PROJECT N. 037033

EXIOPOL

A NEW ENVIRONMENTAL ACCOUNTING FRAMEWORK USING EXTERNALITY DATA AND INPUT-OUTPUT TOOLS FOR POLICY ANALYSIS

TECHNICAL REPORT: Policy impact assessment – resources, products and imports and exports

Deliverable: IV.2.b

Report of the EXIOPOL project

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Preamble

EXIOPOL ("A New Environmental Accounting Framework Using Externality Data and Input-Output Tools for Policy Analysis") is an Integrated Project set up by FEEM and TNO with funding from the EU's 7th Framework Program. It runs between March 2007 and 2011. The main project set-up is in three content clusters, one on externalities modelling (Cluster II), one on a SUT/IO accounting framework with environmental extensions (Cluster III), and one on using the combined result in modelling for decision support (Cluster IV). Furthermore, one overarching cluster is dedicated to keeping the scope of this conceptually complex project focused (Cluster I), one is reserved for management (Cluster VI), and a final one is for dissemination of results (Cluster V).

This technical report reflects the following deliverable, named: Policy impact assessment – resources, products and imports and exports

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Executive Summary

This technical report reflects the following deliverable, named: DIV.2.b: Policy impact assessment – resources, products and imports and exports. This report is build up in 2 main parts.

Part I analyses the life cycle impacts of final consumption for the EU27. It further will indicate how much of these impacts take place outside Europe, and how impacts are embodied in Europe's exports. The findings confirm the results found in reviews of e.g. Tukker (2006) and Hertwich (2005) as well as a recent Resource Panel report (UN, 2010). It is quite obvious that food products, mobility related expenditures, expenditure on housing, and energy using products dominate the impacts of final consumption. The analysis further shows that Europe is a net importer of natural resources via trade. This is particularly true for land and water. The land use embodied in trade is higher as the land use in Europe itself. There is also a significant material imports embodied in trade. For energy and greenhouse gases, we see that the flows embodied in imports and exports are relatively close. A striking finding of this study is as well that the external costs creating by our current economic system are significant. The externality assessment in our study is far from complete, neglecting for instance the value of ecosystem services and biodiversity. Emission related impacts alone create an amount of damage costs that is 7% of the global GDP, mainly due to climate impacts and respiratory health effects.

Part II does an analysis of the improvement the MR EE IO approach of the EXIOPOL database implies compared to other approaches of assessing pollution embodied in imports, most notably the 'domestic technology assumption'. The partial *specification* errors relate to using domestic emission coefficients instead of country-specific coefficients, and to using a single-country IO framework instead of an intercountry one. The empirical outcomes show that for CO_2 emissions the large percentage errors in general have a positive sign and hence overestimate emissions when domestic emission coefficients are applied. The partial *aggregation* errors relate to aggregating the 129 EXIOPOL sectors to the 59 EU-sectors, to 10 aggregate sectors, and to aggregating the remaining 42 countries of each of the 43 EXIOPOL countries to, respectively, 4 broad regions and a single large 'Rest of the World'. The empirical outcomes show that the aggregation of sectors has a larger impact on the errors made in the estimation of water use than the errors made in the estimation of CO_2 emissions. This holds when looking at the results for both the four final demand categories and for countries. The larger errors are found for the aggregation from 59 to 10 sectors compared to the aggregation of 129 to 59 sectors.

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1 Introduction

1.1 Aim and structure of this report

This technical report reflects the following deliverable, named: DIV.2.b: Policy impact assessment – resources, products and imports and exports. The aim of the deliverable is to assess the following issues:

1. Estimates of life cycle environmental impacts, full cost and external costs of the final consumption in the EU and/or output of different sectors, as well as the use of natural resources. Here, the EE I-O database will be used in very much the same way as in the study Environmental Impacts of Products (EIPRO). It will identify hot spots in the economic system from a product and consumption perspective, relevant for policy dossiers such as Integrated Product Policy and Sustainable Consumption and Production. The analysis will for instance point at products for which 'the price is not yet right', for which there is a significant difference in total costs (including external costs) and costs paid by the consumer. It concerns a rather straightforward task once the full database produced in Cluster III is ready.
2. Estimates of environmental impacts, full costs and external costs embodied in the EU's imports versus the EU's exports. We will compare results achieved via older default assumptions (import to the EU is made with domestic technology) and make full use of the global database (i.e. specific technologies for countries exporting to the EU). This question echoes the breakthrough initial IO analyses of Leontief, in which he showed that unlike expected the 'embodied labour' in products exported from the US was relatively high. The analysis we propose here may point at types of products the EU could produce from a the perspective of competitiveness and sustainability.

This report is build up in 2 main parts. Part I will analyse most of the questions above, providing for the EU27 an analysis of the life cycle impacts of final consumption (point 1). It further will indicate how much of these impacts take place outside Europe, and how impacts are embodied in Europe's exports (part of point 2). Part II will furthermore do a more extensive analysis of the improvement the MR EE IO approach of the EXIOPOL database implies compared to other approaches of assessing pollution embodied in imports.

1.2 Overview of the Exiobase database

The EXIOPOL project was launched in view of significant limitations in existing data sources in the field of MR EE SUT and IOT. National Statistical Institutes (NSIs) provide SUT and IOT for single countries, without trade links. Sector and product detail is not as good as it ought to be. Environmental extensions are often lacking or include only a few types of emissions and primary resource uses. There is little or no harmonization of sector and product classifications across different countries. It is therefore difficult to assess the extent to which a country induces environmental impacts abroad via trade, let alone trends therein. Trade-linked tables are also essential for analyzing the effects of sustainability measures taken in Europe on Europe's economic competitiveness. From a theoretical viewpoint, the MR EE IO approach is best way of taking trade into account, but existing studies tend to be aggregated at sector and regional level and to focus on a fairly small number of environmental extensions.

The EE I-O work in EXIOPOL sought to make a crucial advance in finding a solution to this problem. The project's aim was really to leapfrog: it would give the EU a fully-fledged, detailed, transparent, public, global MR EE I-O database with externalities, allowing for numerous types of analyses for policy support purposes. In short, the following steps were taken

1. Harmonizing and detailing SUT
    a. Gathering SUT from the EU27 via Eurostat, and other SUT and IOT from 16 other countries (covering in total 95% of the global GDP). Gap filling of missing European SUT via 'same country assumption'. For non EU countries with only IOT, converting IOT into SUT by assuming a diagonal Supply table.
    b. Constructing Use tables in basic prices via reversed engineering or distributing valuation columns from the Supply table proportionally in the Use table. Adjusting various specific issues in non EU countries
    c. Harmonizing and detailing SUT with auxiliary data from FAO and a European AgriSAMS for agriculture, the EIA database for energy carriers and electricity, various resource databases for resources, etc.
2. Harmonizing and estimating extensions
    a. Allocating available resource extraction data (e.g. FAOSTAT, Aquastat) to industry sectors
    b. Allocating the International Energy Agency database for 60 energy carriers to sectors of use. Estimating emissions on the basis of energy and other activity data and TNOs TEAM model
3. Importing all data in EXIOBASE developed by CML, a specially constructed database system with extensive reporting on errors and inconsistencies allowing for iterative improvement of the database.

4. Linking the country SUT via trade
    a. Splitting of Import Use tables and allocating imports to countries of exports using UN COMTRADE trade shares
    b. Confronting the resulting implicit exports with exports in the SUT, adjusting differences and rebalancing via RUGs GRAS procedure
5. Transforming the global, MR EE SUT into a global, product by product MR EE IOT and an industry by industry MR EE IOT based on technology assumptions suggested by the Eurostat IO Manual (Eurostat, 2008).

The result of the former steps is visualized in Figure 1.1: the EXIOBASE database. In essence it consists of three blocks:

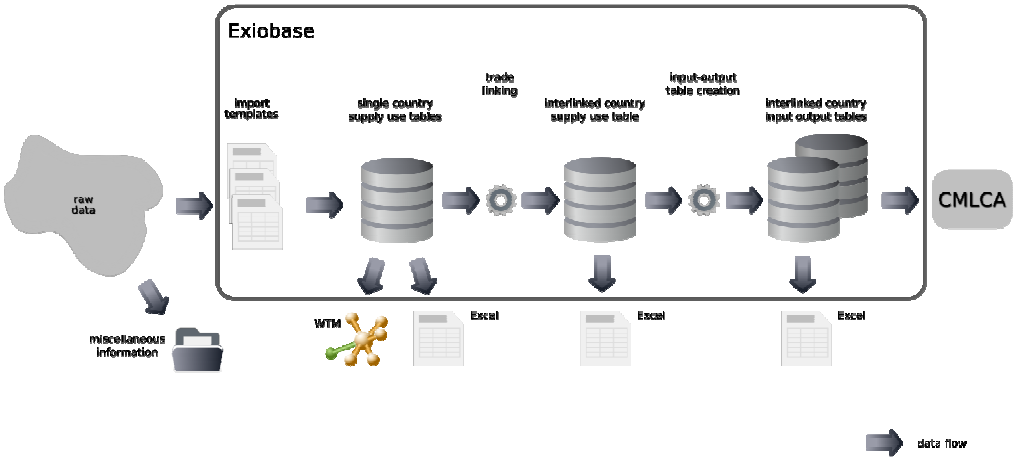
1. Block 1: a storage facility for the single country environmentally extended supply-use data. Into this block all data from the harmonization steps are imported and EE SUT for countries are created
2. Block 2: the storage of the international supply-use table (interlinked supply-use table or MR EE SUT) and
3. Block 3: the storage of the international input-output table (interlinked country input-output table or MR EE IOT).

Between block 1 and 2 a script is installed that performs the trade linking procedure as described in section discussed above. Since most analytical applications use IOT rather than SUT, another script creates in Block 3 the MR EE IOT (both of industry by industry as product by product MR EE IOTs). The MR EE SUT and MR EE IOTs that are available have the following characteristics:

- Covering 43 countries (95% of the global economy) and a Rest of World (the other 150+ countries in the world combined)
- Distinguishing 129 industry sectors and products
- Covering 30 emitted substances and 80 resources as extensions by industry.
- Full trade matrices: insight is given into which product from which country is exported to which industry sector in another country.

We refer to the reports produced as part of Cluster III of EXIOPOL for further details.

Figure 1.1: The EXIOBASE system



Part I: Impacts of European final consumption and pollution embodied in imports and exports

Arjan de Koning, Reinout Heijungs (CML) and Arnold Tukker (TNO)

2 Analysing impacts of final consumption

The final result of the steps indicated in the Introduction is in essence a global economic input-output database with environmental extensions by industry. Calculating impacts related to final consumption is a well known exercise and is done as follows.

An input-output model describes how supply x follows demand with the following identity:

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f}$$

In this x is total output, A the matrix of direct input coefficients and f the vector of final demand. Solving the model for output gives (Miller & Blair, 2009):

$$\mathbf{x} = \left(\mathbf{I} - \mathbf{A}\right)^{-1}\mathbf{f} = \mathbf{L}\mathbf{f}$$

The matrix $(\mathbf{I} - \mathbf{A})^{-1}$ is commonly referred to as the Leontief-inverse and denoted by **L**., the multiplier matrix of direct and indirect industry output requirements per unit of final demand. In the Leontief quantity model, from which the backward multipliers are derived, the assumption is made that prices are fixed in the short term. Another assumption in IO modeling is that input coefficients do not change regardless of output, final demand, or other relevant changes. The structure of the economy is taken to be constant, at least in the short term.

The environmental extensions are given as a matrix of direct impact coefficients $\mathbf{D} = d_{kj}$ of which each element represents the amount (in physical units per Euro worth of output) of the environmental factor k used in the production of sector j. These environmental extensions can be emissions, pollution, raw material, land use, water use, etc. The total requirement of environmental factors x^E can be calculated as:

$$\mathbf{x}^E = \mathbf{D}\mathbf{x} = \mathbf{D}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{f}$$

For an international input-output table the same equation holds, where x is now a vector of all individual country sub vectors x_R, for all countries R.

The total requirement of environmental factors x^E (both resources as emissions/sinks) signifies the dependency of a sector on environmental resource inputs. Resource use and emissions may take place domestically, but especially for the countries that do are not endowed with material resources, these requirements will be imported.

3 Indicators used

EXIOBASE contains over 100 extensions and it is not useful to show all of them invidiually. We hence have used a number of well-known indicators that express all resource uses and emissions in a more aggregated form. These include:

- Life cycle impact assessment indicators, most notably Global Warming Potential, Acidification and Eutrophication. These indicators aggregate substances emitted (mainly to air) to type of impact. We refer to Guinee et al. (2002) for approach and weighting factors to aggregate emissions.
- Material flow indicators, most notably Total Material Requirement. This indicator simply adds up all resource extractions in ton.
- Land use. This indicator simply calculates the land occupation (mainly for agricultural products).
- External costs. In a separate EXIOPOL report, external cost factors by industry sector by country and by emitted substance have been calculated. This allows calculated the external costs for all emissions of an industry, taking into account specificities such as average population density in a country, and if the substance is emitted from a very low, low or high stack (which has implications for how far emissions are distributed). These cost factors mainly relate to air emissions. In essence the approach implies:
    - For European countries, damage costs are calculated to human health, loss of crop yields, ecosystem health (PDFs) and climate change. Using stack height categories and an assessment if the emission takes place in rural or urban regions, by country diffusion patterns of air emissions are calculated.
    - For non EU countries, due to the lack of externality data they have been calculated with European data corrected with purchasing power parities.

4 Results by indicator

4.1 Introduction

Because EXIOBASE covers the global economy it is possible to create a complete regionalized picture of the impacts related to all economic activities. The emissions as a result of the operation of the world economy can be been subdivided into four different parts, see Figure 4.1.

Ee) emissions within the EU as a result of the final consumption of the EU

Ne) emissions outside the EU as a result of the final consumption of the EU which might be labeled emission embodied in imports to satisfy EU final demand.

En) emissions within the EU as a result of the final consumption of non-EU countries which might be labeled as emissions embodied in exports of the EU.

Nn) emissions outside the EU as a result of the final consumption of the non-EU countries

The emissions on European territory are the sum of Ee + En and are indicated by E. Emissions outside Europe are the sum of Ne + Nn indicated by N. Finally the emissions related to final consumption of Europe are the sum of Ee + Ne. The impacts related to EU final consumption are hence equal to impacts in its territory (E) plus imported impacts (Ne), minus exported impacts (En).

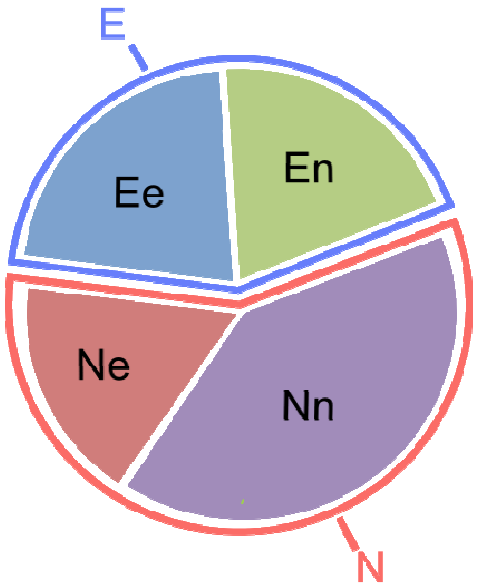


Figure 4.1: Impacts in the EU (E) and non EU (N) and impacts embodied in trade from the Non EU to the EU (Ne) and from the EU to non EU (En)

In the sections below we do an analysis of the impacts on selected indicators for the total European final demand, the non-European final demand, and related to the imports and exports from and to Europe. For the purpose of readability we give aggregated data and figures only. Summary results are provided in Figures 4.2, 4.3 and Table 4.1. In annexes to this report, we have provided more detailed tables providing results for each of the 129 final demand categories. The analyses have been made with the industry by industry MR EE IOT. We start with a discussion on final demand, followed by one on external costs, various resource-related indicators and various emission related indicators. Note that throughout this report we define 'Europe' as the ensemble of 27 countries making up the European Union in 2011 (in short: EU27). In 2000, the base year, quite some European countries had not yet formally accessed the EU. All data reported (GDP, emissions, trade, pollution embodied in trade) hence relate to the EU27.

4.2 Final demand and value added.

Global final demand is per definition equal to global GDP: the world has neither imports nor exports. This GDP can also be calculated from the total value added in the MR EE IOT. The EXIOPOL database estimates via both approaches a global GDP of 34.1 Trillion (10^{12}) Euro in 2000. Differences with other statistics may be at stake due to:

- The use of country SUT to estimate GDP (sometimes the official published GDP is not entirely equal to GDPs a country's SUT)
- The estimate of the real Rest of World. In order to create a table that was balanced and was otherwise realistic (e.g. a positive final demand) assumptions had to be made that lead to a slightly different GDP as could be calculated from e.g. UN statistics.

