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Structural decomposition of environmental accounts data – the Swedish case

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1 Introduction

The Environmental Accounts are devised to be a satellite accounting system to the National Accounts. This means linking environmental data to economic data in useful ways. In most cases this means allocating energy use and emissions from fuel use to the industries that use the fuels and cause the emissions or to private or public consumption for the parts that go directly to final demand. The result is a yearly account of energy use, emissions etc. by domestic producers and final consumers with system boundaries defined by the National Accounts and thereby possible to link to economic activities and variables.

The aim of this study is to do a structural decomposition analysis of Swedish data for the 1993-1999 period. Two different methods will be used, both the elaborate input-output based analysis as well as the Supply-Use-table based analysis. The results obtained in the two will be compared. This should be of interest to other member states that may or may not have access to the input-output data in knowing the relative strengths and weaknesses of the methods.

Over time the environmental accounts produces time series of economic activity and environmental pressures that can be used to monitor and analyze the development for instance against requirements for a sustainable development.

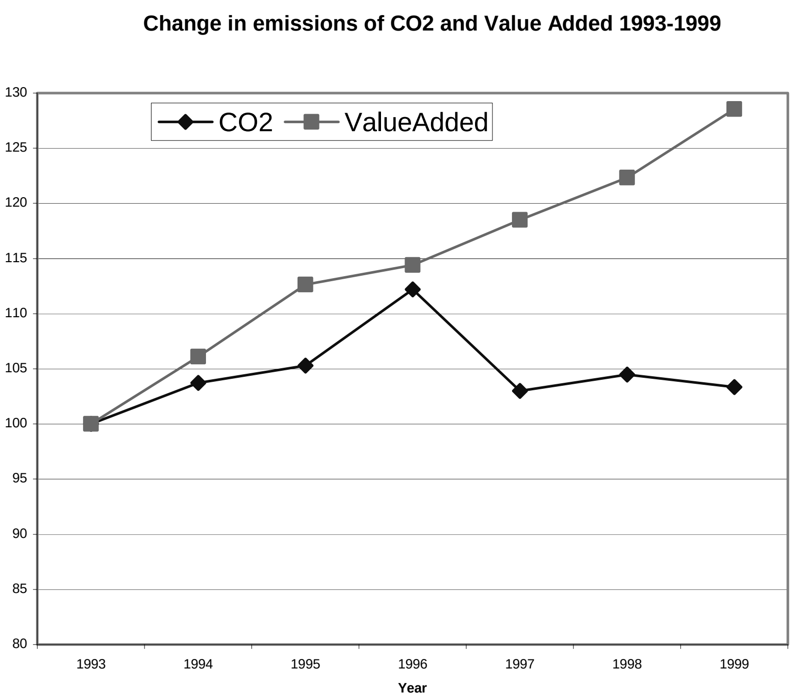

Figure 1. Index on change in co2-emissions and value added 1993-1999

The graph above shows the relationship between the development of aggregated Value Added for industry and emissions of CO_2 (including emissions from Final Demand) over time with 1993 as base year. This series shows a relative decoupling in the sense that economic growth is greater than growth in emissions. The bump in the series for 1996 is due to a cold and dry year, which meant increased energy demand and less power generated from hydro power. The import of electricity from Denmark increased by a factor 15 in 1996 and the domestic CO2 emission intensities in electricity generation doubled.

Given the level of detail of the environmental accounts and the properties of a satellite account it is possible to show relationships between changes in Value Added and changes in emissions to air by industry, thereby making it possible to look at absolute or relative decoupling at a disaggregated level as well as for an aggregates. The chart below shows the change over the whole period 1993-1999 by industry (Figure 2).

