is directed to the transport-related environmental burdens, leading to initial indications of the priority fields of action of a sustainability-orientated transport and environmental policy. By showing transport-related shares in macroeconomic environmental burdens, interlinkages become visible here in turn. The study of efficiency in Chapter 5 expands the analysis of causes of the previous chapter above all by observing the environmental intensities of freight transport broken down by modes of transport. Behind the activities of the driving forces of environmental burdens, however, there are **causes** of action which were successfully broken down in Chapters 6 and 7.

Using decomposition analysis, selected basic trends can be quantified, both for freight and for passenger transport, in the economic and technical environment from which the transport that has actually taken place and environmental burdens result. Environmental-economic modelling approaches are indispensable as a support for formulating balanced and cost-efficient policy measures. It is only this last stage of analysis which satisfies the concept of sustainability as an integrated strategy which leaves the narrow focus of a specific environmental or economic policy problem and takes the connecting lines to the other fields of activity of sustainability policy into consideration. Questions such as "What links are there between transport and economic growth?", "What impact does technical and economic progress have on the amount of transport-related environmental burdens?" present not only sector-spanning cause-and-effect structures, but also clarify goal relationships within the goal system of the Sustainability Strategy:

- Thus, the economic growth goal (measured by the indicator "gross domestic product") may conflict with the transport goals.
- Economic and social goals on participation in work (measured by the "labour market participation" and "ratio of annual gross earnings of men and women") can lead to higher transport volumes if they are achieved, and thus for instance disturb the emission goals.
- In the same way progress in the organisation of work, which leads to increasing efficiency by meeting economic and social goals for development promotion (measured by "imports to the EU from developing countries" and also "expenditure on development cooperation"), can increase the spatial and factual division of labour. This in turn may worsen the environmental goal indicators.

The conflicting goals named must be identified and qualified early so that corrections and priority setting can be incorporated into the goal system of the Sustainability Strategy in order to keep it authoritative and realistic. Instead of this, only providing the details and celebrating or criticising the meeting or failing of individual indicators after the fact is out of place in a holistic approach. An accounts approach provides the necessary overall view to the fundamental information to a special degree. The exaggerated theory that "sustainability analysis is accounts analysis" then becomes comprehensible.

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