Figure 1: Impacts embodied in Europe's imports and exports, relative to impacts caused by EU final demand in 2000. Trade taken relative to Europe's GDP. The global warming excludes emissions from land use change

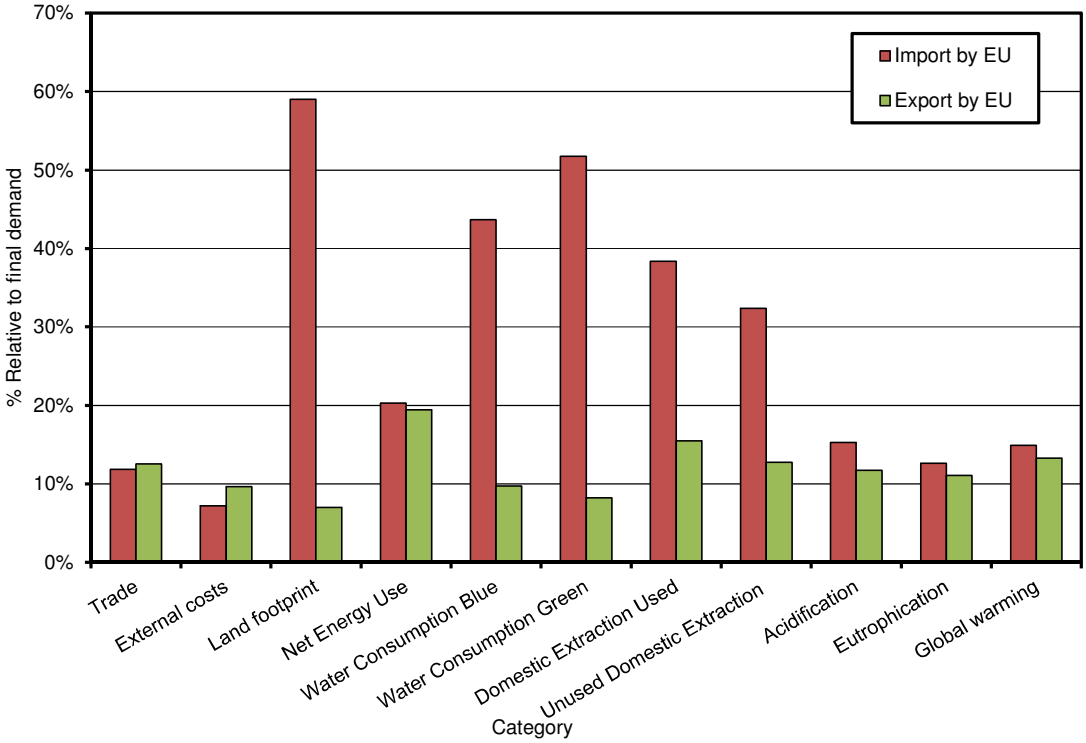
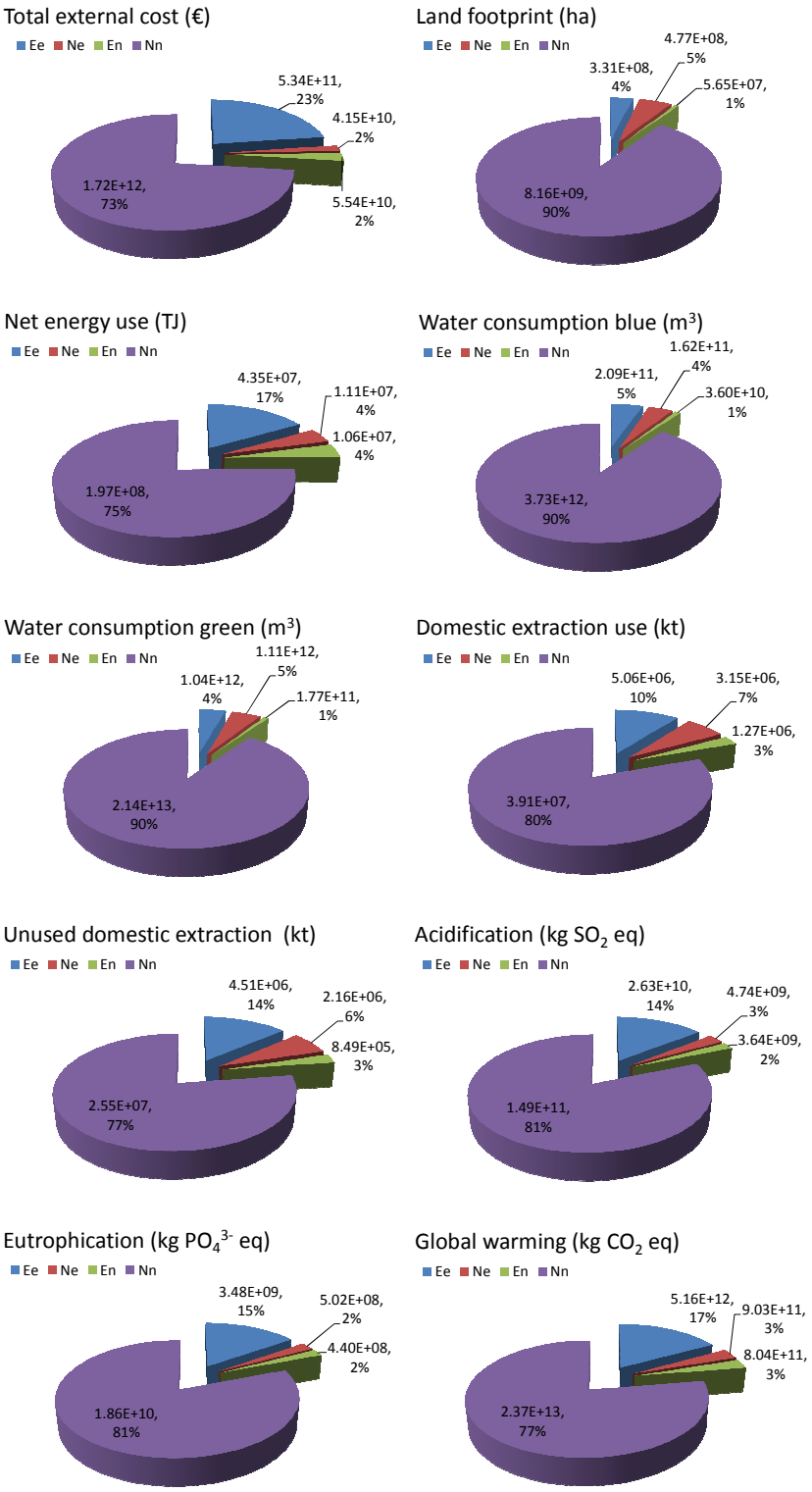


Table 4.1: Impacts per capita related to EU27 final demand, 2000, as well as impacts related to EU27 imports and exports per capita

Impact type	Unit	Final demand /cap	Import/ cap	Export/ cap
External costs	Euro	1191	86	115
Land footprint	km2	1,7	1,0	0,1
Net Energy Use	GJ	113	23	22
Water Consumption Blue	m3	767	335	75
Water Consumption Green	m3	4446	2301	367
Material Extraction Used	Ton	17,0	6,5	2,6
Unused Material Extraction	Ton	13,8	4,5	1,8
Acidification	kg SO2 eq.	64,2	9,8	7,5
Eutrophication	kg PO4 eq.	8,2	1,0	0,9
GWP	Ton CO2 eq.	12,5	1,9	1,7

* Assuming an EU27 population of 483 Million in 2000 (figure taken from the Eurostat website, http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-QA-09-031/EN/KS-QA-09-031-EN.PDF accessed 2 September 2011.

Figure 4.2: Impacts in the EU (E) and non EU (N) and impacts embodied in trade from the Non EU to the EU (Ne) and from the EU to non EU (En)



- Trade linking: since imports and exports are not balanced if one builds a global MR SUT from country SUT, a reconciliation must be applied – which inevitably results in minor changes in imports and exports from countries, and hence GDP. For the global GDP, the difference between the sum of GDP from country SUT and the MR SUT is about 0.2% or close to 100 billion Euro

In our base year, Europe created around 25% of the global GDP and was responsible for around 25% of final consumption. Figure 4.1 shows that just over 10% of the EU's GDP is imported and exported to other countries.

4.3 Land, water, energy and material footprints

Figures 4.2, 4.3 and Table 4.1 show the results for various resource-related indicators: land use, material extraction (used and unused), (blue and green) water use, and energy use. They shows that for virtually all resources uses embodied in trade, Europe is a net importer. There are however significant differences between types of resources:

- Land use: according to this analysis, the land use embodied in Europe's imports is higher as the domestic land use in Europe.
- Blue and green water extraction embodied in Europe's imports are 70-90% of Europe's domestic use [total water consumption seems wrong and lower as blue and green combined]
- The used and unused Material extraction embodied in Europe's imports are around 40-50% of the used and unused Material extraction within Europe
- The energy embodied in imports and exports are in the same order of magnitude. Imports of embodied energy is around 20% of the total energy use for final consumption.

These figures suggest that particularly for production of goods depending on land use and water Europe is depending highly on non EU countries. The same applies but to a lesser extent for materials.

4.4 LCIA Impact assessment categories: GWP, AC, Eutrophication

For all emission related LCIA indicators the pollution embodied in imports is higher as for pollution embodied in exports (see Figures 4.2, 4.3 and Table 4.1). This can have three major reasons

a) Europe uses cleaner technologies, and the European industry is more efficient as foreign industries (less inputs are needed to produce the same output).

b) Europe concentrates on relatively 'clean' industries and products, and has outsourced more resource- and energy intensive production abroad.

c) Per Euro imports compared to Euro production in Europe, more physical goods are imported as produced in Europe – i.e. the price of imports is relatively low. This then automatically implies that emissions per Euro imports also will be relatively high.

The pollution embodied in imports and exports is relatively low compared to domestic pollution (10-20%). The GWP embodied in imports is not much higher as the GWP embodied in exports, where the difference is more pronounced for Acidification and Eutrophication. This is probably due to the fact that for greenhouse gases in general no emission reduction measures are possible, where fore acidifying and eutriphying gases this is. It is hence most probable that we see here the effect that Europe's industry is relatively clean compared to industry abroad.

4.5 External costs

Table 4.2 shows the results with regard to external costs, also split up in different type of categories. A number of findings stand out:

- External costs related to climate change and emissions of inorganic substances causing respiratory effects are responsible for around 90% of the total external costs.
- For Europe, the external costs embodied in imports are lower than in exports (see figure 4.1). This suggests that Europe, unlike for other indicators expression pollution embodied in trade, is a next exporter of external costs. The reasons for this can be two-fold:
    - Inorganic emissions causing respiratory effects dominate external costs, and within this category, PM10 and PM2.5 that is mainly emitted by traffic is relatively relevant. Europe is relatively densely populated and has a high traffic density, which implies a relatively high contribution to external costs.
    - For non-EU countries, due to the lack of data the relatively crude assumption of using European external cost data weighted via Purchasing Power Parity was used. Particularly the dense populated fast developing economies outside Europe (e.g. China,

India), have relatively low PPPs, implying that in the approach used here (health) damage weights not as heavy as in Europe.

- The total external costs in our calculation are 2.35 Trillion Euro globally. This is around 7% of the global GDP. This suggests that the environmental impacts of our current economic system lead to significant negative impacts on GDP. This calculation is obviously based on relatively crude and incomplete data. For instance, our approach only included emission-related externalities, but missed for instance damage on biodiversity or ecosystem services almost in full. We feel that for this reason our estimate could be lower as the actual monetarised damage.

Table 4.2: External costs due to air emissions on European and non EU territory by category[1]

Category	Region	External costs in Euro	% of total*
Carcinogenic effects	EU	5,55E+09	0,9%
	non-EU	1,76E+10	1,0%
Non-carcinogenic effects	EU	6,64E+07	0,0%
	non-EU	1,85E+08	0,0%
Respiratory effects (inorganic)	EU	3,96E+11	67,2%
	non-EU	1,15E+12	65,3%
Aquatic ecotoxicity	EU	2,42E+08	0,0%
	non-EU	1,01E+09	0,1%
Terrestrial ecotoxicity	EU	3,53E+10	6,0%
	non-EU	1,27E+11	7,2%
Terrestrial acidification/nutrification	EU	3,19E+10	5,4%
	non-EU	9,41E+10	5,3%
Total Climate Change	EU	1,20E+11	20,4%
	non-EU	4,99E+11	28,4%
Total, all categories	*EU*	*5,89E+11*	*100,0%*
	non-EU	*1,76E+12*	*100,0%*
Total	**World**	**2,35E+12**	

* Relative to total external costs on EU and non EU territory respectively

[1] Note that EXIOBASE neglects emissions in the Rest of World, which makes up around 5-7% of global GDP. .

5 Comparison and conclusion

The overall picture is that Europe is a net importer of natural resources. This is particularly true for land and water. The land use embodied in trade is higher as the land use in Europe itself. There is also a significant material imports embodied in trade. For energy and greenhouse gases, we see that the flows embodied in imports and exports are relatively close. Figure 4.1 is probably the best summary from chapter 4 of this report, comparing monetary value of imports, exports and domestic production with resources and pollution embodied in imports and exports as well as for Europe itself.

The only factor for which Europe is a net exporter is external costs. The main reason for this is probably that externalities in economies that have a lower wealth tend to count less. For non-EU countries, due to the lack of data the relatively crude assumption was applied of using European external cost data weighted via Purchasing Power Parity. Particularly the dense populated fast developing economies outside Europe (e.g. China, India), have relatively low PPPs, implying that in the approach used here (health) damage weights not as heavy as in Europe. This obviously is a relatively subjective assumption, which can be questioned from an ethical perspective. The issue of how to deal with the relative value of damage done to human health, ecosystem health and economic production in rich and poor countries is in our view an important issue of future research for the externality community.

A striking finding of this study is as well that the external costs creating by our current economic system are significant. The externality assessment in our study is far from complete, neglecting for instance the value of ecosystem services and biodiversity. Emission related impacts alone create an amount of damage costs that is 7% of the global GDP, mainly due to climate impacts and respiratory health effects.

In an Annex to this report, we also show more detailed results of the impacts of European final consumption for each of the 129 final demand categories. The findings confirm the results found in reviews of e.g. Tukker (2006) and Hertwich (2005) as well as a recent Resource Panel report (UN, 2010). It is quite obvious that food products, mobility related expenditures, expenditure on housing, and energy using products dominate the impacts of final consumption.

Overall this analysis shows the enormous power of the database produced in the EXIOPOL project. For the first time, it has become possible to create a truly global view of how resources and emissions are embedded in transactions in the global economic system. It shows interconnections between economies, and which economy depends for which resources on which other economy. Expanding this database with time series, adding additional cross-checks with for instance aggregated economic data like GDP and total trade, and improving particularly the emission inventory is the way forward to make the database an even more powerful tool to analyze the global economic/physical metabolism.

Part II: Specification and aggregation errors in environmentally extended international input-output models

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6 Introduction

Trends of globalization, the creation of global value chains, stronger international inter-industry linkages, and the rise in outsourcing are all drivers in the search for international comparative data and the construction of comprehensive databases to study these developments. Over the past decades, concerns over the environment have steadily risen, and policies are designed and implemented at all levels of governance. Some environmental issues, like global warming through CO_2 emissions, should be addressed at a global level. Other issues result in more localized problems, like water shortages, but their cause can also be global because of international trade in intermediate and final products.

The discussion with regards to the estimation of especially CO_2 emissions has revolved largely around measuring the emissions from a consumer perspective as opposed to a producer perspective. In order to compute the emissions from the consumer perspective, the emissions embodied in imports are included, whereas the emission embodied in exports are excluded from the estimates. (G. P. Peters, 2008; G. Peters & Hertwich, 2008; Serrano & Dietzenbacher, 2010) Including the emissions embodied in imports requires information about trading partners, the production technologies of the trading partners, and the emissions produced by these trading partners. Only an environmentally extended international input-output model provides for this extensive information requirement. When using a single-country model for the calculation of emissions embodied in consumption, the assumption is made that both the environmental coefficients and the production structure of the country at hand more or less resemble the coefficients and technologies of the trading partners. An overview of models used for the estimations from a consumption perspective is given by Wiedmann (2009).

The environmentally extended multi-regional input-output (IO) databases compiled in the past decade promise an improvement over previously used methods to estimate environmental indicators. At the same time, the errors made by older approximations of lacking information can be studied by means of the newer generation of environmentally extended IO models. An early attempt to do so is Lenzen, Pade, & Munksgaard (2004) in which the authors studied the international feedback effects, and hence the errors made when using a single-region IO model, in a model including 4 countries and a rest of world region. They also study the effect of sector aggregation on the estimations. Their findings suggest that it is important to explicitly include trading partner's technologies in terms of production structure and emission coefficients. Also large errors are found when aggregating the sectors to ten sectors.

In Su, Huang, Ang, & Zhou (2010) it is suggested that a sector detail of around 40 sectors is sufficient to capture the majority of CO_2 emissions embodied in production. These authors, however, use a single country model and only investigate the emissions embodied in exports of China and Singapore. Combining two databases often requires aggregation or disaggregation of one of the two datasets in order to match the classifications. Lenzen (2011) addresses

the question whether environmental data should be aggregated or input-output data should be disaggregated, given that the first usually have a more detailed classification. Aggregating the environmental data implies a loss of detail, which is undesirable, but disaggregating the input-output data can often only be done with partial data which increases the uncertainty about the validity of the final dataset. Using Monte-Carlo simulations, it is shown that disaggregating the input-output data should be preferred over aggregating the environmental data in determining environmental IO multipliers.