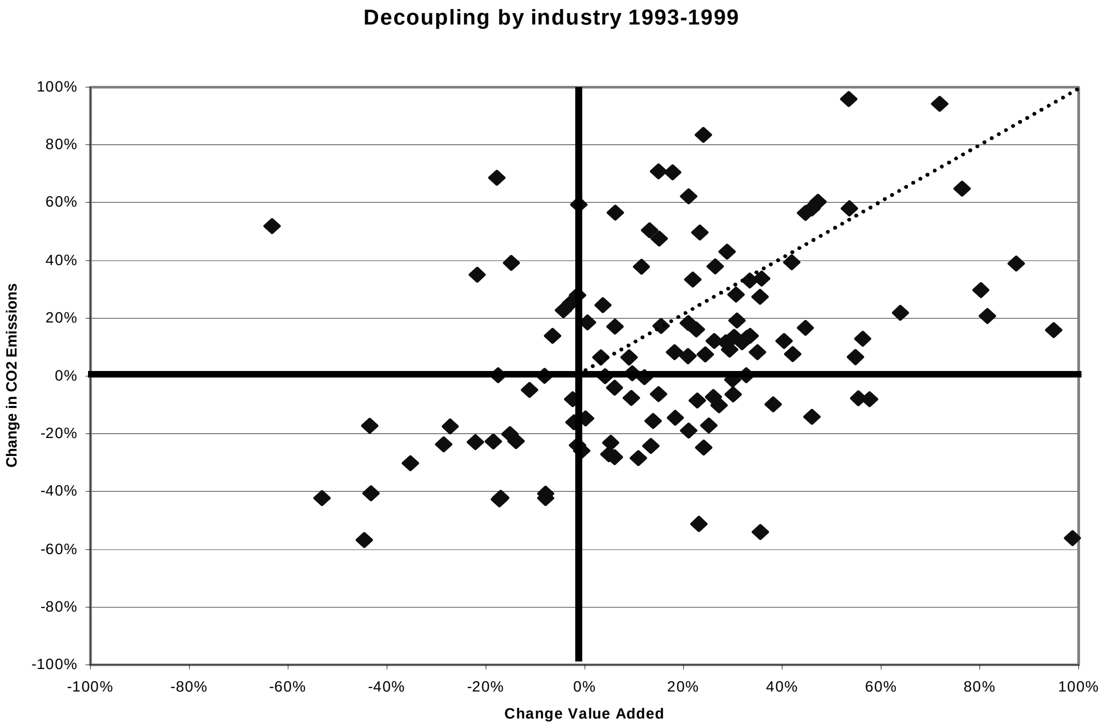

Figure 2. The relation between change in CO2-emission and change in value added for industries in Sweden. Below the dotted line lies industries that have a relative decoupling.

As an indicator this is just fine. But in terms of analysis it is not very rewarding as an apparent decoupling between growth in Value Added and changes in emissions can be caused by different factors. This is where decomposition analysis comes in.

Decomposition analysis is a way to isolate the different factors that add up to a change in emission, energy use, or some other variable between two periods. It can be done in different ways and for different sets of factors. Besides being a useful tool for analyzing changes as such it can also be useful in the calculation of accounts data.

2 Decomposition analysis

2.1 Decomposition studies from environmental accounts

Some decomposition analyses based on environmental accounts data have been performed in Europe. The Netherlands 1987-1998, for CO2, waste, acid emissions have been analyzed. For all variables, but especially for CO2, the increasing volume was the factor that increased environmental pressure, while changes in the industrial structure were not so significant. However, structural effects can be significant on industry level, while not showing in the overall picture. The case of acidification and solid waste show how efficiency gains and structural changes outweighed the volume increases so that acid emissions and waste significantly decreased between 1987 and 1997/1998 (de Haan, 2000). The decrease of waste seem to be caused by increased incineration of waste.

Also the UK have investigated the trends of CO2 and acidification, between 1990 and 1998 (Harris, 2002, SEEA, 2003). The increasing use of gas and nuclear power in the UK's energy system instead of coal and non-transport oils have offset the increase attributable to economic growth.

In Germany, an analysis mostly dealing with methodological issues also show the production related CO emissions between1993-2000 (Seibel, 2003). These production related emissions have decreased with 30 million tons over the period, partly due to an increase of imported products. Also emissions from housing have gone down, mainly due to a switching of fuels from coal to gas. Transport emissions for private households fell in this period too, due to an increasing use of diesel oil.

In Denmark, (Munksgaard et al, 2000) the CO2 emissions between 1966 to 1992 have been studied. CO2 emissions increased with 7 % in this period, due to the overall growth in private consumption. Factors decreasing the growth were energy conservation in the energy supply and manufacturing sectors. The long time period makes it possible to cover also the time before the oil crisis, and several trends concerning the types of fuel used.

2.2 Two types of analyses

Although being a fairly recent addition to the toolbox in Environmental Accounts, decomposition analysis has been used quite a lot in energy research (Ang 1999, Hoekstra et al 2003). Apparently there are two distinct types of decomposition analysis in this field – Structural Decomposition Analysis (SDA) and Index Decomposition Analysis (IDA).

SDA uses an input–output model. But contrary to regular IOA it is less restricted by the assumptions of constant input–output coefficients as SDA uses data from two or more years to highlight, among other things, varying input–output coefficients.

An IDA usually starts from the output of the sectors to be used which means that IDA measures the direct effects only. SDA, on the other hand, uses the IOA to map output per sector from Final Demand and the indirect effects that emerge when a direct demand increase in one sector leads to increases in the demand for inputs from other sectors. This is captured by the Leontief inverse of the IO-model (Miller & Blair, 1985).

A number of effects can be studied in IDA and SDA. Both analyse *production* effects, i.e. the changes in output from the sectors. The IDA analyze effects from changes in the *structure of production* while the SDA typically analyze the *technological effects* in production that comes through in changes of the input requirements matrix and the Leontief matrix. Both methods analyze *intensity effects*, i.e. the change in energy use or emission per unit ouput. This intensity effect can be further decomposed into *volume of energy use* per sector, *structure of energy use* per sector and *emission intensities* per unit of energy use.

Decomposition analysis can be done either on *levels, intensities* or *elasticities*. SDA almost exclusively work with levels, i.e. explaining the changes in the level of emissions between two periods. IDA can do levels but it is also used frequently for intensities (i.e. emission per output unit) or elasticities (relative change in emissions compared to change in output).

The time frame is very much given by available data. For SDA, the need for complete IO-tables often means that the analysis is done for interval that corresponds to the availability of base year calculated IO tables. IDA is less demanding in terms of data as there are often time-series on sector outputs etc.

One of the key issues in decomposition analysis is the choice of index. There are several options. Both SDA and IDA use the Laspeyres (with base year weights), Paasche (with target year weights) and Marshall–Edgeworth (that use the mean of base and target year weights). The IDA field, on the other hand, has developed indexes such as the conventional Divisia, the refined Divisia and the adaptive weighting Divisia index (Hoekstra et al 2003).

Using the Laspeyre or Paasche index will mean having to deal with a residual effect that is supposed to capture cross effects between the effects themselves. This has to be allocated or explained in the analysis in some way. Dietzenbacher & Los (1998), however proposed not a single index, but rather a range of index combinations that produce a decomposition without a residual. They show that if there are n determinants, then there will be n! different index combinations that lead to complete decompositions assuming Laspeyres or Paasche weights for each determinant variable and that an average over the two polar decomposition forms can be used for a complete decomposition.

De Haan (2002) then showed that these polar forms are not unique in themselves but that an average of all n! forms will give a better estimate. In practise this means weighting with fewer than the n! forms as several appears more than once. This was then further elaborated in Siebel (2003) that developed a more general formulation of these weights.

3 The decomposition approach in this report

3.1 Introduction

The present study was done on data from the Swedish Environmental Accounts using a SDA technique influenced by work by de Haan (2001) and further elaborated in Siebel (2003). Another point of reference for the present study is the work done by Harris (2002) that uses Environmental accounts data for the UK but is more based on an IDA technique. The reason for including the latter type of analysis is the lack of time series IO-data in countries that may well have Environmental Accounts time series.

The focus in this report is not on the methodology and algorithms of decomposition in itself, as that has been dealt with extensively in de Haan (2001) and Siebel (2003). It has a more pragmatic approach in that we apply the basic decomposition technique to available Environmental and National Accounts data and apply different numbers of change factors, look at sector patterns and components of final demand as well as try both IO-based and sector output based decomposition using the same data. A specific analysis of the direct emissions caused by households (and the public sectors) purchases of fuel for heating and transportation is not included in this report.

3.2 Data sources

The Swedish Environmental Accounts have a time series covering 1993-2001. Due to a methodological change for the 2000 figures the present study only uses data for 1993-1999. Furthermore, this time series is divided into two series – one covering 1993-1995 and another covering 1997-1999. There were basically three reasons for this:

1 -The extreme values for 1996, with its low temperature and low water supply for hydro power, will dominate the analysis of the time series.

2 -The growth patterns in the early 1990’s and the late 1990’s are different and therefore interesting to study separately.

3 –The calculations of the Environmental Accounts data for the former period was done more intermittently and the production process has developed over the years. There has also been numerous revisions of parts of the data in recent years that mostly applies to the latter years.

There is no official IO time series for Sweden so it had to be developed within the Environmental Accounts based on the Supply and Use Tables from the national accounts in currents and T-1 prices. This meant allocating the product balances over domestic and imported products to construct yearly IO-tables in both prices. Mostly this was done with simple proportionality assumptions on the product level and deflating accordingly. The tables used covered 134 industries. For the IDA-type of analysis the Value Added for these 134 industries in current and T-1 prices was used.

The Environmental Accounts data used covered fossil fuel use by industry (15 fuels by 134 industries, see appendix 2) in TJ, Emission factors per fuel, calculated emissions to air of CO_2, NO_x, SO_2, CH_4, CO, N_2O, NH_3 and NMVOC, per industry.

3.3 Types of analysis

Building on the work done by de Haan, Harris and Siebel we decided use the following approaches to the decomposition of the Swedish data:

1 – a SDA based analysis on calculated emissions of CO_2, NO_x and SO_2 data from the Environment Accounts.

2 – a SDA based analysis based on Fuel use and emission factors to calculate the emissions.

3 – a IDA based analysis based on Value Added and fuel use akin to what was done by Harris (2002)

The reasons for applying these methods is on the one hand to see what differences they produce using roughly the same data and on the other to see what data requirements they pose. The IDA-based analysis is much less demanding on the data and therefore probably more relevant for many countries that lack such data.

So, with the following abbreviations:

CO2 = CO2 emissions for a given year

CO2/E = CO2 Emission factors by fuel

E/Etot = Composition of fuels in energy use by industry

Etot/O = Total energy intensity per MSek output (Production value) by industry

INV(I-A) = Leontief inverse linking final demand to output in MSek by industry

C/Ctot = Structure of final demand

Ctot = Total final demand

VA = Value Added by industry

VA/VAtot = Structure of production – share of total Value Added by industry

VAtot = Total Value Added

The emissions of CO2 in the three approaches can be calculated as follows:

1 - CO2=CO2/O * INV(I-A) * C/Ctot * Ctot

2 - CO2=CO2/E * E/Etot * Etot/O * INV(I-A) * C/Ctot * Ctot

3 – is done to reflect both 1 and 2 but without the IO-analysis i.e.
CO2= CO2/E * E/Etot * Etot/VA *VA/VAtot *VAtot and
CO2= CO2/VA * VA/VAtot * VAtot

In all cases the evaluation is done on the change in level of emissions so:

For approach 1 it means that:

$\Delta CO2 = \Delta(CO2/O) + \Delta(INV(I-A)) + \Delta(C/Ctot) + \Delta Ctot$

With:

$\Delta(CO2/O)$ = Change in emission intensity

$\Delta(INV(I-A))$ = Change in IO structure

$\Delta Ctot$ = Change in volume of Final Demand

$\Delta(C/Ctot)$ = Change in Structure of Final Demand

$\Delta CO2$ = Actual change

For approach 2 it means that:

$$\Delta CO2=\Delta(CO2/E) + \Delta(E/Etot) + \Delta(Etot/O) + \Delta(INV(I-A)) + \Delta(C/Ctot) + \Delta Ctot$$

With:

$\Delta(CO2/E)$ = Emission factors – not included as they do not vary over the periods[1]

$\Delta(E/Etot)$ = Change in fuel mix

$\Delta(Etot/O)$ = Change in fuel intensity per industry

$\Delta(INV(I-A))$ = Change in IO structure

$\Delta Ctot$ = Change in volume of Final Demand

$\Delta(C/Ctot)$ = Change in Structure of Final Demand

$\Delta CO2$ = Actual change

For approach 3 it means that:

$$\Delta CO2= \Delta(CO2/VA) + \Delta(VA/VAtot) + \Delta Vatot$$

and

$$\Delta CO2= \Delta(CO2/E) + \Delta(E/Etot) + \Delta(Etot/VA) + \Delta(VA/Vatot) + \Delta VAtot$$

With:

$\Delta(CO2/VA)$ = Change in emission intensity per MSEK Value Added by industry

$\Delta(VA/VAtot)$ = Changes in structure of Value Added

$\Delta VAtot$ = Changes in total Value Added

$\Delta(CO2/E)$ = Emission factors – not included as they do not vary over the periods (see comment on the former page)

$\Delta(E/Etot)$ = Change in fuel mix

$\Delta(Etot/VA)$ = Changes in Energy intensity by industry Value Added

$\Delta CO2$ = Actual change

[1] The Swedish EPA have chosen not to update the emission factors for the official emission figures. In the future this is however planned and then it can be included in the analyses.

All calculations were done using the full IO- and Environmental Accounts tables (134 industries) and comparisons were made stepwise using current and T-1 prices matrices as shown in de Haan (2001).

In the following tables the results for each period is the accumulated change between over the period, i.e. 1993-1995 or 1997-1999.

The calculations are based on the two polar decomposition forms of Dietzenbacher & Los (1998) or Munksgaard et al (2000) rather than the more elaborate weighting system proposed in de Haan (2001) and Siebel (2003), as the differences between the methods did not show any significant differences for Swedish data. See Appendix 1 for a comparison.

4 Results

4.1 Introduction

The following chart shows a decomposition of Swedish Environmental Accounts data for CO2 over the time period 1993-1999 using the four factors of approach 1 above (Figure 3). The bars illustrate the contribution from each of the four factors and the line shows the actual development in emissions of CO2 with 1993 as a base year.

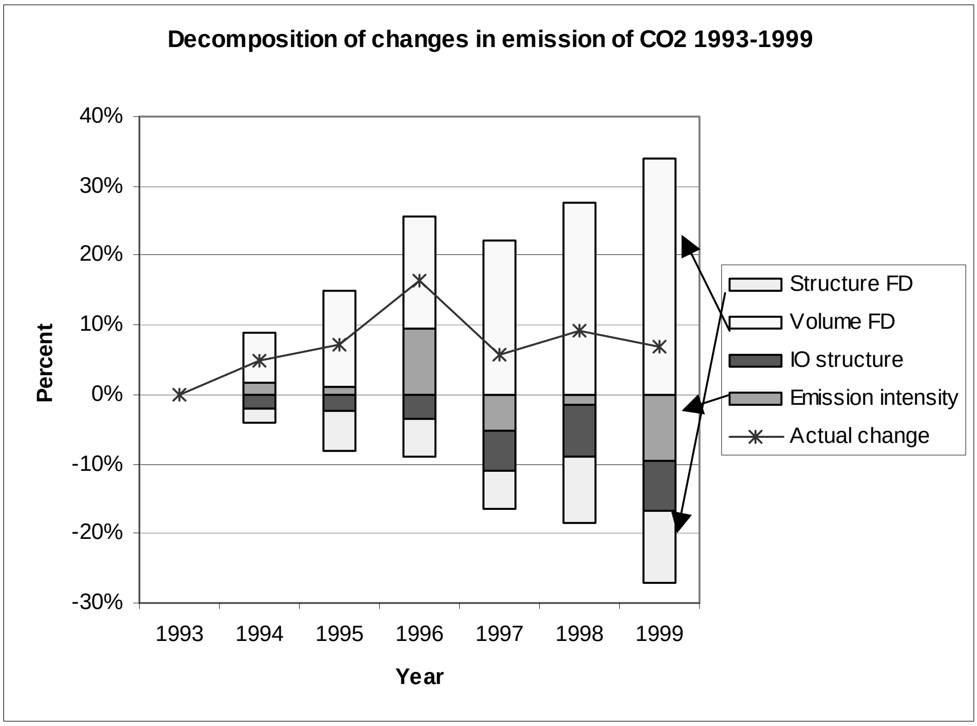

Figure 3. Decomposition of CO2 emissions 1993-1999

The structural change in Final Demand and the IO-structure over the period has had a dampening effect on CO2 emission while emission intensities (emissions per MSEK Output) contributed to the increase in emissions in the earlier period and held them back in the latter part of the period. Compared to Figure 1 this shows the same decoupling tendency but now with estimates of how this decoupling is composed.