Andrew, Peters, & Lennox (2009) look at the errors in CO_2 estimation introduced by approximations of the full model. They find that, when the number of regions in the model is small, a unidirectional trade model can give a reasonable approximation to the full model. In this type of model the technologies of trading partners are included, but only through trade-linkages with the country at hand. Bilateral linkages between the other countries are either excluded or approximated through a domestic technology assumption. Especially including the trade partner that is responsible for the largest share in emissions embodied in the imports of a country, can significantly improve the estimates. They also show that a world average IO table can offer a suitable substitute for an aggregate rest of the world table. The authors denounce using a single-country IO model, although they indicate it is still better than ignoring imports altogether. Spatial aggregation is also subject of study by Su & Ang (2010) in which the authors subdivide the data of China into eight regions. They find that the values of CO_2 emissions embodied in exports of China reduce as the number of regions increases.

In this paper, the specification and aggregation errors made in the calculation of environmental indicators when using approximations in the modelling are investigated using the EXIOPOL database (Tukker et al., 2009).

7 Methodology

7.1 Data and notation

The EXIOPOL database consists of 43 countries; all countries that are part of the EU27 and 16 other large countries – see Appendix 1, for a list of individual country names. All 43 countries are linked to each other through international trade flows (Bouwmeester & Oosterhaven, 2008). The level of sector detail in the EXIOPOL database is 129 industries – see Appendix 2. Compared to the 59 by 59 detail level of the ESA-95, the products and sectors that are important from an environmental point of view have been disaggregated. These products and sectors relate to food and agriculture products, metals ores and products, mineral products, and energy products. (Wood, Hawkins, van Bree, & Poliakov, 2010). In some of our results we distinguish four final demand categories; household consumption expenditure, government consumption expenditure, gross fixed capital formation, and changes in inventories and valuables combined with exports to the rest of the world.

Matrices are denoted by bold capitals letters, vectors by bold lower case letters, and scalars by italicized lower case letters. A prime indicates a transposed matrix or vector. A hat indicates a diagonal matrix or vector. The

vector **i** is a summation vector with ones, and the identity matrix is denoted by **I**. Indices and parameters used are:

i sectors, from 1 to *I*,

q final demand categories, from 1 to *Q*,

r countries, from 1 to *R*,

• summation over the index at hand.

7.2 The international input-output model

In an international IO model, all bilateral intermediate trade flows are specified by four indices: the country of origin and destination, and the industry of origin and destination. A matrix representation of the international IO model is given in equation (1).

$$\begin{bmatrix} \mathbf{x}^1 \\ \mathbf{x}^2 \\ \vdots \\ \mathbf{x}^R \end{bmatrix} = \begin{bmatrix} \mathbf{A}^{11} & \mathbf{A}^{12} & \cdots & \mathbf{A}^{1R} \\ \mathbf{A}^{21} & \mathbf{A}^{22} & \cdots & \mathbf{A}^{2R} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}^{R1} & \mathbf{A}^{R2} & \cdots & \mathbf{A}^{RR} \end{bmatrix} \begin{bmatrix} \mathbf{x}^1 \\ \mathbf{x}^2 \\ \vdots \\ \mathbf{x}^R \end{bmatrix} + \begin{bmatrix} \mathbf{f}^{1\bullet} \\ \mathbf{f}^{2\bullet} \\ \vdots \\ \mathbf{f}^{R\bullet} \end{bmatrix} \quad (1)$$

The vectors $\mathbf{x}^1$ to $\mathbf{x}^R$ represent the total output vectors of countries 1 to *R*. The matrix $\mathbf{A}^{rs}$ shows the imports from country *r* used per unit of output of country *s*. The matrices $\mathbf{A}^{11}$ to $\mathbf{A}^{RR}$, on the diagonal, show the domestic input coefficient matrices. The final demand vectors $\mathbf{f}^{r\bullet}$ reflect the country of origin, i.e. they show the final demand of all countries for products produced in *r*.

In the EXIOPOL database the categorical and geographical destination of this final demand is also given. The categories distinguished are: household consumption expenditure, government consumption expenditure and gross fixed capital formation. The exports to the rest of the world (RoW) are combined with changes in inventories and valuables ($\mathbf{f}^{rRoW}$). In the case of the EXIOPOL database, the exports to the rest of the world relate to exports to countries that are not included in the database. Each of the *R* final demand vectors shown in equation (1) thus result from the following aggregation.

$$\mathbf{f}^{r\bullet} = \mathbf{F}^{r1}\mathbf{i} + \mathbf{F}^{r2}\mathbf{i} + \cdots + \mathbf{F}^{rR}\mathbf{i} + \mathbf{f}^{rRoW} \quad (2)$$

If the country superscripts are omitted, system (1) can simply be represented as:

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f} \quad (3)$$

Its well-known solution is straightforward (see inter alia (Miller & Blair, 2009)):

$$\mathbf{x} = \left(\mathbf{I} - \mathbf{A}\right)^{-1}\mathbf{f} = \mathbf{L}\mathbf{f} \tag{4}$$

The matrix $(\mathbf{I} - \mathbf{A})^{-1}$ is commonly referred to as the Leontief-inverse and denoted by $\mathbf{L}$.

7.3 An environmentally extended international IO model

Any input-output table can be extended with satellite accounts with additional information. These are often related to the column totals of the IO table, representing, for example, total labor used, total water used, or total CO_2 emitted sector by each sector. Dividing, e.g., sectoral emissions by total sectoral output gives a row $\mathbf{d}'$ with emission coefficients, indicating the total sectoral emissions per unit of output of each sector, in each country. Multiplication with the total output by sector, by country reproduces the direct emissions by sector, by country:

$$\mathbf{e}' = \mathbf{d}'\hat{\mathbf{x}} \tag{5}$$

Where $\mathbf{e}'$ is the row vector of pollutants emitted or material resources used by each sector, in each country. Total emissions or total material use at the world level is then given by:

$$e = \mathbf{d}'\mathbf{L}\mathbf{f} \tag{6}$$

This total e can be disaggregated from different points of view. To see how, we write (6) in its fullest possible partitioned form:

$$\begin{bmatrix} \mathbf{E}^{11} & \mathbf{E}^{12} & \cdots & \mathbf{E}^{1R} \\ \mathbf{E}^{21} & \mathbf{E}^{22} & \cdots & \mathbf{E}^{2R} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{E}^{R1} & \mathbf{E}^{R2} & \cdots & \mathbf{E}^{RR} \end{bmatrix} = \begin{bmatrix} \hat{\mathbf{d}}^1 & 0 & \cdots & 0 \\ 0 & \hat{\mathbf{d}}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \hat{\mathbf{d}}^R \end{bmatrix} \begin{bmatrix} \mathbf{L}^{11} & \mathbf{L}^{12} & \cdots & \mathbf{L}^{1R} \\ \mathbf{L}^{21} & \mathbf{L}^{22} & \cdots & \mathbf{L}^{2R} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{L}^{R1} & \mathbf{L}^{R2} & \cdots & \mathbf{L}^{RR} \end{bmatrix} \begin{bmatrix} \mathbf{F}^{11} & \mathbf{F}^{12} & \cdots & \mathbf{F}^{1R} \\ \mathbf{F}^{21} & \mathbf{F}^{22} & \cdots & \mathbf{F}^{2R} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{F}^{R1} & \mathbf{F}^{R2} & \cdots & \mathbf{F}^{RR} \end{bmatrix} \tag{7}$$

Note that the submatrices $\mathbf{E}^{rs} = \hat{\mathbf{d}}^r \sum_k \mathbf{L}^{rk}\mathbf{F}^{ks}$ have dimension I x Q, and indicate which part of the direct emissions by sector i in country r is explained by the final demand of category q of country s.

Hence, matrix $\mathbf{E}$ directly combines on all possible causes (types of final demand by country) with all possible impacts (direct emissions or resource use by sector by country). Aggregation along a row of $\mathbf{E}$ gives the total emissions by sector by country, i.e. an aggregation according to the producer responsibility

principle. Aggregation along the columns of **E** gives the total worldwide emissions caused by the final demand of each category in each country, i.e. an aggregation according to an extended consumer responsibility principle (Peters, 2008, Peters & Hertwich, 2008, Serrano & Dietzenbacher, 2010). We use the word 'extended' as part of the worldwide emissions has to be allocated to government expenditures and private investments.

7.4 Specification errors

We compare the outcomes of the classical, in our case extended, consumer responsibility study with the outcome based on the use of the full environmentally extended international IO model of equation (7), thus aggregated by column. In the classical study, typically (e.g. Wyckoff & Roop, 1994 or Lenzen, 1998), the foreign import coefficient matrix (i.e. $\sum_{s\neq r}\mathbf{A}^{sr}$) is added to the domestic input coefficient matrix (i.e. $\mathbf{A}^{rr}$), and the associated Leontief-inverse (i.e. $(\mathbf{I}-\sum_{s}\mathbf{A}^{sr})^{-1}$) is pre-multiplied with the row domestic emission coefficients $\mathbf{d}^{r}$. Compared with the full international IO model two specification errors are made. The first specification error is the use of domestic emission coefficients where foreign emission coefficients should have been used. The second is the use of the single-country Leontief-inverse, with imports coefficients included, where the full international Leontief-inverse should have been used. We study these errors consecutively such that their sum equals the total specification error.

7.4.1 Error of using domestic emission coefficients

We measure the effect of using domestic emission coefficients, instead of foreign emission coefficients, by means of the extended international IO model. In that way, we obtain the pure specification error associated with assuming that foreign industries have domestic emission coefficients. We measure the *absolute* coefficient errors country-by-country, as follows:

$$\tilde{e}^{r}-e^{r}=\begin{bmatrix}\mathbf{d}^{r}\\ \mathbf{d}^{r}\\ \vdots\\ \mathbf{d}^{r}\end{bmatrix}'\begin{bmatrix}\mathbf{L}^{11} & \mathbf{L}^{12} & \cdots & \mathbf{L}^{1R}\\ \mathbf{L}^{21} & \mathbf{L}^{22} & \cdots & \mathbf{L}^{2R}\\ \vdots & \vdots & \ddots & \vdots\\ \mathbf{L}^{R1} & \mathbf{L}^{R2} & \cdots & \mathbf{L}^{RR}\end{bmatrix}\begin{bmatrix}\mathbf{f}^{1r}\\ \mathbf{f}^{2r}\\ \vdots\\ \mathbf{f}^{Rr}\end{bmatrix}-\begin{bmatrix}\mathbf{d}^{1}\\ \mathbf{d}^{2}\\ \vdots\\ \mathbf{d}^{R}\end{bmatrix}'\begin{bmatrix}\mathbf{L}^{11} & \mathbf{L}^{12} & \cdots & \mathbf{L}^{1R}\\ \mathbf{L}^{21} & \mathbf{L}^{22} & \cdots & \mathbf{L}^{2R}\\ \vdots & \vdots & \ddots & \vdots\\ \mathbf{L}^{R1} & \mathbf{L}^{R2} & \cdots & \mathbf{L}^{RR}\end{bmatrix}\begin{bmatrix}\mathbf{f}^{1r}\\ \mathbf{f}^{2r}\\ \vdots\\ \mathbf{f}^{Rr}\end{bmatrix} \qquad (8)$$

The last term of (8) indicates the true total worldwide emission caused by country *r*'s total final demand, while the first term indicates the estimate of this total, made by assuming that the foreign $\mathbf{d}^{s}$ equal the domestic $\mathbf{d}^{r}$.

Besides absolute country-by-country errors, which will of course be larger the larger the country, we also study the related *relative* coefficient errors. In shorthand, these equal:

$$\left(\tilde{e}^r - e^r\right)\Big/ e^r = \left(\mathbf{d}^{r\prime}\,\mathbf{L}\,\mathbf{f}^r - \mathbf{d}'\mathbf{L}\,\mathbf{f}^r\right)\Big/ \mathbf{d}'\mathbf{L}\,\mathbf{f}^r \tag{9}$$

Where $\mathbf{f}^r$ is defined as:

$$\mathbf{f}^r = \left[\mathbf{f}^{1r} \quad \mathbf{f}^{2r} \quad \cdots \quad \mathbf{f}^{Rr}\right]' \tag{10}$$

This column vector shows country *r*'s final demand for products produced domestically or imported, by country of origin. Note that $\mathbf{f}^r$ is not equal to $\mathbf{f}^{\bullet r}$ as defined in (2).

The *total relative world* error then equals:

$$\tilde{\varepsilon} = \left(\sum_r \tilde{e}^r - \sum_r e^r\right)\Big/ \sum_r e^r \tag{11}$$

We also present it by causing *sector-specific* final demand, by means of:

$$\tilde{\varepsilon}_i = \left(\sum_r \tilde{e}_i^r - \sum_r e_i^r\right)\Big/ \sum_r e_i^r \tag{12}$$

Where e_i^r and $\tilde{e}_i^r$ are calculated as:

$$e_i^r = \mathbf{d}'\mathbf{l}_i^r\, f_i^r \text{ and } \tilde{e}_i^r = \mathbf{d}^{r\prime}\,\mathbf{l}_i^r\, f_i^r \tag{13}$$

Finally, we also present the errors by causing *category-specific* final demand errors, with $\tilde{\varepsilon}_q$ calculated analogously to (12).

7.4.2 Error of using a single-country IO model

To get a pure estimate of the error made when using a single-country IO model, as opposed to an international IO model, we use the domestic emission coefficients of the country at hand in both cases. The *absolute* single-country errors are thus calculated as follows:

$$\bar{e}^r - \tilde{e}^r = \mathbf{d}^{r\prime}\left(\mathbf{I} - \mathbf{A}^{\bullet r}\right)^{-1}\mathbf{f}^{\bullet r} - \mathbf{d}^{r\prime}\left(\mathbf{I} - \mathbf{A}\right)^{-1}\mathbf{f}^r \tag{14}$$

The last term of (14) equals the first term of (8), and in the first term of (14) we use:[2]

$$\mathbf{A}^{\bullet r} = \mathbf{A}^{1r} + \mathbf{A}^{2r} + \cdots + \mathbf{A}^{Rr} \text{ and } \mathbf{f}^{\bullet r} = \mathbf{f}^{1r} + \mathbf{f}^{2r} + \cdots + \mathbf{f}^{Rr} \tag{15}$$

Again, note that $\mathbf{f}^{\cdot r}$ is not equal to either $\mathbf{f}^{\cdot r}$ as defined in (2) or $\mathbf{f}^{r}$ as defined in (10).

Besides absolute errors, which vary mainly by country size, we again also present relative country-by-country errors, which are calculated as follows:

$$\left(\bar{e}^{r} - \tilde{e}^{r}\right) \Big/ e^{r} = \left(\mathbf{d}^{r\prime}\left(\mathbf{I} - \mathbf{A}^{\bullet r}\right)^{-1}\mathbf{f}^{\bullet r} - \mathbf{d}^{r\prime}\mathbf{L}\mathbf{f}^{r}\right) \Big/ \mathbf{d}^{\prime}\mathbf{L}\mathbf{f}^{r} \tag{16}$$

Note that these relative single-country errors are expressed as a ratio of the true value e^r, instead of $\tilde{e}^r$. In this way, the first set of relative errors of (9) can be added to the second set of relative errors of (16), to obtain the total relative error of the classical extended single-country IO model compared to the present extended international IO model.

The relative single-country specification error for worldwide total emissions is defined as:

$$\bar{\varepsilon} = \left(\sum_r \bar{e}^{r} - \sum_r \tilde{e}^{r}\right) \Big/ \sum_r e^{r} \tag{17}$$

We again also present a disaggregation by causing *sector-specific* final demand analogously to (12):

$$\bar{\varepsilon}_i = \left(\sum_r \bar{e}_i^{r} - \sum_r \tilde{e}_i^{r}\right) \Big/ \sum_r e_i^{r} \tag{18}$$

And, the disaggregation by causing *category-specific* of final demand into $\bar{\varepsilon}_q$ again proceeds analogously.

Finally, in all cases, the total relative specification error can be decomposed into the specification errors due to using domestic emissions coefficients and those due to using a single-country IO model, respectively, e.g., in the case of the worldwide total emissions:

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[2] The total coefficient matrix $\mathbf{A}^{\bullet r}$, used here, deviates from the IO data published by the individual countries due to the estimation method of the international input-output table (see, Bouwmeester & Oosterhaven, 2008, for details). The country-by-country trade flows have been made consistent, and in the process they revalued in basic prices of the producing (i.e. exporting instead of importing) country.

$$\varepsilon = \frac{\sum_r \bar{e}^r - \sum_r e^r}{\sum_r e^r} = \frac{\sum_r \bar{e}^r - \sum_r \tilde{e}^r}{\sum_r e^r} + \frac{\sum_r \tilde{e}^r - \sum_r e^r}{\sum_r e^r} \qquad (19)$$

7.5 Aggregation errors

Next to specification errors, we investigate aggregation errors. In an international IO model aggregation errors can be due to either sectoral aggregation or spatial aggregation.