In the following tables we look at the same data in more ways, varying the number of factors, looking at components of final demand and over production sectors. All results are presented for two periods 1993-1995 and 1997-1999, excluding the extreme year 1996.

The first set of tables are based on Approach 1 with an IO-based analysis and four factors i.e. $\Delta CO2 = \Delta(CO2/O) + \Delta(INV(I-A)) + \Delta(C/Ctot) + \Delta Ctot$

4.2 Approach 1 – IO-based using emissions

The first set of results show the changes in CO2 emissions for the two periods for Total Final Demand and for Private Consumption and Export. The increase in domestic emissions over the two periods is increasingly linked to Swedish exports.

		Emission intensity	IO structure	Volume FD	Structure FD	Actual change	In other countries
TotFD	1993-1995	525	-1045	5908	-2372	3017	2211
	1997-1999	-1769	-591	5071	-2170	541	3127
Priv Cons	1993-1995	-236	-230	390	-110	-186	-83
	1997-1999	-824	-77	728	-97	-270	683
Export	1993-1995	685	-430	5064	-2630	2689	1835
	1997-1999	-621	-467	4030	-2410	533	1938

Table 4.1 Domestic and external emissions of CO2 by Final Demand Component (KTon). The last column shows the emissions in other countries due to Swedish imports, which was calculated separately.

The last column in the table shows the calculated emissions in other countries due to import of products both for intermediate use and for final use. This is done using the method proposed by de Haan (2002), which means using the domestic production and energy structure to calculate the emissions caused in other countries. According to SCB (2002) this will most likely lead to an underestimation of the emissions. There appear to be an outsourcing of emissions from the Swedish production system, which is especially apparent for private consumption.

The next step is to look at these factors on a more disaggregated level in terms of production. In the following table the figures for total Final Demand has been addressed for a number of sectors or industry groups. The changes among these over the four factors add up to the total (Tot FD) in the table above.

The aggregation of industries is Basic Industries (NACE 01-05, 13-14), Manufacturing (NACE 15-39 excl 23), Transport (NACE 60-641), Energy (NACE 10-13, 23, 40) Building/Housing (NACE 45,70), Services (NACE 502, 55, 642-67, 71-95), Whole-/Retail trade (NACE 50-52 excl 502).

		Emission intensity	IO structure	Volume FD	Structure FD	Actual change
Basic Ind	1993-1995	71	-76	329	-132	193
	1997-1999	-40	-36	284	-268	-59
Manufacturing	1993-1995	9	-425	1878	318	1781
	1997-1999	-708	-422	1557	-771	-344
Transport	1993-1995	1299	-130	1428	-1365	1232
	1997-1999	145	87	1376	-298	1310
Energy	1993-1995	-377	-253	1410	-923	-142
	1997-1999	-874	-219	1074	-736	-756
Building/Housing	1993-1995	-33	-37	358	-369	-80
	1997-1999	-96	-31	279	-155	-2
Services	1993-1995	-115	-133	288	69	108
	1997-1999	-46	38	281	7	280
Whole-/Retail	1993-1995	-331	8	217	30	-76
	1997-1999	-150	-8	221	50	112

Table 4.2 Total domestic emissions of CO2 by sector (Kton)

In terms of actual change the domination of transportation is evident, particularly in latter period.

The increase attributed to the emission intensity for the first period in the aggregated table above can be found in the transportation sector.

In the latter period the remaining factors manage to counteract the volume increase for basic industries, manufacturing and energy. For the first period, this is only the case for Building/Housing and Whole-/Retail.

As Transportation played a key role in the development in the table above one can assume that this should be more emphasized when splitting CO2 emissions into stationary and mobile sources. The first tables below show the development in terms of CO2 emissions from stationary sources.

		Emission intensity	IO structure	Volume FD	Structure FD	Actual change
TotFD	1993-1995	-383	-566	2973	-946	1079
	1997-1999	-1692	-534	2392	-1372	-1207
Priv Cons	1993-1995	-170	-96	239	-91	-118
	1997-1999	-789	-115	418	-218	-703
Export	1993-1995	-183	-271	2294	-840	1000
	1997-1999	-551	-334	1748	-1176	-312

Table 4.3 Domestic emissions of CO2 (Stationary sources) by Final Demand Component (KTon)

On the aggregate level the actual increase in the first period is almost entirely linked to Export, with structural changes in demand and IO-structure not being able to counteract the effects from increasing final demand volumes (Table 4.3).

The latter period shows an actual decrease which is almost entirely due to Private Consumption and the dominant effect in terms of change in emission intensity, IO and structure of final demand.

In the latter period, the major contributors to stationary emissions of CO2 – manufacturing and energy – show a positive development in terms of relative sharp decreases of emissions compared to the earlier period (Table 4.4). This is due to counteracting effects in both emission intensities, IO and Final Demand structure.

		Emission intensity	IO structure	Volume FD	Structure FD	Actual change
Basic Ind	1993-1995	17	-6	114	-28	97
	1997-1999	-70	-14	98	-109	-95
Manufacturing	1993-1995	157	-269	1210	155	1254
	1997-1999	-459	-294	1019	-503	-237
Transport	1993-1995	-26	-2	11	-3	-20
	1997-1999	-41	-2	9	-2	-36
Energy	1993-1995	-362	-255	1398	-915	-135
	1997-1999	-876	-216	1064	-729	-757
Building/Housing	1993-1995	-83	-22	163	-153	-95
	1997-1999	-57	-20	116	-65	-25
Services	1993-1995	-16	-13	47	-6	13
	1997-1999	-44	13	49	27	44
Whole-/Retail	1993-1995	-71	1	30	4	-35
	1997-1999	-144	-1	37	9	-100

Table 4.4 Total domestic emissions of CO2 (Stationary Sources) by sector (KTon)

Turning to CO_2 emissions from mobile sources the picture changes radically. Both in terms of the over all development of the emissions and the sectors involved (Table 4.5).

The actual changes in emissions from mobile sources increased in both periods and more so in the latter. Being almost entirely caused by the changes linked to Exports in the first period, both exports and private consumption contributes to the increase in the latter period. The only counteracting effect for total Final demand in the latter period was the structure of Final demand.

		Emission intensity	IO structure	Volume FD	Structure FD	Actual change
TotFD	1993-1995	940	-321	2348	-1526	1440
	1997-1999	270	62	2192	-553	1970
Priv Cons	1993-1995	-110	-112	135	-17	-104
	1997-1999	72	48	279	126	525
Export	1993-1995	1062	-104	2154	-1734	1378
	1997-1999	59	-25	1814	-902	946

Table 4.5 Domestic emissions of CO_2 (Mobile sources) by Final Demand Component (KTon)

Over all, CO_2 emissions from mobile sources, i.e. transportation is driving the development in terms of total CO_2 emissions (Table 4.6). The positive effects in terms of emissions intensities and structural changes that contribute to the more positive for stationary sources is eaten up by the changes in mobile sources.

If the direct emissions from mobile sources for households is added to the analysis this would further increase the negative development over the latter period. An analysis of the environmental pressures of households is presented in a separate report where this development is also traced over household types.

		Emission intensity	IO structure	Volume FD	Structure FD	Actual change
Basic Ind	1993-1995	57	-69	213	-104	97
	1997-1999	46	-23	184	-159	48
Manufacturing	1993-1995	-125	-2	106	52	30
	1997-1999	-38	-7	83	-20	19
Transport	1993-1995	1337	-127	1415	-1362	1262
	1997-1999	184	90	1365	-296	1343
Energy	1993-1995	-14	3	9	-5	-7
	1997-1999	0	-2	6	-5	0
Building/Housing	1993-1995	45	-14	188	-207	12
	1997-1999	-80	-11	157	-87	-20
Services	1993-1995	-100	-118	235	75	92
	1997-1999	23	21	227	-24	247
Whole-/Retail	1993-1995	-260	6	181	25	-47
	1997-1999	133	-7	169	38	333

Table 4.6 Total domestic emissions of CO2 (Mobile Sources) by sector (KTon)

The type of analysis presented above can also be made for all variables calculated in the environmental accounts as the formats and links to the IO-tables are the same.

In the following tables the decomposition analysis over components of final demand is done for total emissions of SO2 and NOx, i.e:
$\Delta SO2 = \Delta(SO2/O) + \Delta(INV(I-A)) + \Delta(C/Ctot) + \Delta Ctot$ and
$\Delta NOx = \Delta(NOx/O) + \Delta(INV(I-A)) + \Delta(C/Ctot) + \Delta Ctot$

Comparing the results with the ones obtained above for CO2, the development for SO2 is positive over both periods with actual reductions in total SO2 emissions. All factors counteract the pull from the volume of Final Demand (Table 4.7).

		Emission intensity	IO structure	Volume FD	Structure FD	Actual change
SO2						
TotFD	1993-1995	-7269	-1703	10785	-7241	-5427
	1997-1999	-12975	-986	8132	-3345	-9173
Priv Cons	1993-1995	-2015	-307	577	-305	-2050
	1997-1999	-3044	-80	960	-332	-2496
Export	1993-1995	-5126	-758	11315	-9291	-3860
	1997-1999	-6628	-888	7615	-4899	-4800
NOx						
TotFD	1993-1995	-4521	-7397	40630	-26874	1838
	1997-1999	-25327	78	34371	-9997	-874
Priv Cons	1993-1995	-6538	-2558	2527	-1294	-7863
	1997-1999	-9375	729	4220	2177	-2250
Export	1993-1995	5519	-1974	37461	-29184	11822
	1997-1999	-10581	-1083	31068	-18218	1186

Table 4.7 Domestic total emissions of NOx and SO2 by Final Demand Component (Ton)

The same holds for Private Consumption linked emissions of NOx although it appears to decline between the periods. The demand from private consumption and export pull in opposite directions with regards to NOx emissions. The big increase in the early period for export related emissions is mainly caused by deteriorating emission intensities – on par with the opposite effect from emission intensities in private consumption related emissions of NOx. Note that Private Consumption related emissions of NOx is enforced by both IO- and Final Use structure. Due to the dominant role of emissions from mobile sources in NOx these results can perhaps best be compared with the results on CO2 emissions from mobile sources above. There are similarities in these patterns.