To understand the nature of aggregation errors, it is important to be aware that, for any base year, equation (6) will always result in exactly the same estimate of emissions **e**, no matter the actual level of sectoral or spatial aggregation. This is simply the case, because base year $\hat{\mathbf{d}}$ times base year **L** times base year **f** in (6) always reproduces base year **e** at any aggregation level chosen. Aggregation errors will only occur when the actual final demand weights are different from those of *total* final demand in the base year.

To investigate the impact of the aggregation of sectors and countries, we again evaluate the errors from the extended consumer responsibility perspective. Hence, we will measure the aggregation errors by using the weights of the four different types of final demand available in the EXIOPOL database, for the 43 countries distinguished, which results in 172 different weighting options.

7.5.1 Sectoral aggregation errors

To investigate the impact of the aggregation of sectors, CO_2 emissions and water use are calculated at three levels of sectoral detail. The 'true' value of the worldwide emissions that are embodied in final demand category q of country r, is calculated at the most disaggregate level of 129 industries:

$$e_q^r = \begin{bmatrix} \mathbf{d}^1 \\ \mathbf{d}^2 \\ \vdots \\ \mathbf{d}^R \end{bmatrix}' \begin{bmatrix} \mathbf{L}^{11} & \mathbf{L}^{12} & \cdots & \mathbf{L}^{1R} \\ \mathbf{L}^{21} & \mathbf{L}^{22} & \cdots & \mathbf{L}^{2R} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{L}^{R1} & \mathbf{L}^{R2} & \cdots & \mathbf{L}^{RR} \end{bmatrix} \begin{bmatrix} \mathbf{f}_q^{1r} \\ \mathbf{f}_q^{2r} \\ \vdots \\ \mathbf{f}_q^{Rr} \end{bmatrix} = \mathbf{d}'\mathbf{L}\mathbf{f}_q^r \qquad (20)$$

This results in Q x R = 172 different 'true' values. Besides, (20) is calculated at the level of the 59 sectors of the EU27 input-output tables, and at the level of 10 very aggregate industries, which results in $e_q^r(59)$ and $e_q^r(10)$, respectively (see Appendix 3, for details on the sectors that are combined).

We will compare only *relative* aggregation errors, and do that sequentially, such that the total error from aggregating 127 detailed industries to 10 broad sectors equals the sum of the two partial aggregation errors:

$$\left[e_q^r(10) - e_q^r\right] \Big/ e_q^r = \left[e_q^r(10) - e_q^r(59)\right] \Big/ e_q^r + \left[e_q^r(59) - e_q^r\right] \Big/ e_q^r \quad \textbf{(21)}$$

Note that the two partial errors do not necessarily have the same sign. They may compensate each other, possibly making the total error, even absolutely, smaller that than each of the two partial errors. The results of comparison (21) will be combined and presented at two levels.

First, we present aggregation errors for each of the 4 final demand categories at the level of the 10 broad sectors to see which sectors are most heavily impacted. For this purpose we post-multiply with the diagonal matrix of the final demand columns used in (20):

$$\mathbf{e}_q = \mathbf{d}'\mathbf{L}\hat{\mathbf{f}}_q^{\bullet} \quad \textbf{(22)}$$

Where $\mathbf{e}_q$ has 10 elements showing the impact of the worldwide final demand category q on the value of the water used or CO_2 emitted by each of the 10 broad sectors. The 3 x 40 outcomes of (22) are compared as indicated in (21).

Second, we present aggregation errors for each of the 43 countries to see which countries are most heavily impacted. For this purpose we post-multiply with total final demand by country, instead of with the separate categories as was done in (20):

$$e^r = \mathbf{d}'\mathbf{L}\mathbf{f}^r \quad \textbf{(23)}$$

The 3 x 43 outcomes of (23) are compared as indicated in (21).

7.5.2 Spatial aggregation errors

As we want to compare the impact of spatial aggregation for each individual country r separately, the spatial aggregation relates for each country at hand to a different set of the 42 remaining countries $s \neq r$. We present only the results for total final demand and not those for each of the 4 categories separately. Hence, the 'true' values of the worldwide water use and CO_2 emissions are calculated with the extended international IO model with all 43 individual countries included, as shown in (23).

These 43 'true' values are compared with calculations at two higher levels of aggregation for the remaining 42 countries:

1. The remaining countries are split into EU countries and non-EU countries, and both groups of countries are further split into developed and developing ones. The latter subdivision is based on GDP/capita data (see Appendix 4 for details). This results in an aggregation into 5 regions, which are each time a little different.

2. The remaining countries are aggregated into one Rest of the World region. This results in an aggregation into 2 regions, again each time a little different.

The 3 x 43 outcomes of (23) are sequentially compared analogously to (21):

$$\left[e^r(2)-e^r\right]/e^r=\left[e^r(2)-e^r(5)\right]/e^r+\left[e^r(5)-e^r\right]/e^r \qquad \textbf{(24)}$$

Where e^r is the worldwide water use or worldwide CO_2 emission allocated to the total final demand of country r, as calculated with the full 43 country model, whereas $e^r(2)$ and $e^r(5)$ are calculated with the aggregated model, with 2 and 5 regions, respectively.

8 Results and discussion

In this section we compare the differences in CO2 emissions and water use estimations due to alternative model specifications and varying levels of sector and spatial detail. The analysis is based on the EXIOPOL database with 43 countries and 129 sectors. The estimates for the full model are considered to be the 'true' values. We first discuss the specification errors due to using domestic environmental coefficients and a single-country framework. Next, we turn to the differences in the results stemming from sectoral and spatial aggregation.

8.1 Specification errors

Table 8-1 reports the specification errors for each of the 43 EXIOPOL countries. The columns with heading $\tilde{e}-e$ represent the absolute error of using domestic emissions coefficients for both domestic and foreign industries. The columns with $\tilde{\varepsilon}$ show the same error as a percentage of the 'true' estimate. The columns with heading $\bar{e}-\tilde{e}$ represent the absolute error of using the single-country model. The columns of $\bar{\varepsilon}$ show the same error as percentage of the 'true' estimate. Note that for each country the sum of the values in the columns $\tilde{e}-e$ and $\bar{e}-\tilde{e}$ gives a value for the total error $\bar{e}-e$, which comparable studies generally focus on (for example, Andrew et al., 2009). The row labelled 'Total net error' records the sum of the errors for the columns with absolute numbers and the results of equation (11) and (17) for the columns with the percentage errors. The row labelled 'Sum absolute deviations' shows the sum of the absolute values of the deviations as a measure of the total gross error made. The last row of the table records the number of errors that have a negative value and the number of errors that have a positive value, i.e. the extent of underestimation or overestimation respectively.

The total net error shows, both for CO_2 emissions and water use, a general overestimation when applying the model with domestic emission (or use) coefficients. The overestimation for CO_2 emissions is 5299 Mt, or 27% and for water 3362 km^3, or 19%. The overestimation of CO_2 emissions is largely

cancelled out by using a single-country model; the overall net error is 741 Mt, which amount to 4% of the full model emissions. For water, when using a single country model compared to the full model, the overestimation is slightly corrected by 1% (-185 km^3), but the total net error still amounts to a total overestimation of 18%.

For the CO_2 estimations an interesting result is that the errors of using a single-country model (partially) cancel out the errors made from using domestic emission coefficients for 19 of the 42 countries. India and the United States are especially noteworthy in terms of the magnitude of the absolute errors, as they add up to 84% of the total net error of 5299 Mt. Using domestic coefficients in an international model overestimates these country's CO_2 emissions. However, when a single-country model is used, the domestic production technology assumption cancels out the effects of the high domestic CO_2 coefficients. In terms of large percentage errors compared to the world average error of 27%, India also stands out with 232%, joined by Norway (104%), Finland (63%) and Sweden (60%). In addition, each of these countries has relatively larger compensating errors, respectively 201% in case of India, 56% for Norway, 65% for Finland and 62% for Sweden, compared to a world average error of 23%.

Looking at the results for water use, it is directly clear that the range of the errors associated with applying domestic use coefficients is even wider (from -583 km^3 for Japan to 3397 km^3 for the Russian Federation) than the range of absolute deviations of CO_2 emissions (from -102 Mt for Germany to 2511 Mt for India). Apparently, water is particularly abundant in the Russian Federation and it is abundantly used in producing. This country by itself accounts for 55% of the 6164 km^3 sum of absolute errors caused by using domestic use coefficients only. The value of 3397 km^3 overestimation corresponds with 247% of the full model estimations, whereas the world average error is 19% in terms of full model estimations. The impact in percentage terms of using domestic use coefficients in an international model is even more remarkable for Norway, with a value of 2296%. The estimates for Norway are not very extreme under the limiting model assumptions, but the water use estimated under the full model is relatively very low and amounts to only 12 km^3 whereas the estimation with domestic use coefficients amounts to 286 km^3.

When looking at the single-country errors for water use, there are six countries with relatively large absolute errors. Indonesia and the United States show an overestimation of the single-country estimates compared to the domestic use model, whereas the Russian Federation, Germany, Mexico and Norway show an underestimation. Again, in percentage terms, the most remarkable country is Norway with a relative error of -636%. Most countries show comparatively small absolute errors. Water use in countries of the European Union is underestimated for 18 out of the 27 countries when using single country model (i.e. which corresponds to the sum of the two errors).

Table 8-2 shows the results for the same specification errors but now by industry. The results have been calculated at the 129 sector level, but are represented at the 59 sector level. The total net errors in Table 8-2 correspond directly to the total net errors in Table 8-1. For the CO_2 emission estimates we see even more clearly that the errors of using a single-country (partially) cancel out the errors made from using domestic emission coefficients for almost all sectors. We observe almost only positive values for $\tilde{e} - e$ and negative values for

$\bar{e} - \tilde{e}$ with regards to CO_2 emissions. This can be seen directly by comparing the net total errors with the sum of the absolute deviations; they are almost equal. The order of magnitude for the two errors is strikingly comparable, one error clearly cancelling out the effect of the other error. The larger errors are found for the agricultural and manufacturing industries, which is especially clear when looking at the sum of the two errors.

The largest users of water by far are sectors i01 agriculture, hunting and i15 food products and beverages. Both sectors are also associated with large absolute errors of using domestic use coefficients in the international model. In terms of relative errors of using domestic use coefficients, the metal industries (i27, i28 and i29) are noteworthy, as well as financial intermediation services (i65 and i67).

Table 8-1: Absolute and relative specification errors, by country

	CO_2 emissions				water use			
	$\tilde{e}-e$	$\tilde{\varepsilon}$	$\overline{e}-\tilde{e}$	$\overline{\varepsilon}$	$\tilde{e}-e$	$\tilde{\varepsilon}$	$\overline{e}-\tilde{e}$	$\overline{\varepsilon}$
	Mt	%	Mt	%	km³	%	km³	%
Australia	10	3	3	1	42	25	-41	-25
Austria	-7	-8	-11	-14	-8	-30	-1	-4
Belgium	-11	-11	11	12	-16	-46	-2	-6
Brazil	43	8	-22	-4	-109	-9	13	1
Bulgaria	4	14	5	17	1	3	1	6
Canada	36	9	-14	-4	103	32	-54	-17
China	741	24	-259	-8	-73	-5	39	2
Cyprus	4	49	2	18	-3	-63	0.3	8
Czech Republic	6	6	15	14	-2	-5	3	7
Denmark	-14	-24	-2	-4	-8	-42	-0.4	-2
Estonia	-1	-8	4	31	3	47	3	51
Finland	45	63	-46	-65	-4	-22	0.4	2
France	-49	-12	-44	-11	-50	-22	12	5
Germany	-102	-12	-29	-3	109	43	-100	-39
Greece	27	23	-17	-14	-5	-7	2	4
Hungary	10	21	3	6	3	10	5	14
India	2511	232	-2175	-201	-35	-1	23	1
Indonesia	27	11	-12	-5	164	5	245	8
Ireland	-2	-3	-2	-5	-3	-20	1	4
Italy	-85	-19	-1	-0.1	-27	-15	11	6
Japan	-10	-1	-110	-7	-583	-82	-6	-1
Latvia	0.4	4	-3	-24	-0.4	-2	-0.2	-1
Lithuania	3	21	-3	-20	-11	-23	-0.3	-1
Luxembourg	-1	-24	0.1	1	-0.5	-17	1	25
Malta	1	27	2	57	-1	-99	0.00	0.2
Mexico	-2	-1	-4	-1	595	50	-91	-8
Netherlands	14	9	3	2	-40	-86	0.5	1
Norway	45	104	-24	-56	274	2296	-76	-636
Poland	34	12	32	11	-0.01	-0.00	-1	-1
Portugal	10	14	5	7	-2	-4	5	13
Romania	23	30	11	14	4	6	13	22
Russian Federation	164	20	9	1	3397	247	-164	-12
Slovak Republic	6	23	1	2	0.1	0.5	1	4
Slovenia	-1	-10	1	4	-3	-55	1	11
South Africa	24	8	29	10	28	19	-5	-3
South Korea	-44	-9	28	6	-113	-62	-9	-5
Spain	-35	-12	10	4	-6	-2	-7	-3
Sweden	53	60	-55	-62	9	24	-12	-32
Switzerland	-21	-28	-8	-11	21	43	1	1
Taiwan	-17	-7	15	6	0.2	0.3	-37	-42
Turkey	7	3	4	2	10	7	-18	-12
United Kingdom	-88	-15	-23	-4	-78	-53	-10	-7
United States	1941	33	-1886	-32	-220	-7	71	2
Total net error	5299	27	-4559	-23	3362	19	-1840	-1
Sum abs. deviations	6279		4941		6164		1082	
# of values <0 / >0	17 / 26		22 / 21		26 / 17		20 / 23	

Table 8-2: Absolute and relative specification errors, by industry

		CO_2 emissions				water use			
		$\bar{e}-\tilde{e}$	$\tilde{\varepsilon}$	$\bar{e}-\tilde{e}$	$\bar{\varepsilon}$	$\bar{e}-\tilde{e}$	$\tilde{\varepsilon}$	$\bar{e}-\tilde{e}$	$\bar{\varepsilon}$
		Mt	%	Mt	%	km^3	%	km^3	%
i01	Agriculture, hunting	308	71	-214	-50	2223	32	-58	-1
i02	Forestry, logging	4	18	-2	-10	13	20	3	4
i05	Fishing	7	26	-5	-17	-14	-5	-2	-1
i10	Mining of coal and lignite - peat	4	14	-1	-4	0.1	7	0.01	0.3
i11	Crude petroleum and natural gas	5	17	-4	-12	1	9	-1	-5
i12	Mining of uranium and thorium ores	0.1	14	-0.2	-19	-0.1	-13	-0.01	-2
i13	Mining of metal ores	0.3	1	1	2	3	47	-2	-27
i14	Other mining and quarrying	-0.4	6	-0.2	4	0.3	16	-0.001	-0.1
i15	Food products and beverages	456	42	-306	-28	964	22	-134	-3
i16	Tobacco products	24	53	-17	-37	-4	-0.4	74	6
i17	Textiles	186	89	-181	-86	-35	-24	-14	-10
i18	Wearing apparel, fur	73	44	-97	-58	-23	-20	-14	-12
i19	Leather products	24	32	-36	-47	-9	-14	7	11
i20	Wood, cork and straw products	5	14	-5	-15	-1	-1	2	2
i21	Pulp, paper and paper products	43	37	-33	-28	-18	-8	15	7
i22	Publishing, printing, recorded media	51	35	-36	-24	-13	-19	-1	-1
i23	Coke, refined petroleum products, nuclear fuels	90	36	-33	-13	-1	-9	1	5
i24	Chemicals and chemical products	396	77	-315	-61	19	11	-14	-8
i25	Rubber and plastic products	148	117	-143	-112	-40	-14	21	7
i26	Non-metallic mineral products	50	32	-44	-28	2	19	-2	-21
i27	Basic metals	30	8	-33	-9	30	454	-4	-65
i28	Fabricated metal products	56	25	-59	-26	20	127	-8	-52
i29	Machinery and equipment n.e.c.	427	58	-310	-42	70	107	-38	-58
i30	Office machinery and computers	43	32	-43	-31	2	5	-11	-31
i31	Electrical machinery and apparatus n.e.c.	255	98	-213	-82	14	27	9	18
i32	Radio, television, communication equipment	173	59	-141	-48	-6	-10	-6	-11
i33	Medical, precision and optical instruments	41	34	-30	-25	10	57	-6	-37
i34	Motor vehicles, trailers and semi-trailers	414	54	-426	-55	21	20	-6	-6
i35	Other transport equipment	107	48	-99	-44	10	33	8	27
i36	Furniture; manufacturing n.e.c.	126	26	-190	-39	-12	-10	-9	-8
i37	Recycling	-1	-22	-0.2	-7	0.04	13	-0.2	-52
i40	Electricity, gas, steam and hot water supply	27	1	-14	-1	0.2	1	-0.3	-1
i41	Collection, purification and distribution of water	3	9	-3	-8	-0.3	-10	-0.1	-4
i45	Construction	541	18	-449	-15	-18	-2	14	2
i50	Sale, maintenance and repair of motor vehicles	43	21	-44	-22	-0.1	-0.2	2	2
i51	Wholesale trade and commission trade	21	8	-20	-8	5	7	-3	-4
i52	Retail trade; repair personal and household goods	71	11	-67	-11	18	8	1	0.4
i55	Hotels and restaurants	91	14	-94	-14	-8	-1	-42	-5
i60	Land transport; transport via pipelines	62	17	-73	-20	1	2	5	10
i61	Water transport	114	43	-139	-53	-1	-2	2	6
i62	Air transport	93	11	-89	-10	4	7	6	12
i63	Supporting transport activities; travel agencies	6	8	-6	-8	2	16	-1	-13
i64	Post and telecommunications	23	11	-18	-9	4	15	-4	-17
i65	Financial intermediation	22	20	-16	-15	23	100	-7	-32
i66	Insurance and pension funding	10	13	-10	-12	7	33	0.02	0.1
i67	Activities auxiliary to financial intermediation	2	7	-0.5	-1	24	147	-1	-7
i70	Real estate activities	36	7	-28	-5	8	4	2	1
i71	Renting of machinery and equipment	2	8	-2	-7	0.004	0.1	0.1	2
i72	Computer and related activities	10	14	-9	-13	-1	-11	-1	-6
i73	Research and development	11	13	-8	-9	2	6	-1	-2
i74	Other business activities	17	14	-10	-9	-1	-2	1	2
i75	Public administration and defense	166	14	-137	-12	48	13	8	2
i80	Education	26	8	-18	-5	3	4	-1	-1
i85	Health and social work	238	34	-185	-27	20	6	15	4
i90	Sewage and refuse disposal, sanitation	0.5	1	-1	-2	0.3	3	1	6
i91	Activities of membership organisation n.e.c.	21	18	-18	-15	-2	-5	1	2
i92	Recreational, cultural and sporting activities	21	9	-23	-10	-1	-2	-3	-4
i93	Other service activities	69	45	-61	-39	2	7	1	5
i95	Private households with employed persons	4	4	-2	-2	1	3	13	31
	Total net error	5299	27	-4559	-23	3362	19	-185	-1
	Sum absolute deviations	5301		4560		3779		605	
	# of values <0 / >0	2 / 57		58 / 1		22 / 37		33 / 26	