4.3 Approach 2 – IO-based with fossil fuel use

The calculations above were made with IO-models linked to emissions directly through emission factors that represent emissions in tonnes per MSEK in production value per industry.

This means that changes in these emission factors cover changes in three variables – the total volume of fuels used, the structure of fuels used (mix of fuel types) and the emission coefficients by fuel type.

In order to capture these changes another set of runs were made with the following factors (called approach 2)

$\Delta CO2=[\mathit{\Delta(CO2/E)}\ ] + \Delta(E/Etot) + \Delta(Etot/O) + \Delta(INV(I\text{-}A)) + \Delta(C/Ctot) + \Delta Ctot$

The emission factors were excluded as they were identical through the periods. These figures are not identical to the ones presented above for changes in CO2 using the emission coefficients directly (approach 1). The present calculations use the fuel uses directly without the adjustments that are made in the accounts for the emission figures. This leads to discrepancies mainly in the latter period, that would indicate that there are some methodological changes in the calculations of emissions. Some of this has to do with the adjustments for process emissions and a coming revision of the environmental accounts time series will focus on this area to get a more transparent linkage between the fuel based calculations and the published emissions.

		Fuel mix	Fuel volume	IO structure	Volume FD	Structure FD	Actual change
TotFD	1993-95	-985	945	-1024	5853	-2073	2716
	1997-99	-83	910	-772	5105	-2324	2835
Priv Cons	1993-95	-698	319	-219	377	-104	-326
	1997-99	-69	-348	-105	721	-91	107
Export	1993-95	-61	512	-469	5259	-2678	2562
	1997-99	-3	1311	-566	4204	-2480	2467

Table 4.8 Domestic total emissions of fossil fuel based CO2 by Final Demand Component (KTon)

Apart from the fact that there are differences in the actual emissions, especially in the latter period, it is also evident that the fuel based decomposition gives slightly different weights to the changes in the factors that appear in both methods – IO structure, Volume and structure of Final Demand (4.8). The main change between the two types of analysis lies in the fuel volume (or intensity) and mix compared to the emission intensity factors in the earlier result where there was a contribution to emissions from the emission intensities in the first period, mainly from exports demand. In the fossil fuel based calculations this is replaced with a slight negative over all effect due to the strong dampening effect of the fuel mix – mainly due to the demand from Private Consumption.

		Fuel mix	Fuel volume	IO structure	Volume FD	Structure FD	Actual change
Basic Ind	1993-95	-8	81	-75	327	-132	193
	1997-99	-16	-8	-37	282	-268	-47
Manufacturing	1993-95	202	-633	-417	1880	589	1621
	1997-99	-65	1460	-598	1589	-906	1479
Transport	1993-95	-36	1344	-129	1420	-1361	1239
	1997-99	60	78	89	1364	-291	1301
Energy	1993-95	-1195	697	-246	1384	-911	-270
	1997-99	-144	-350	-226	1111	-763	-372
Building/Housing	1993-95	-58	19	-35	347	-357	-85
	1997-99	4	-119	-28	272	-151	-22
Services	1993-95	23	-143	-130	283	69	101
	1997-99	28	-56	36	279	7	294
Whole-/Retail	1993-95	88	-420	8	212	30	-83
	1997-99	50	-96	-8	209	47	203

Table 4.9 Domestic total emissions of fuel based CO2 by sector (KTon)

Looking at the industry break down the major differences come back in the manufacturing sectors (Table 4.9). For the latter period, a dampening effect of the emission coefficients of the first analysis has been turned into quite a substantial contributing factor. This has to be further analyzed in the revision of the series.

4.4 Non-IO method with emissions and fuel use

The final exercise is done without the IO-model. The idea is to use the Use-table and the fuel/emissions data directly – more in line with a IDA than a SDA. The data requirements are therefore much lower.

The two methods used to calculate the results without an IO-table are reflections of the ones used with the IO-based analysis. One is done directly on the calculated emissions and the other use the fossil fuel use data combined with emission coefficients per fossil fuel type. So the two types are:

$$\Delta CO2= \Delta(CO2/VA) + \Delta(VA/VAtot) + \Delta VAtot$$

and

$$\Delta CO2= \Delta(CO2/E) + \Delta(E/Etot) + \Delta(Etot/VA) + \Delta(VA/Vatot) + \Delta VAtot$$

Beginning with the three factor analysis on calculated emissions (Table 4.10) and comparing it to the results in the IO-based analysis, it is evident that the share of the change that is attributed to the emission intensity is greater in the first period using this simpler approach. On the other hand it contribute less in the second period. The share attributed to the changes in the structure of production (VA) in the first period is roughly equal to the sum of the structural elements (IO and FD) in the IO-based analysis. For the second period the differences are large in terms of the contribution from structural change.

	Emission intensity	Structure VA	Volume VA	Actual change
1993-1995	947	-3407	5477	3017
1997-1999	-71	-3905	4516	541

Table 4.10 VA-based Domestic total emissions of Total CO2 by sector (KTon)

In the four factor analysis, compared to the IO-based one earlier there are also differences. The contributions from the changes in the volume of fuels used is substantially larger in the simpler method (Table 4.11). The contribution from the structural factor is much larger in the simpler version in the latter period.