8.2 Aggregation errors

8.2.1 Sector aggregation

Table 8-3 shows the percentage differences in estimated CO_2 emissions and water use when the sector detail is reduced from 129 to 59 to 10 sectors. The results are presented by sector (at the 10 sector level) and by final demand category. The results for CO_2 emissions are rather mixed showing no distinctive cases, except for the persistent underestimation of CO_2 emissions of construction (sector F), The largest percentage errors – all negative, indicating underestimations – are found for the aggregation from 129 to 59 sectors for final demand category 4: changes in inventories and valuables and exports to the rest of the world. This most certainly is caused by the fact that this category will have the most peculiar structure, because of negative changes in stocks and the residual character of the export to the RoW.

The percentage errors resulting from the aggregation from 129 to 59 sectors is far more prominent for water use than for CO_2 emissions. However, the extreme percentage errors, mostly overestimations, are found in the aggregation from 59 to 10 sectors. Sector E – Electricity, gas and water supply shows the largest positive percentage errors, especially for household and government consumption. For final demand resulting from changes in inventories and valuables, and export to the 'Rest of the World', sector E also shows an extreme percentage in the aggregation to 10 sectors, which is now negative. Water use percentage errors resulting from the aggregation to 10 sectors are especially large and positive for all sectors when the structure of gross fixed capital formation is used for weighting.

Table 8-4 reports the percentage sectoral aggregation errors for the 43 EXIOPOL countries. For CO_2 emissions, the slightly larger errors are related to the aggregation to 10 sectors, but in all the aggregation errors should be considered quite small. The total net errors confirm this with a total error of 1.3%. This error is fully caused by the aggregation from 129 to 59 sectors, even though the largest error values can be found at the 59 to 10 aggregation level. Only the Russian Federation is an extreme outlier when aggregating to 59 sectors with an error of 21%.

Also here, it is clear that the effect of the aggregation of sectors is much larger for water use than for CO_2 emissions. For water use, the percentage errors obtained from aggregating to 59 sectors partially cancel when aggregation to 10 sectors, but these errors are not small. As before, it may be observed that aggregating from 129 to 59 sectors is less harmful than aggregating further to 10 sectors for individual countries, despite the fact that the 129-classification is especially detailed for agriculture and food, which use a lot of water. In terms of net total error we also find here that the average world error percentage is mostly determined by the aggregation from 59 to 10 sectors.

Table 8-3: Sectoral aggregation errors, by final demand, by impacted sector, %

	CO_2 emissions			water use		
	$\mathcal{E}$ (129 ≫ 59)	$\mathcal{E}$ (59 ≫ 10)	$\mathcal{E}$ (129 ≫ 10)	$\mathcal{E}$ (129 ≫ 59)	$\mathcal{E}$ (59 ≫ 10)	$\mathcal{E}$ (129 ≫ 10)
Final demand 1: household consumption						
ABC	-0.3	10	10	9	-32	-22
D	1	18	19	-1	-33	-34
E	18	3	21	-46	2232	2186
F	-6	-26	-33	-51	220	169
GH	-3	1	-2	23	-40	-17
I	3	-15	-12	-16	121	106
JK	-3	25	22	-51	66	15
L	1	-5	-4	-36	79	43
MN	-6	1	-4	-26	28	2
OPQ	-4	2	-2	-23	54	31
Final demand 2: government consumption						
ABC	-3	12	9	-2	-26	-28
D	-4	-2	-5	-13	-0.4	-14
E	-9	89	80	-32	1595	1563
F	-14	-25	-39	-48	131	83
GH	6	-10	-4	8	-46	-39
I	3	12	15	-13	114	101
JK	11	5	16	36	27	64
L	2	-2	-0.4	-28	61	32
MN	4	2	6	-17	50	34
OPQ	-3	5	2	-16	4	-12
Final demand 3: gross fixed capital formation						
ABC	-3	10	7	12	111	123
D	-1	12	11	-47	496	449
E	16	7	23	-44	903	859
F	-5	-32	-37	-53	124	72
GH	-0.2	22	22	-37	147	109
I	11	1	12	-3	121	119
JK	-5	0.1	-4	-46	90	44
L	-9	7	-3	-52	234	182
MN	7	0.5	7	5	526	531
OPQ	-5	0.3	-4	-21	35	14
Final demand 4: changes in inventories and valuables; export to the rest of the world						
ABC	-76	7	-69	-28	-7	-35
D	-86	2	-84	-84	8	-75
E	-92	-16	-107	-148	-7528	-7676
F	-85	-5	-89	-98	49	-49
GH	-92	2	-90	-99	1	-99
I	-96	-1	-98	-102	6	-96
JK	-98	-0.4	-98	-99	1	-98
L	-93	0.3	-93	-97	7	-91
MN	-71	-1	-72	-84	23	-61
OPQ	-96	1	-95	-96	2	-94

Table 8-4 Sectoral aggregation errors, by country, %

	CO_2 emissions			water use		
	$\mathcal{E}$ (129 ≫ 59)	$\mathcal{E}$ (59 ≫ 10)	$\mathcal{E}$ (129 ≫ 10)	$\mathcal{E}$ (129 ≫ 59)	$\mathcal{E}$ (59 ≫ 10)	$\mathcal{E}$ (129 ≫ 10)
Australia	-0.5	3	2	-16	4	-13
Austria	5	-3	1	-9	52	44
Belgium	2	4	6	-10	21	11
Brazil	1	4	5	-6	-3	-9
Bulgaria	7	10	17	7	54	60
Canada	1	1	2	-15	-5	-20
China	3	-1	1	-0.5	2	1
Cyprus	1	-3	-3	5	25	30
Czech Republic	4	0.5	4	-5	37	33
Denmark	2	7	9	-12	30	18
Estonia	3	-6	-3	33	-1	32
Finland	2	-0.05	2	-6	52	46
France	1	1	2	-1	25	24
Germany	1	3	4	2	48	51
Greece	7	14	21	-6	6	0.1
Hungary	-0.1	-4	-4	-18	21	3
India	-1	1	0.5	-0.5	-3	-3
Indonesia	-0.5	-0.2	-1	22	-28	-5
Ireland	-1	-13	-14	-7	24	17
Italy	1	-3	-3	-6	38	32
Japan	-1	0.4	-0.3	-39	70	31
Latvia	0.5	1	2	-9	-12	-20
Lithuania	2	0.3	2	-13	-1	-14
Luxembourg	5	6	11	-36	41	4
Malta	1	-5	-4	31	29	60
Mexico	-5	-8	-13	-3	-24	-28
Netherlands	1	5	6	9	37	47
Norway	-1	26	25	41	40	81
Poland	2	-1	1	-9	8	-1
Portugal	2	-3	-1	12	16	28
Romania	2	6	8	4	9	14
Russian Federation	21	7	28	-1	-40	-41
Slovak Republic	2	11	13	-12	45	33
Slovenia	3	-6	-3	-24	26	2
South Africa	3	8	11	1	-42	-41
South Korea	-5	-1	-6	-42	100	58
Spain	-0.5	0.1	-0.4	-8	19	11
Sweden	1	4	5	-1	15	14
Switzerland	0.1	-8	-8	-44	14	-30
Taiwan	-2	-6	-8	-16	68	52
Turkey	2	-5	-3	51	5	56
United Kingdom	0.8	-4	-3	3	40	43
United States	0.05	-1	-1	-5	24	19
Total net error	1.3	-0.1	1.3	-0.1	0.3	0.2
# of values <0 / >0	11 / 32	20 / 23	18 / 25	30 / 13	10 / 33	12 / 31

8.2.2 Spatial aggregation

Table 8-5 shows the spatial aggregation errors. Each country´s CO_2 emissions and water use from the full 43 intercountry IO model are compared to the estimations with an IO model with the country at hand combined with four aggregate regions, and with an IO model with the country at hand and one large rest of world. The four regions and rest of world both result from the aggregation of the remaining 42 partners of the country at hand. The choice of the four regions can be found in Appendix 4.

The total net error, which is again a world average percentage error, shows a small overestimation (1.6%) of the CO_2 emissions when aggregating to two regions. However, values for individual countries range from an error of 38% for Luxembourg to -29% for Lithuania. The overestimation at the overall level is completely determined by the aggregation from five to two regions, as the aggregation from full detail to five regions is actually associated with a -0.5% underestimation of the emissions. For water use the aggregation from 43 to 5 regions shows an overall underestimation of 4%, whereas the further aggregation to 2 regions results in a positive effect of 3.5%.

In terms of individual countries, when the five region model is used instead of the 43 country model, most aggregation errors of CO_2 emissions are small, except for those of the Baltic countries and Cyprus. In the Baltic case, the CO_2 emissions are underestimated when the five region model is used, whereas aggregation in the Cyprus case leads to overestimation by 17%, which is compensated fully when the model is further reduced to two regions. In the aggregation from five to two regions case all large errors are overestimations of CO_2 except the error for Cyprus. In general, we observe that the aggregation errors going from 43 to five regions tend to be smaller than when aggregating further to two regions. This indicates that a carefully designed aggregation, like our four region classification, may be acceptable.

This optimistic conclusion, however, is refuted in the case of water use. Although the errors of going from 43 to five regions are show less extreme values than those of further aggregating to two regions, both types of errors are unacceptably large. And what is worse is that they hardly compensate for each other, as is shown in the last column of Table 3-5. At the individual country level, Norway again stands out with an overestimation of 267% of the water use as its trading partners become more aggregated. Again, underestimation occurs at the aggregation of the individual countries to the four general regions, whereas the overestimation occurs mostly at the aggregation of the four regions into a rest of the world region.

Table 8-5 Spatial aggregation errors, by country, %

	CO_2 emissions			water use		
	$\mathcal{E}$ (43 ≫ 5)	$\mathcal{E}$ (5 ≫ 2)	$\mathcal{E}$ (43 ≫ 2)	$\mathcal{E}$ (43 ≫ 5)	$\mathcal{E}$ (5 ≫ 2)	$\mathcal{E}$ (43 ≫ 2)
Australia	0.2	2	2	-16	2	-15
Austria	-2	15	13	-1	55	54
Belgium	0.5	21	22	-17	100	83
Brazil	-0.3	1	0.3	-7	-1	-8
Bulgaria	-2	-2	-4	5	-2	3
Canada	0.3	4	4	-14	11	-4
China	-0.3	0.2	-0.1	-3	-1	-4
Cyprus	17	-16	2	81	-12	69
Czech Republic	-2	2	-0.2	-0.4	11	11
Denmark	-3	12	10	-9	51	42
Estonia	-10	-1	-11	-2	11	9
Finland	-4	4	1	-6	13	6
France	-1	16	15	-6	29	23
Germany	-2	8	6	-3	38	35
Greece	1	5	6	-2	20	18
Hungary	-2	6	4	-5	8	4
India	-1	-0.5	-1	-1	-0.5	-1
Indonesia	-1	0.4	-1	0.03	0.001	0.03
Ireland	1	17	18	-7	70	64
Italy	-2	7	6	-10	36	26
Japan	-2	-1	-3	-16	-3	-19
Latvia	-17	-5	-22	-16	2	-14
Lithuania	-21	-8	-29	-25	1	-24
Luxembourg	-2	40	38	-7	190	183
Malta	8	4	11	-15	98	83
Mexico	-3	5	2	-3	0.5	-2
Netherlands	-4	16	12	-14	61	48
Norway	-5	21	16	98	169	267
Poland	-2	3	0.3	-3	4	1
Portugal	4	14	17	-5	49	43
Romania	-1	1	0.01	0.2	2	2
Russian Federation	-0.5	0.4	-0.1	2	-1	1
Slovak Republic	-6	1	-5	-6	16	10
Slovenia	0.04	14	14	-14	27	13
South Africa	-0.1	1	1	-4	1	-4
South Korea	-2	-0.3	-3	-27	-10	-38
Spain	1	9	10	-4	16	12
Sweden	-0.2	18	18	-4	33	28
Switzerland	-1	26	26	28	115	143
Taiwan	0.02	1	1	-31	6	-25
Turkey	-4	1	-3	-5	7	2
United Kingdom	-2	9	7	-12	45	33
United States	1	-0.2	1	-7	2	-4
Total net error	-0.5	2.1	1.6	-4	3.5	-0.6
# of values <0 / >0	31 / 12	9 / 34	13 / 30	36 / 7	8 / 35	13 / 30

9 Conclusion: the contribution of this paper

Within the environmentally extended international input-output accounting framework EXIOPOL, we developed a methodology to estimate model specification errors and aggregation errors, such that the partial errors consistently sum to the total error.

The partial *specification* errors relate to using domestic emission coefficients instead of country-specific coefficients, and to using a single-country IO framework instead of an intercountry one. The empirical outcomes show that for CO_2 emissions the large percentage errors tend to overestimate emissions when domestic emission coefficients are applied. However, most large errors (partially) cancel out when further simplifying the specification to a single-country model. This is even more prevalent when looking at the industry results and the services industries in particular. These findings indicate that emissions coefficients and economic structure are closely related. When assessing the CO_2 emissions of an industry, region, or country it is important to verify the combination of economic interrelationships and emission coefficients estimated for that particular economy.

For water use the range of the errors is wider than for CO_2 emissions. The sum of the partial specification errors is also much further off mark than the sum of the partial errors of the CO_2 emissions. The deviation from the full model estimates is primarily caused by using domestic emission coefficient, i.e. the pairing of economic interrelationships of arbitrary countries with the water use coefficients of one particular economy. At the individual country level, especially Norway stands out considering the relative errors in the estimation of water use.

The partial *aggregation* errors relate to aggregating the 129 EXIOPOL sectors to the 59 EU-sectors, to 10 aggregate sectors, and to aggregating the remaining 42 countries of each of the 43 EXIOPOL countries to, respectively, 4 broad regions and a single large 'Rest of the World'. The empirical outcomes show that the aggregation of sectors has a larger impact on the errors made in the estimation of water use than the errors made in the estimation of CO_2 emissions. This holds both when looking at the results for the four final demand categories or for countries. For both representations, the larger errors are found for the aggregation from 59 to 10 sectors than for 129 to 59 sectors. Only final demand 4: changes in inventories and valuables, and exports to the 'Rest of the World', shows quite contrary results, probably because of its peculiar character compared to the other final demand categories. When looking at the country results it is clear that the individual country errors are within a wider range when aggregating from 59 to 10 sectors.

The spatial aggregation also shows much more extreme results for water use. Aggregating countries into main regions has as result an underestimation of the water use of countries. Aggregating to one individual country and a 'Rest of the World' region also leads to an underestimation of water use, but to a much lesser extent. In estimating CO_2 emissions the large errors are all related to

European countries. For both water use and CO_2 emissions the larger errors are found for the aggregation from five to two regions.

Overall, the effects of different specification and aggregation options are more sizeable with regards to the estimates of water use compared to CO_2 emissions. One explanation may be that only certain sectors are linked to large water use coefficients, whereas each and every sector uses energy and is therefore producing CO_2 emissions, albeit also at variable intensities, but less variable than the water use intensities.

This paper shows that differences in specification or level of detail in either sector detail or spatial detail may have a sizeable effect on the estimates of emissions or resource use. However, due to the explorative nature of the analysis which is far from exhaustive, no explicit recipe can be given for the number of sectors or regions that should be included when assessing environmental issues within an input-output framework. The different settings we chose to compare are in all cases the most extreme settings possible: a full model versus a single-country model, many sectors versus only a select few, and individual countries versus one country and the 'Rest of the World'. For each of these comparisons we included 'half-way' options which especially for the aggregation errors reflect settings that resemble some of the practices in the literature. Some very interesting results have been presented in this paper, but a more systemic comparison has been left for future research.

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Appendices

Appendix 1: EXIOPOL country list

The 43 EXIOPOL countries – the 27 EU member countries are marked

Australia		Hungary	(EU)	South Korea	
Austria	(EU)	India		Romania	(EU)
Belgium	(EU)	Indonesia		Russian Federation	
Bulgaria	(EU)	Ireland	(EU)	Slovakia	(EU)
Brazil		Italy	(EU)	Slovenia	(EU)
Canada		Japan		South Africa	
China		Latvia	(EU)	Spain	(EU)
Cyprus	(EU)	Lithuania	(EU)	Sweden	(EU)
Czech Republic	(EU)	Luxembourg	(EU)	Switzerland	
Denmark	(EU)	Malta	(EU)	Taiwan	
Estonia	(EU)	Mexico		Turkey	
Finland	(EU)	Netherlands	(EU)	United States	
France	(EU)	Norway		United Kingdom	(EU)
Germany	(EU)	Poland	(EU)		
Greece	(EU)	Portugal	(EU)		

Appendix 2: EXIOPOL sector classification

i01.a	Cultivation of paddy rice
i01.b	Cultivation of wheat
i01.c	Cultivation of cereal grains nec
i01.d	Cultivation of vegetables, fruit, nuts
i01.e	Cultivation of oil seeds
i01.f	Cultivation of sugar cane, sugar beet
i01.g	Cultivation of plant-based fibers
i01.h	Cultivation of crops nec
i01.i	Cattle farming
i01.j	Pigs farming
i01.k	Poultry farming
i01.l	Meat animals nec
i01.m	Animal products nec
i01.n	Raw milk
i01.o	Wool, silk-worm cocoons
i02	Forestry, logging and related service activities (02)
i05	Fishing, operating of fish hatcheries and fish farms; service activities incidental to fishing (05)
i10	Mining of coal and lignite; extraction of peat (10)
i11.a	Extraction of crude petroleum and services related to crude oil extraction, excluding surveying
i11.b	Extraction of natural gas and services related to natural gas extraction, excluding surveying
i11.c	Extraction, liquefaction, and regasification of other petroleum and gaseous materials
i12	Mining of uranium and thorium ores (12)
i13.1	Mining of iron ores
i13.20.11	Mining of copper ores and concentrates
i13.20.12	Mining of nickel ores and concentrates
i13.20.13	Mining of aluminum ores and concentrates
i13.20.14	Mining of precious metal ores and concentrates
i13.20.15	Mining of lead, zinc and tin ores and concentrates
i13.20.16	Mining of other non-ferrous metal ores and concentrates
i14.1	Quarrying of stone
i14.2	Quarrying of sand and clay
i14.3	Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.
i15.a	Processing of meat cattle
i15.b	Processing of meat pigs
i15.c	Processing of meat poultry
i15.d	Production of meat products nec
i15.e	Processing vegetable oils and fats
i15.f	Processing of dairy products
i15.g	Processed rice
i15.h	Sugar refining
i15.i	Processing of Food products nec
i15.j	Manufacture of beverages
i15.k	Manufacture of fish products

i16	Manufacture of tobacco products (16)
i17	Manufacture of textiles (17)
i18	Manufacture of wearing apparel; dressing and dyeing of fur (18)
i19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear (19)
i20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (20)
i21	Manufacture of pulp, paper and paper products (21)
i22	Publishing, printing and reproduction of recorded media (22)
i23.1	Manufacture of coke oven products
i23.20.a	Manufacture of motor spirit (gasoline)
i23.20.b	Manufacture of kerosene, including kerosene type jet fuel
i23.20.c	Manufacture of gas oils
i23.20.d	Manufacture of fuel oils n.e.c.
i23.20.e	Manufacture of petroleum gases and other gaseous hydrocarbons, except natural gas
i23.20.f	Manufacture of other petroleum products
i23.3	Processing of nuclear fuel
i24	Manufacture of chemicals and chemical products (24)
i25	Manufacture of rubber and plastic products (25)
i26.a	Manufacture of glass and glass products
i26.b	Manufacture of ceramic goods
i26.c	Manufacture of bricks, tiles and construction products, in baked clay
i26.d	Manufacture of cement, lime and plaster
i26.e	Manufacture of other non-metallic mineral products n.e.c.
i27.a	Manufacture of basic iron and steel and of ferro-alloys and first products thereof
i27.41	Precious metals production
i27.42	Aluminum production
i27.43	Lead, zinc and tin production
i27.44	Copper production
i27.45	Other non-ferrous metal production
i27.5	Casting of metals
i28	Manufacture of fabricated metal products, except machinery and equipment (28)
i29	Manufacture of machinery and equipment n.e.c. (29)
i30	Manufacture of office machinery and computers (30)
i31	Manufacture of electrical machinery and apparatus n.e.c. (31)
i32	Manufacture of radio, television and communication equipment and apparatus (32)
i33	Manufacture of medical, precision and optical instruments, watches and clocks (33)
i34	Manufacture of motor vehicles, trailers and semi-trailers (34)
i35	Manufacture of other transport equipment (35)
i36	Manufacture of furniture; manufacturing n.e.c. (36)
i37.1	Recycling of metal waste and scrap
i37.2	Recycling of non-metal waste and scrap
i40.11.a	Production of electricity by coal
i40.11.b	Production of electricity by gas
i40.11.c	Production of electricity by nuclear
i40.11.d	Production of electricity by hydro
i40.11.e	Production of electricity by wind
i40.11.f	Production of electricity nec, including biomass and waste
i40.12	Transmission of electricity

i40.13	Distribution and trade of electricity
i40.2	Manufacture of gas; distribution of gaseous fuels through mains
i40.3	Steam and hot water supply
i41	Collection, purification and distribution of water (41)
i45	Construction (45)
i50.a	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessories
i50.b	Retail sale of automotive fuel
i51	Wholesale trade and commission trade, except of motor vehicles and motorcycles (51)
i52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods (52)
i55	Hotels and restaurants (55)
i60.1	Transport via railways
i60.2	Other land transport
i60.3	Transport via pipelines
i61.1	Sea and coastal water transport
i61.2	Inland water transport
i62	Air transport (62)
i63	Supporting and auxiliary transport activities; activities of travel agencies (63)
i64	Post and telecommunications (64)
i65	Financial intermediation, except insurance and pension funding (65)
i66	Insurance and pension funding, except compulsory social security (66)
i67	Activities auxiliary to financial intermediation (67)
i70	Real estate activities (70)
i71	Renting of machinery and equipment without operator and of personal and household goods (71)
i72	Computer and related activities (72)
i73	Research and development (73)
i74	Other business activities (74)
i75	Public administration and defense; compulsory social security (75)
i80	Education (80)
i85	Health and social work (85)
i90.01	Collection and treatment of sewage
i90.02.a	Collection of waste
i90.02.b	Incineration of waste
i90.02.c	Landfill of waste
i90.03	Sanitation, remediation and similar activities
i91	Activities of membership organization n.e.c. (91)
i92	Recreational, cultural and sporting activities (92)
i93	Other service activities (93)
i95	Private households with employed persons (95)
i99	Extra-territorial organizations and bodies

Appendix 3: Sector aggregation

	NACE Rev. 1.1 classification*	EXIOPOL sectors				
A	Agriculture, hunting and forestry	i01	i02			
B	Fishing	i05				
C	Mining and quarrying	i10	i11	i12	i13	i14
D	Manufacturing	i15	i16	i17	i18	i19
		i20	i21	i22	i23	i24
		i25	i26	i27	i28	i29
		i30	i31	i32	i33	i34
		i35	i36	i37		
E	Electricity, gas and water supply	i40	i41			
F	Construction	i45				
G	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and	i50	i51	i52		
H	Hotels and restaurants	i55				
I	Transport, storage and communication	i60	i61	i62	i63	i64
J	Financial intermediation	65	i66	i67		
K	Real estate, renting and business activities	i70	i71	i72	i73	i74
L	Public administration and defense; compulsory social security	i75				
M	Education	i80				
N	Health and social work	i85				
O	Other community, social and personal service activities	i90	i91	i92	i93	
P	Activities of households	i95	i96	i97		
Q	Extra-territorial organizations and bodies	i99				

* A description of the NACE Rev. 1.1 classification can be found at:

http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=DSP_GEN_DESC_VIEW_NOHDR&StrNom=NACE_1_1&StrLanguageCode=EN

Appendix 4: Spatial aggregation

EU-high	PPP $ 2000
Luxembourg	53652
Netherlands	29403
Denmark	28829
Austria	28773
Ireland	28639
Sweden	27961
Belgium	27612
United Kingdom	26072
Germany	25945
Finland	25653
Italy	25595
France	25328
Spain	21323

EU-low	PPP $ 2000
Cyprus	19412
Greece	18412
Malta	18291
Portugal	17751
Slovenia	17474
Czech Republic	14993
Hungary	12266
Slovak Republic	10997
Poland	10514
Estonia	9882
Lithuania	8602
Latvia	8031
Bulgaria	6301
Romania	5654

Other-high	PPP $ 2000
Norway	36130
United States	35081
Switzerland	31731
Canada	28407
Australia	26422
Japan	25619
Taiwan	19866
Korea, Rep.	17219

Other-low	PPP $ 2000
Mexico	9201
Turkey	8867
Brazil	7021
Russian Federation	6824
South Africa	6773
Indonesia	2417
China	2364
India	1574

Data on GDP per capita, PPP (current international $) for 2000
World Development Indicators, http://data.worldbank.org/indicator, accessed 25-3-2011
Source: World Bank national accounts data, and OECD National Accounts data files.

Annex 1: Result tables related to Part I for the EU27: impacts of EU27 final consumption in 2000

		Footprints					
		Land footprint	Net Energy Use	Water Consumption Blue	Water Consumption Green	Domestic Extraction Use	Unused Domestic Extraction
		ha	TJ	m3	m3	kt	kt
1	Cultivation of paddy rice	4,94E+05	5,62E+03	2,15E+09	1,76E+09	2,18E+03	2,61E+03
2	Cultivation of wheat	8,17E+06	5,45E+04	4,93E+08	2,45E+10	3,79E+04	1,42E+04
3	Cultivation of cereal grains nec	6,46E+06	3,81E+04	1,43E+09	4,50E+09	2,47E+04	8,75E+03
4	Cultivation of vegetables	2,27E+07	3,76E+05	6,46E+09	3,97E+10	1,86E+05	1,66E+05
5	Cultivation of oil seeds	-5,33E+05	4,85E+04	2,91E+08	3,90E+09	8,17E+02	5,40E+03
6	Cultivation of sugar cane	1,03E+04	4,27E+02	1,69E+06	1,05E+07	4,60E+02	8,56E+01
7	Cultivation of plant-based fibers	6,45E+05	9,56E+03	1,97E+08	9,72E+08	2,13E+03	2,56E+03
8	Cultivation of crops nec	3,40E+07	1,47E+05	6,22E+10	2,88E+11	2,17E+05	2,39E+04
9	Cattle farming	1,80E+06	1,82E+04	1,93E+09	9,69E+09	9,90E+03	2,73E+03
10	Pigs farming	1,46E+06	2,20E+04	7,79E+08	4,44E+09	7,00E+03	3,62E+03
11	Poultry farming	7,51E+06	1,08E+05	3,13E+09	2,03E+10	3,65E+04	2,59E+04
12	Meat animals nec	2,99E+05	4,50E+03	2,11E+08	1,24E+09	1,54E+03	5,79E+02
13	Animal products nec	5,55E+05	8,02E+03	2,92E+08	2,30E+09	2,75E+03	1,87E+03
14	Raw milk	3,43E+06	4,16E+04	3,49E+09	1,75E+10	2,06E+04	6,97E+03
15	Wool	2,20E+04	8,21E+01	1,00E+07	6,32E+07	5,87E+01	2,19E+01
16	Forestry	3,29E+07	3,54E+04	7,91E+08	3,65E+09	1,14E+05	1,69E+04
17	Fishing	2,55E+06	5,59E+04	1,73E+09	1,13E+10	1,50E+04	7,70E+03
18	Mining of coal and lignite; extraction of peat (10)	5,66E+04	2,34E+04	2,03E+07	1,14E+08	6,50E+04	3,76E+05
19	Extraction of crude petroleum and services related to crude oil extraction	1,36E+04	6,38E+03	4,10E+06	2,95E+07	4,33E+03	1,22E+03
20	Extraction of natural gas and services related to natural gas extraction	-2,32E+04	-5,70E+04	1,67E+07	1,94E+07	-2,56E+04	-5,07E+03
21	Extraction	2,74E+04	4,50E+03	1,23E+07	6,98E+07	2,01E+03	3,67E+02
22	Mining of uranium and thorium ores (12)	1,02E+05	1,19E+03	5,15E+07	3,09E+08	2,26E+03	4,68E+03
23	Mining of iron ores	2,42E+04	2,39E+03	2,87E+06	9,70E+07	2,08E+03	3,53E+03
24	Mining of copper ores and concentrates	6,52E+03	3,65E+03	2,32E+06	1,38E+07	1,06E+04	5,56E+03
25	Mining of nickel ores and concentrates	1,41E+03	2,67E+02	4,58E+05	3,19E+06	2,28E+02	1,77E+02
26	Mining of aluminium ores and concentrates	1,29E+04	2,76E+03	3,44E+05	2,54E+07	-1,01E+02	-2,81E+03

		Footprints					
		Land footprint	Net Energy Use	Water Consumption Blue	Water Consumption Green	Domestic Extraction Use	Unused Domestic Extraction
		ha	TJ	m3	m3	kt	kt
27	Mining of precious metal ores and concentrates	9,76E+03	1,54E+03	1,34E+06	1,31E+07	7,38E+02	2,25E+03
28	Mining of lead	3,85E+02	-1,45E+01	1,22E+05	1,18E+06	-7,15E+01	-5,92E+01
29	Mining of other non-ferrous metal ores and concentrates	5,28E+02	-7,93E+01	3,17E+05	2,20E+06	-8,20E+01	1,38E+02
30	Quarrying of stone	2,39E+04	5,62E+03	7,01E+06	4,76E+07	4,54E+04	6,65E+03
31	Quarrying of sand and clay	3,82E+04	7,39E+03	9,04E+06	5,74E+07	8,40E+04	1,38E+04
32	Mining of chemical and fertilizer minerals	7,75E+04	8,83E+03	1,44E+07	1,21E+08	4,28E+04	2,50E+04
33	Processing of meat cattle	1,19E+07	2,50E+05	1,09E+10	5,58E+10	7,25E+04	3,17E+04
34	Processing of meat pigs	1,02E+07	2,43E+05	5,07E+09	2,92E+10	5,45E+04	3,54E+04
35	Processing of meat poultry	2,23E+07	5,37E+05	1,02E+10	6,02E+10	1,18E+05	7,74E+04
36	Production of meat products nec	1,02E+07	2,31E+05	6,36E+09	3,38E+10	5,47E+04	2,83E+04
37	Processing vegetable oils and fats	1,70E+07	1,70E+05	2,54E+09	1,85E+10	3,55E+04	1,86E+04
38	Processing of dairy products	1,80E+07	5,97E+05	1,46E+10	7,57E+10	1,28E+05	9,58E+04
39	Processed rice	9,06E+05	1,38E+04	1,94E+09	3,85E+09	3,84E+03	3,53E+03
40	Sugar refining	2,10E+06	1,12E+05	4,83E+08	3,05E+09	6,81E+04	1,69E+04
41	Processing of Food products nec	4,66E+07	5,49E+05	1,94E+10	1,28E+11	1,60E+05	7,76E+04
42	Manufacture of beverages	3,86E+06	9,19E+04	1,43E+09	9,55E+09	1,96E+04	1,25E+04
43	Manufacture of fish products	5,66E+06	7,55E+05	2,39E+09	1,57E+10	5,37E+04	5,40E+04
44	Manufacture of tobacco products (16)	1,27E+07	1,07E+05	1,15E+10	6,47E+10	4,43E+04	1,16E+04
45	Manufacture of textiles (17)	1,45E+07	5,43E+05	1,06E+10	7,05E+10	7,79E+04	5,56E+04
46	Manufacture of wearing apparel; dressing and dyeing of fur (18)	1,57E+07	6,83E+05	8,13E+09	5,53E+10	8,58E+04	6,64E+04
47	Tanning and dressing of leather; manufacture of luggage	6,75E+06	3,60E+05	2,73E+09	1,87E+10	3,01E+04	2,21E+04
48	Manufacture of wood and of products of wood and cork	2,62E+07	1,59E+05	7,55E+08	6,28E+09	4,34E+04	1,57E+04
49	Manufacture of pulp	1,15E+07	3,92E+05	5,66E+08	7,66E+09	4,26E+04	3,08E+04
50	Publishing	7,23E+06	5,48E+05	1,09E+09	9,74E+09	4,41E+04	4,15E+04
51	Manufacture of coke oven products	6,86E+04	6,60E+04	2,42E+07	1,48E+08	9,20E+03	5,11E+04
52	Manufacture of motor spirit (gasoline)	3,50E+06	8,22E+05	1,17E+09	8,37E+09	2,53E+05	1,32E+05
53	Manufacture of kerosene	1,77E+05	2,18E+04	7,73E+07	4,77E+08	4,97E+03	2,31E+03
54	Manufacture of gas	6,88E+05	1,64E+05	2,23E+08	1,60E+09	4,72E+04	2,48E+04