	Fuel mix	Fuel volume	Structure VA	Volume VA	Actual change
1993-1995	-1003	1501	-3219	5436	2716
1997-1999	-179	2614	-4163	4562	2835

Table 4.11 VA-based Domestic total emissions of fuel based CO2 (KTon)

One source of difference between the IO-based and VA based methods is of course that the latter use VA-based emission or fuel intensities while the former uses production based intensities.

5 Concluding remarks

Decomposition analysis can be used to look behind the numbers that are presented in the time series of the environmental accounts. Whether or not a decoupling is taking place over time, decomposition analysis can contribute to the understanding of the forces at work and possibly also to policy relevant measures.

This analysis shows the importance of transportation as a sector with increasing emissions, similar to what has been shown in other countries such as the UK. The importance of the level, composition and structure of Final Demand and of the import and export patterns are also evident. To assess these latter influences the Supply-Use tables do not give enough information.

Another important aspect of the different versions of decomposition analysis presented here is that it can function as a tool for assessing the methods and production process involved in calculating the emissions that are published in the environmental accounts. The discrepancies found between the two IO-based approaches clearly indicates that there are adjustments made in the calculations that needs to be reviewed. This should be done on a continuous basis in the future.

As for the non-IO based methods (especially when based on Value Added intensities) they do yield different results. It is probably not a question of choosing between them, but rather that the data demands posed by the IO-based method makes the choice for you. If possible, it is of course interesting to be able to include the effects of changes in final demand and the IO-structure. But with non-existing or intermittent time series IO-tables the simpler method does provide a focus for some of the factors involved in the changes in emissions over time.

The presentation of the results from decoupling and decomposition analyses should preferably be done both in tables and in graphical time series. The graphical time series are more easy to understand for those not involved in the methods. A decoupling can have many explanations and it is interesting to compare those studies that have already been made, since the trends and energy systems in the countries are different.

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Appendix 1

Comparison of results for the different decomposition methods on Swedish data. CO2 emissions from Final demand.

		Emission intensity	IO structure	Volume FD	Structure FD	Actual change
Using the two polar forms of Dietzenbacher & Los						
Total	1993-1995	525	-1045	5908	-2372	3017
	1997-1999	-1769	-591	5071	-2170	541
Basic Ind	1993-1995	71	-76	329	-132	193
	1997-1999	-40	-36	284	-268	-59
Manufacturing	1993-1995	9	-425	1878	318	1781
	1997-1999	-708	-422	1557	-771	-344
Transport	1993-1995	1299	-130	1428	-1365	1232
	1997-1999	145	87	1376	-298	1310
Energy	1993-1995	-377	-253	1410	-923	-142
	1997-1999	-874	-219	1074	-736	-756
Building/Housing	1993-1995	-33	-37	358	-369	-80
	1997-1999	-96	-31	279	-155	-2
Services	1993-1995	-115	-133	288	69	108
	1997-1999	-46	38	281	7	280
Whole-/Retail	1993-1995	-331	8	217	30	-76
	1997-1999	-150	-8	221	50	112

		Emission intensity	IO structure	Volume FD	Structure FD	Actual change
Using average over all 24 forms						
Total	1993-1995	528	-1043	5900	-2368	3017
	1997-1999	-1766	-593	5068	-2168	541
Basic Ind	1993-1995	72	-76	329	-132	193
	1997-1999	-40	-36	284	-268	-59
Manufacturing	1993-1995	10	-423	1874	320	1781
	1997-1999	-707	-423	1556	-771	-344
Transport	1993-1995	1301	-129	1425	-1364	1232
	1997-1999	148	86	1373	-296	1310
Energy	1993-1995	-377	-253	1410	-923	-142
	1997-1999	-875	-219	1074	-736	-756
Building/Housing	1993-1995	-33	-37	358	-369	-80
	1997-1999	-96	-30	279	-155	-2
Services	1993-1995	-115	-133	287	69	108
	1997-1999	-46	38	281	7	280
Whole-/Retail	1993-1995	-331	8	217	30	-76
	1997-1999	-150	-8	221	50	112

Appendix 2

Fossil fuels covered in the calculations:

Res. fuel oil (EO1)

Res. fuel oil (EO2-5)

Propane (LP-gas)

Gas works gas

Natural gas

Coke oven gas

Blast furnace gas + LD gas

Coal

Coke

Waste

Motor gasoline

Jet gasoline

Kerosene for air transports

Diesel oil

Other kerosene

The Nace coded industries.

1	18	271	321	55	71
2	19	272	322	601	72
5	201	273	323	6021	73
10+11+12	202	274+275	331	6022	741
131	203	281	332+333	6023	742+743
132	204	282+283	334+335	6024	744
14	205	284+285	341	603	745-748
151	2111	286	342	61	75
152	2112	287	343	62	80
153	212	291	351	631	851
154	221	292	352	6321	852
155	222+223	293	353	6322	853
156	23	294	354+355	6323	90ex90001
157	241+242	295	361	633	91
1581	243	296	362+363	634	92
1582	244	297	364-366	641	93
1583	245	300	39	642	95-99
1584	246+247	311	37	65	private consumption
1585-1589	251	312	401,403	66	NGOs
159	252	313	402	67	Public
160	261	314	410+90001	small houses 702	
171-173	262-264	315	45	other 702	
174-177	265+266	316	502	701+703	
	267+268		other50-52		