		Footprints					
		Land footprint	Net Energy Use	Water Consumption Blue	Water Consumption Green	Domestic Extraction Use	Unused Domestic Extraction
		ha	TJ	m3	m3	kt	kt
	oils						
55	Manufacture of fuel oils n.e.c.	4,03E+04	1,38E+04	1,20E+07	8,60E+07	2,46E+03	1,21E+03
56	Manufacture of petroleum gases and other gaseous hydrocarbons	1,57E+05	3,66E+04	5,76E+07	3,87E+08	9,17E+03	4,69E+03
57	Manufacture of other petroleum products	2,64E+04	3,12E+04	8,97E+06	6,17E+07	2,02E+03	6,37E+02
58	Processing of nuclear fuel	-8,55E+03	-5,95E+05	-9,93E+04	-3,02E+06	-4,50E+02	-5,40E+02
59	Manufacture of chemicals and chemical products (24)	1,39E+07	3,17E+06	6,22E+09	3,68E+10	2,49E+05	1,72E+05
60	Manufacture of rubber and plastic products (25)	2,84E+06	4,00E+05	1,17E+09	1,41E+10	3,39E+04	3,05E+04
61	Manufacture of glass and glass products	5,82E+05	1,47E+05	1,38E+08	9,23E+08	2,35E+04	2,03E+04
62	Manufacture of ceramic goods	1,49E+05	1,15E+05	4,28E+07	3,07E+08	3,31E+03	3,02E+03
63	Manufacture of bricks	5,82E+04	3,93E+04	1,25E+07	7,96E+07	1,33E+03	1,82E+03
64	Manufacture of cement	1,85E+05	7,28E+04	5,27E+07	3,33E+08	3,93E+04	1,20E+04
65	Manufacture of other non-metallic mineral products n.e.c.	2,99E+05	5,03E+04	8,42E+07	5,01E+08	3,63E+04	1,40E+04
66	Manufacture of basic iron and steel and of ferro-alloys and first products thereof	4,70E+05	2,21E+05	1,05E+08	8,43E+08	2,26E+04	3,89E+04
67	Precious metals production	4,90E+04	7,25E+03	7,49E+06	4,79E+07	1,26E+03	1,51E+03
68	Aluminium production	1,88E+05	4,16E+04	2,45E+07	1,72E+08	3,13E+03	4,79E+03
69	Lead	1,69E+05	2,09E+04	5,64E+07	3,56E+08	5,70E+03	3,69E+03
70	Copper production	3,31E+05	2,38E+04	5,54E+07	3,57E+08	1,73E+04	1,85E+04
71	Other non-ferrous metal production	7,34E+04	5,43E+03	6,24E+06	4,45E+07	1,31E+03	1,35E+03
72	Casting of metals	3,97E+04	6,74E+03	9,39E+06	7,28E+07	1,35E+03	1,09E+03
73	Manufacture of fabricated metal products	4,25E+06	8,06E+05	1,11E+09	7,30E+09	9,66E+04	1,29E+05
74	Manufacture of machinery and equipment n.e.c. (29)	1,10E+07	1,71E+06	3,07E+09	2,08E+10	2,02E+05	2,45E+05
75	Manufacture of office machinery and computers (30)	4,31E+06	4,81E+05	1,08E+09	9,70E+09	4,86E+04	5,08E+04
76	Manufacture of electrical machinery and apparatus n.e.c. (31)	9,09E+06	4,79E+05	1,06E+09	7,48E+09	6,97E+04	7,97E+04
77	Manufacture of radio	7,52E+06	6,83E+05	1,80E+09	1,37E+10	8,12E+04	7,95E+04
78	Manufacture of medical	2,88E+06	4,56E+05	7,72E+08	5,44E+09	4,23E+04	4,18E+04

		Footprints					
		Land footprint	Net Energy Use	Water Consumption Blue	Water Consumption Green	Domestic Extraction Use	Unused Domestic Extraction
		ha	TJ	m3	m3	kt	kt
79	Manufacture of motor vehicles	1,73E+07	2,70E+06	4,85E+09	3,59E+10	2,82E+05	3,51E+05
80	Manufacture of other transport equipment (35)	4,08E+06	5,42E+05	8,93E+08	6,46E+09	6,40E+04	6,94E+04
81	Manufacture of furniture; manufacturing n.e.c. (36)	3,33E+07	1,26E+06	3,18E+09	2,68E+10	2,10E+05	1,26E+05
82	Recycling of metal waste and scrap	1,36E+05	1,75E+04	3,52E+07	2,15E+08	2,07E+03	2,35E+03
83	Recycling of non-metal waste and scrap	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
84	Production of electricity by coal	4,67E+05	1,76E+06	1,31E+08	8,84E+08	1,38E+05	8,01E+05
85	Production of electricity by gas	7,89E+05	9,14E+05	2,86E+08	1,85E+09	8,47E+04	2,25E+04
86	Production of electricity by nuclear	1,42E+05	2,99E+06	4,63E+07	2,94E+08	3,26E+03	3,19E+03
87	Production of electricity by hydro	1,01E+05	7,06E+04	3,22E+07	2,07E+08	4,26E+03	6,10E+03
88	Production of electricity by wind	6,66E+03	2,17E+03	2,70E+06	1,70E+07	1,27E+02	8,35E+01
89	Production of electricity nec	1,37E+06	5,77E+05	5,02E+08	2,77E+09	2,43E+04	1,70E+04
90	Transmission of electricity	1,15E+05	3,47E+04	3,81E+07	2,61E+08	3,94E+03	5,59E+03
91	Distribution and trade of electricity	5,12E+05	4,91E+05	1,60E+08	1,11E+09	1,86E+04	2,87E+04
92	Manufacture of gas; distribution of gaseous fuels through mains	5,76E+05	1,94E+05	1,89E+08	1,20E+09	5,84E+04	2,02E+04
93	Steam and hot water supply	4,52E+05	2,95E+05	9,80E+07	5,91E+08	2,93E+04	5,83E+04
94	Collection	5,44E+05	1,29E+05	1,77E+08	1,09E+09	1,69E+04	2,19E+04
95	Construction (45)	6,69E+07	4,88E+06	1,50E+10	8,96E+10	1,76E+06	7,31E+05
96	Sale	3,95E+06	6,83E+05	1,37E+09	9,13E+09	6,20E+04	8,32E+04
97	Retail sale of automotive fuel	8,84E+05	1,02E+05	6,12E+08	3,27E+09	1,06E+04	9,80E+03
98	Wholesale trade and commission trade	1,32E+07	1,49E+06	6,16E+09	3,61E+10	1,65E+05	1,26E+05
99	Retail trade	1,81E+07	1,78E+06	8,51E+09	4,97E+10	2,09E+05	1,81E+05
100	Hotels and restaurants (55)	1,21E+08	2,15E+06	7,57E+10	4,24E+11	4,46E+05	2,43E+05
101	Transport via railways	5,45E+05	1,77E+05	1,74E+08	1,06E+09	9,91E+03	8,77E+03
102	Other land transport	4,29E+06	7,38E+05	1,86E+09	1,14E+10	7,29E+04	5,95E+04
103	Transport via pipelines	2,18E+05	7,71E+04	7,96E+07	4,73E+08	5,20E+03	6,71E+03
104	Sea and coastal water transport	9,26E+05	7,14E+05	4,74E+08	3,38E+09	1,04E+04	1,01E+04
105	Inland water transport	5,22E+05	1,69E+05	2,80E+08	1,74E+09	5,93E+03	5,00E+03
106	Air transport (62)	3,63E+06	1,43E+06	1,90E+09	1,11E+10	3,80E+04	2,78E+04

		Footprints					
		Land footprint	Net Energy Use	Water Consumption Blue	Water Consumption Green	Domestic Extraction Use	Unused Domestic Extraction
		ha	TJ	m3	m3	kt	kt
107	Supporting and auxiliary transport activities; activities of travel agencies (63)	2,96E+06	4,90E+05	1,36E+09	7,96E+09	3,40E+04	2,83E+04
108	Post and telecommunications (64)	2,86E+06	5,82E+05	8,82E+08	5,64E+09	4,11E+04	3,70E+04
109	Financial intermediation	1,86E+06	2,77E+05	6,61E+08	4,03E+09	2,23E+04	2,26E+04
110	Insurance and pension funding	2,93E+06	4,05E+05	1,04E+09	6,28E+09	3,59E+04	3,46E+04
111	Activities auxiliary to financial intermediation (67)	3,75E+05	5,62E+04	1,20E+08	8,54E+08	4,43E+03	5,09E+03
112	Real estate activities (70)	1,07E+07	1,47E+06	4,22E+09	2,29E+10	2,01E+05	1,96E+05
113	Renting of machinery and equipment without operator and of personal and household goods (71)	3,41E+05	7,39E+04	1,28E+08	7,56E+08	5,18E+03	5,65E+03
114	Computer and related activities (72)	2,06E+06	2,66E+05	7,88E+08	4,74E+09	2,30E+04	2,21E+04
115	Research and development (73)	7,83E+05	2,02E+05	2,89E+08	1,75E+09	1,01E+04	9,12E+03
116	Other business activities (74)	2,78E+06	3,37E+05	9,60E+08	5,79E+09	3,08E+04	2,72E+04
117	Public administration and defence; compulsory social security (75)	1,77E+07	2,15E+06	6,07E+09	3,79E+10	2,61E+05	2,29E+05
118	Education (80)	7,42E+06	9,68E+05	3,09E+09	1,81E+10	8,56E+04	1,01E+05
119	Health and social work (85)	1,92E+07	2,45E+06	8,55E+09	5,17E+10	2,30E+05	2,19E+05
120	Collection and treatment of sewage	1,53E+05	5,91E+04	6,02E+07	3,57E+08	3,47E+03	3,72E+03
121	Collection of waste	4,79E+05	1,89E+05	1,63E+08	9,97E+08	1,03E+04	8,21E+03
122	Incineration of waste	1,29E+05	3,68E+04	4,67E+07	2,82E+08	2,79E+03	2,48E+03
123	Landfill of waste	1,25E+05	3,57E+04	4,53E+07	2,74E+08	2,71E+03	2,40E+03
124	Sanitation	2,28E+05	5,51E+04	7,95E+07	4,84E+08	4,90E+03	4,07E+03
125	Activities of membership organisation n.e.c. (91)	1,28E+06	1,87E+05	4,68E+08	2,80E+09	1,48E+04	1,60E+04
126	Recreational	7,18E+06	8,08E+05	3,16E+09	1,78E+10	6,81E+04	6,01E+04
127	Other service activities (93)	2,81E+06	2,97E+05	7,95E+08	4,73E+09	2,47E+04	2,41E+04
128	Private households with employed persons (95)	3,02E+04	8,88E+03	1,29E+07	8,18E+07	3,64E+02	4,86E+02
129	Extra-territorial organizations and bodies	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
130	direct	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
	Sum	8,08E+08	5,46E+07	3,70E+11	2,15E+12	8,21E+06	6,67E+06

		LCA Impact assessment				
		acidification (incl. fate, average Europe total, A&B) (AP (Huijbregts, 1999; average Europe total, A&B))	eutrophication (fate not incl.) (EP (Heijungs et al. 1992)))	photochemical oxidation (high NOx)(incl. NOx average, NMVOC average) (POCP (Jenkin & Hayman, 1999; Derwent et al. 1998; high NOx))	global warming GWP100 (incl. NMVOC average) (GWP100 (IPCC, 2007))	ozone layer depletion ODP steady state (incl. NMVOC average) (ODP steady state (WMO, 2003))
		kg SO2 eq.	kg PO4--- eq.	kg ethylene eq.	kg CO2 eq.	kg CFC-11 eq.
1	Cultivation of paddy rice	6,13E+06	1,48E+06	1,75E+05	9,20E+08	1,54E+01
2	Cultivation of wheat	9,74E+07	3,36E+07	6,97E+05	1,93E+10	9,48E+01
3	Cultivation of cereal grains nec	7,92E+07	2,55E+07	4,86E+05	1,33E+10	6,15E+01
4	Cultivation of vegetables	2,58E+08	5,55E+07	3,10E+06	4,87E+10	3,57E+02
5	Cultivation of oil seeds	4,09E+07	1,12E+07	-9,98E+04	7,51E+09	1,46E+01
6	Cultivation of sugar cane	2,20E+05	5,18E+04	2,72E+03	4,61E+07	2,99E-01
7	Cultivation of plant-based fibers	7,14E+06	2,09E+06	1,16E+05	1,72E+09	2,01E+01
8	Cultivation of crops nec	1,13E+08	2,77E+07	1,09E+06	2,10E+10	1,43E+02
9	Cattle farming	1,79E+08	4,05E+07	3,08E+06	1,52E+10	4,61E+01
10	Pigs farming	2,64E+08	5,85E+07	1,44E+06	7,77E+09	6,50E+01
11	Poultry farming	3,40E+08	7,46E+07	2,68E+06	2,11E+10	2,61E+02
12	Meat animals nec	6,97E+06	1,48E+06	1,91E+05	8,40E+08	1,71E+01
13	Animal products nec	6,05E+07	1,47E+07	5,85E+05	4,32E+09	2,86E+01
14	Raw milk	2,26E+08	5,09E+07	3,92E+06	2,07E+10	9,33E+01
15	Wool	3,47E+05	8,63E+04	6,05E+03	4,07E+07	1,35E-01
16	Forestry	1,10E+07	1,18E+06	3,55E+05	2,79E+09	4,94E+01
17	Fishing	3,72E+07	6,05E+06	-1,86E+06	4,63E+09	1,11E+02
18	Mining of coal and lignite; extraction of peat (10)	1,30E+07	6,20E+05	1,22E+07	2,02E+10	1,16E+03
19	Extraction of crude petroleum and services related to crude oil extraction	5,40E+05	4,63E+04	2,36E+05	1,24E+08	3,64E+01
20	Extraction of natural gas and services related to natural gas extraction	-2,39E+06	-1,23E+05	-5,58E+05	-7,13E+08	-8,74E+01
21	Extraction	1,11E+06	9,92E+04	3,38E+04	2,51E+08	5,32E+00
22	Mining of uranium and thorium ores (12)	7,48E+05	5,08E+04	2,48E+04	1,22E+08	2,28E+00
23	Mining of iron ores	1,22E+06	8,57E+04	5,49E+04	2,92E+08	6,59E+00
24	Mining of copper ores and concentrates	1,43E+06	7,23E+04	5,10E+04	2,15E+08	3,71E+00
25	Mining of nickel ores and concentrates	7,28E+04	5,42E+03	2,55E+03	1,73E+07	2,51E-01
26	Mining of aluminium ores and concentrates	2,13E+06	1,29E+05	8,51E+03	3,94E+08	1,72E+00
27	Mining of precious metal ores and concentrates	1,74E+06	7,50E+04	3,70E+04	1,93E+08	2,03E+00

		LCA Impact assessment				
		acidification (incl. fate, average Europe total, A&B) (AP (Huijbregts, 1999; average Europe total, A&B))	eutrophication (fate not incl.) (EP (Heijungs et al. 1992)))	photochemical oxidation (high NOx)(incl. NOx average, NMVOC average) (POCP (Jenkin & Hayman, 1999; Derwent et al. 1998; high NOx))	global warming GWP100 (incl. NMVOC average) (GWP100 (IPCC, 2007))	ozone layer depletion ODP steady state (incl. NMVOC average) (ODP steady state (WMO, 2003))
		kg SO2 eq.	kg PO4--- eq.	kg ethylene eq.	kg CO2 eq.	kg CFC-11 eq.
28	Mining of lead	-4,06E+04	-6,76E+02	-3,05E+03	-3,52E+06	-1,97E-01
29	Mining of other non-ferrous metal ores and concentrates	4,18E+04	2,44E+03	1,66E+03	2,96E+06	1,14E-01
30	Quarrying of stone	2,24E+06	1,77E+05	3,67E+04	4,78E+08	7,27E+00
31	Quarrying of sand and clay	3,21E+06	2,37E+05	5,97E+04	6,64E+08	1,06E+01
32	Mining of chemical and fertilizer minerals	5,95E+06	3,97E+05	2,85E+05	9,66E+08	2,25E+01
33	Processing of meat cattle	9,98E+08	2,18E+08	1,87E+07	9,04E+10	6,55E+02
34	Processing of meat pigs	1,56E+09	3,38E+08	1,11E+07	5,44E+10	7,83E+02
35	Processing of meat poultry	7,58E+08	1,52E+08	1,58E+07	6,81E+10	1,87E+03
36	Production of meat products nec	3,23E+08	6,51E+07	8,98E+06	3,37E+10	9,73E+02
37	Processing vegetable oils and fats	1,30E+08	3,17E+07	3,77E+06	2,32E+10	5,11E+02
38	Processing of dairy products	1,06E+09	2,06E+08	3,16E+07	1,13E+11	2,74E+03
39	Processed rice	8,09E+06	1,47E+06	3,56E+05	1,47E+09	5,62E+01
40	Sugar refining	4,73E+07	9,01E+06	7,95E+06	1,01E+10	1,19E+03
41	Processing of Food products nec	5,81E+08	1,24E+08	5,04E+07	7,27E+10	6,96E+03
42	Manufacture of beverages	5,42E+07	9,54E+06	3,56E+06	9,01E+09	4,98E+02
43	Manufacture of fish products	2,58E+08	2,93E+07	6,33E+06	5,15E+10	8,64E+02
44	Manufacture of tobacco products (16)	9,36E+07	1,75E+07	2,00E+06	1,23E+10	1,75E+02
45	Manufacture of textiles (17)	3,19E+08	3,54E+07	7,82E+06	4,28E+10	7,10E+02
46	Manufacture of wearing apparel; dressing and dyeing of fur (18)	3,91E+08	4,50E+07	1,08E+07	5,25E+10	1,03E+03
47	Tanning and dressing of leather; manufacture of luggage	2,02E+08	2,87E+07	5,51E+06	2,90E+10	5,05E+02
48	Manufacture of wood and of products of wood and cork	4,97E+07	4,10E+06	2,40E+06	1,15E+10	2,30E+02
49	Manufacture of pulp	1,20E+08	8,57E+06	7,18E+06	2,60E+10	6,38E+02
50	Publishing	1,74E+08	1,46E+07	3,84E+07	3,84E+10	5,53E+03
51	Manufacture of coke oven products	2,66E+06	1,86E+05	1,59E+06	7,26E+09	1,57E+02
52	Manufacture of motor spirit (gasoline)	1,61E+08	1,22E+07	1,24E+07	4,68E+10	1,93E+03
53	Manufacture of	3,36E+06	3,01E+05	2,64E+05	1,19E+09	4,45E+01

		LCA Impact assessment				
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		kg SO2 eq.	kg PO4--- eq.	kg ethylene eq.	kg CO2 eq.	kg CFC-11 eq.
	kerosene					
54	Manufacture of gas oils	3,19E+07	2,52E+06	2,42E+06	9,41E+09	3,84E+02
55	Manufacture of fuel oils n.e.c.	1,03E+07	4,28E+05	2,90E+05	9,93E+08	3,32E+01
56	Manufacture of petroleum gases and other gaseous hydrocarbons	1,25E+07	6,86E+05	6,12E+05	2,08E+09	8,63E+01
57	Manufacture of other petroleum products	1,17E+07	5,44E+05	1,12E+06	1,88E+09	1,68E+02
58	Processing of nuclear fuel	-1,43E+06	-1,12E+05	-1,51E+05	-3,31E+08	-2,25E+01
59	Manufacture of chemicals and chemical products (24)	6,86E+08	5,92E+07	1,72E+07	1,19E+11	2,62E+03
60	Manufacture of rubber and plastic products (25)	1,36E+08	1,09E+07	4,27E+06	2,49E+10	4,35E+02
61	Manufacture of glass and glass products	5,80E+07	3,27E+06	1,88E+06	1,11E+10	1,62E+02
62	Manufacture of ceramic goods	4,58E+07	1,70E+06	2,01E+06	7,59E+09	9,51E+01
63	Manufacture of bricks	1,15E+07	5,66E+05	3,78E+05	2,58E+09	2,53E+01
64	Manufacture of cement	2,86E+07	1,55E+06	9,35E+05	1,29E+10	7,88E+01
65	Manufacture of other non-metallic mineral products n.e.c.	2,28E+07	1,38E+06	7,58E+05	4,74E+09	6,97E+01
66	Manufacture of basic iron and steel and of ferro-alloys and first products thereof	6,54E+07	3,34E+06	3,40E+06	3,21E+10	2,27E+02
67	Precious metals production	3,49E+06	1,58E+05	1,89E+05	5,00E+08	2,05E+01
68	Aluminium production	1,20E+07	6,05E+05	1,14E+06	2,41E+09	3,08E+01
69	Lead	7,56E+06	4,43E+05	2,50E+05	1,39E+09	2,71E+01
70	Copper production	8,71E+06	5,32E+05	3,15E+05	1,56E+09	3,43E+01
71	Other non-ferrous metal production	2,04E+06	1,15E+05	9,53E+04	4,09E+08	9,75E+00
72	Casting of metals	5,23E+06	3,42E+05	4,62E+05	8,69E+08	3,63E+01
73	Manufacture of fabricated metal products	2,88E+08	1,81E+07	1,67E+07	8,38E+10	1,75E+03
74	Manufacture of machinery and equipment n.e.c. (29)	6,26E+08	4,35E+07	2,93E+07	1,63E+11	3,18E+03
75	Manufacture of office machinery and computers (30)	1,66E+08	1,31E+07	1,16E+07	3,48E+10	1,47E+03

		LCA Impact assessment				
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		kg SO2 eq.	kg PO4--- eq.	kg ethylene eq.	kg CO2 eq.	kg CFC-11 eq.
76	Manufacture of electrical machinery and apparatus n.e.c. (31)	1,81E+08	1,22E+07	1,01E+07	4,01E+10	1,17E+03
77	Manufacture of radio	2,65E+08	1,95E+07	1,90E+07	5,16E+10	2,35E+03
78	Manufacture of medical	1,39E+08	9,93E+06	8,41E+06	3,03E+10	1,02E+03
79	Manufacture of motor vehicles	9,61E+08	6,82E+07	7,17E+07	2,38E+11	9,27E+03
80	Manufacture of other transport equipment (35)	1,97E+08	1,37E+07	1,91E+07	4,79E+10	2,43E+03
81	Manufacture of furniture; manufacturing n.e.c. (36)	4,40E+08	3,34E+07	2,11E+07	9,59E+10	1,85E+03
82	Recycling of metal waste and scrap	7,19E+06	4,24E+05	3,50E+05	1,46E+09	2,86E+01
83	Recycling of non-metal waste and scrap	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
84	Production of electricity by coal	3,43E+09	1,30E+08	6,07E+07	3,33E+11	2,49E+03
85	Production of electricity by gas	1,18E+08	2,16E+07	-9,26E+06	1,07E+11	3,67E+02
86	Production of electricity by nuclear	7,65E+06	5,96E+05	3,15E+05	1,68E+09	4,45E+01
87	Production of electricity by hydro	2,09E+07	1,24E+06	3,06E+05	3,88E+09	3,85E+01
88	Production of electricity by wind	2,51E+05	2,10E+04	1,40E+04	5,47E+07	1,95E+00
89	Production of electricity nec	4,42E+08	2,40E+07	1,69E+06	7,15E+10	3,14E+02
90	Transmission of electricity	1,88E+07	1,02E+06	3,88E+05	2,90E+09	4,02E+01
91	Distribution and trade of electricity	9,94E+07	5,38E+06	1,95E+06	1,54E+10	2,03E+02
92	Manufacture of gas; distribution of gaseous fuels through mains	4,93E+07	3,05E+06	2,20E+06	8,94E+09	2,95E+02
93	Steam and hot water supply	2,00E+08	1,07E+07	2,35E+06	3,50E+10	2,56E+02
94	Collection	6,20E+07	3,68E+06	1,87E+06	1,12E+10	1,96E+02
95	Construction (45)	1,78E+09	1,42E+08	1,32E+08	4,93E+11	1,89E+04
96	Sale	2,29E+08	2,02E+07	9,32E+06	5,17E+10	1,46E+03
97	Retail sale of automotive fuel	4,01E+07	4,19E+06	4,94E+07	7,55E+09	7,60E+03
98	Wholesale trade and commission trade	5,61E+08	7,01E+07	1,01E+07	1,16E+11	2,69E+03
99	Retail trade	8,03E+08	9,29E+07	2,40E+07	1,45E+11	3,72E+03
100	Hotels and restaurants	1,69E+09	2,85E+08	4,55E+07	2,16E+11	5,10E+03

		LCA Impact assessment				
		acidification (incl. fate, average Europe total, A&B) (AP (Huijbregts, 1999; average Europe total, A&B))	eutrophication (fate not incl.) (EP (Heijungs et al. 1992)))	photochemical oxidation (high NOx)(incl. NOx average, NMVOC average) (POCP (Jenkin & Hayman, 1999; Derwent et al. 1998; high NOx))	global warming GWP100 (incl. NMVOC average) (GWP100 (IPCC, 2007))	ozone layer depletion ODP steady state (incl. NMVOC average) (ODP steady state (WMO, 2003))
		kg SO2 eq.	kg PO4--- eq.	kg ethylene eq.	kg CO2 eq.	kg CFC-11 eq.
	(55)					
101	Transport via railways	5,06E+07	8,65E+06	-2,64E+06	1,15E+10	2,27E+02
102	Other land transport	2,64E+08	3,89E+07	-2,76E+06	6,04E+10	1,65E+03
103	Transport via pipelines	2,89E+07	2,50E+06	3,38E+05	6,28E+09	9,91E+01
104	Sea and coastal water transport	4,48E+07	5,41E+06	3,16E+05	5,34E+10	1,81E+02
105	Inland water transport	1,38E+08	2,21E+07	-1,12E+07	1,17E+10	2,15E+02
106	Air transport (62)	1,54E+08	2,41E+07	1,97E+06	1,41E+11	7,63E+02
107	Supporting and auxiliary transport activities; activities of travel agencies (63)	1,46E+08	2,18E+07	-3,16E+06	3,81E+10	6,83E+02
108	Post and telecommunications (64)	1,77E+08	2,28E+07	-6,10E+05	3,96E+10	9,39E+02
109	Financial intermediation	8,59E+07	8,16E+06	3,30E+06	1,90E+10	5,22E+02
110	Insurance and pension funding	1,27E+08	1,24E+07	5,15E+06	2,84E+10	8,32E+02
111	Activities auxiliary to financial intermediation (67)	1,33E+07	1,43E+06	8,40E+05	4,11E+09	1,13E+02
112	Real estate activities (70)	6,70E+08	4,41E+07	2,35E+07	1,22E+11	2,69E+03
113	Renting of machinery and equipment without operator and of personal and household goods (71)	2,09E+07	2,34E+06	6,98E+05	5,32E+09	1,43E+02
114	Computer and related activities (72)	8,44E+07	8,09E+06	3,37E+06	1,80E+10	5,01E+02
115	Research and development (73)	4,69E+07	4,15E+06	1,20E+06	1,33E+10	2,12E+02
116	Other business activities (74)	1,16E+08	1,22E+07	5,45E+06	2,49E+10	8,57E+02
117	Public administration and defence; compulsory social security (75)	8,39E+08	8,15E+07	2,94E+07	1,80E+11	4,09E+03
118	Education (80)	4,33E+08	3,90E+07	1,23E+07	7,23E+10	1,58E+03
119	Health and social work (85)	9,72E+08	1,02E+08	2,90E+07	1,63E+11	3,63E+03
120	Collection and treatment of sewage	1,70E+07	1,76E+06	5,88E+05	6,35E+09	7,14E+01
121	Collection of waste	3,73E+07	4,74E+06	5,93E+05	1,59E+10	1,86E+02
122	Incineration of waste	3,47E+07	5,30E+06	-4,67E+05	3,72E+09	2,91E+02
123	Landfill of waste	1,04E+07	1,16E+06	1,19E+07	5,18E+10	4,93E+01
124	Sanitation	1,72E+07	1,95E+06	5,11E+05	5,73E+09	8,70E+01
125	Activities of membership organisation n.e.c. (91)	7,22E+07	8,20E+06	1,87E+06	1,45E+10	3,99E+02

		LCA Impact assessment				
		acidification (incl. fate, average Europe total, A&B) (AP (Huijbregts, 1999; average Europe total, A&B))	eutrophication (fate not incl.) (EP (Heijungs et al. 1992)))	photochemical oxidation (high NOx)(incl. NOx average, NMVOC average) (POCP (Jenkin & Hayman, 1999; Derwent et al. 1998; high NOx))	global warming GWP100 (incl. NMVOC average) (GWP100 (IPCC, 2007))	ozone layer depletion ODP steady state (incl. NMVOC average) (ODP steady state (WMO, 2003))
		kg SO2 eq.	kg PO4--- eq.	kg ethylene eq.	kg CO2 eq.	kg CFC-11 eq.
126	Recreational	2,91E+08	3,51E+07	1,02E+07	5,63E+10	1,65E+03
127	Other service activities (93)	1,07E+08	1,15E+07	7,75E+06	1,97E+10	1,20E+03
128	Private households with employed persons (95)	7,43E+06	1,50E+06	1,84E+05	1,91E+09	8,89E+01
129	Extra-territorial organizations and bodies	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
130	direct	2,98E+09	5,53E+08	1,28E+09	1,22E+12	1,28E+05
	Sum	3,10E+10	3,98E+09	2,26E+09	6,06E+12	2,56E+05

	External cost							
	Carcinogenic effects	Non-carcinogenic effects	Respiratory effects (inorganic)	Aquatic ecotoxicity	Terrestrial ecotoxicity	Terrestrial acidification /nutrification	Total Climate Change	Total
	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro
1 Cultivation of paddy rice	1,24E+05	1,49E+03	1,79E+07	1,02E+04	1,80E+06	3,94E+06	1,89E+07	3,52E+07
2 Cultivation of wheat	2,44E+06	3,16E+04	6,18E+08	9,30E+04	2,19E+07	1,85E+08	4,01E+08	1,22E+09
3 Cultivation of cereal grains nec	1,84E+06	2,45E+04	5,01E+08	6,71E+04	1,58E+07	1,52E+08	2,75E+08	9,43E+08
4 Cultivation of vegetables	1,49E+07	2,10E+05	1,67E+09	6,12E+05	1,47E+08	3,24E+08	9,93E+08	3,11E+09
5 Cultivation of oil seeds	1,94E+06	2,28E+04	3,32E+08	1,07E+05	3,23E+07	8,09E+07	1,54E+08	6,58E+08
6 Cultivation of sugar cane	1,76E+04	2,41E+02	1,63E+06	6,03E+02	1,73E+05	3,28E+05	9,40E+05	3,09E+06
7 Cultivation of plant-based fibers	1,30E+06	7,76E+03	5,02E+07	2,76E+04	4,08E+06	1,15E+07	3,52E+07	1,01E+08
8 Cultivation of crops nec	5,89E+06	7,77E+04	7,39E+08	2,25E+05	5,25E+07	1,66E+08	4,29E+08	1,38E+09
9 Cattle farming	8,15E+05	1,04E+04	1,07E+09	3,41E+04	6,65E+06	3,67E+08	2,97E+08	1,75E+09
10 Pigs farming	1,16E+06	1,39E+04	1,60E+09	4,32E+04	8,35E+06	5,54E+08	1,53E+08	2,33E+09
11 Poultry farming	4,57E+06	7,21E+04	2,10E+09	1,98E+05	4,00E+07	6,36E+08	4,27E+08	3,20E+09
12 Meat animals nec	2,21E+05	2,59E+03	3,82E+07	1,10E+04	1,79E+06	1,02E+07	1,66E+07	6,40E+07
13 Animal products nec	8,69E+05	6,16E+03	3,10E+08	2,73E+04	3,55E+06	1,03E+08	8,66E+07	4,92E+08
14 Raw milk	1,86E+06	2,46E+04	1,37E+09	7,96E+04	1,54E+07	4,56E+08	4,05E+08	2,25E+09
15 Wool	3,44E+03	3,09E+01	1,18E+06	1,74E+02	2,57E+04	3,86E+05	8,11E+05	2,11E+06
16 Forestry	1,69E+06	2,26E+04	9,67E+07	7,92E+04	1,68E+07	9,33E+06	5,60E+07	1,79E+08
17 Fishing	4,95E+06	2,84E+04	3,17E+08	2,18E+05	2,71E+07	4,49E+07	9,27E+07	4,80E+08
18 Mining of coal and lignite; extraction of peat (10)	9,91E+05	1,65E+04	1,37E+08	3,07E+04	6,52E+06	2,22E+06	3,88E+08	5,64E+08
19 Extraction of crude petroleum and services related to crude oil extraction	7,26E+04	8,13E+02	4,22E+06	3,90E+03	5,80E+05	2,11E+05	2,48E+06	7,22E+06
20 Extraction of natural gas and services related to natural gas extraction	3,07E+05	3,56E+03	1,37E+07	1,62E+04	2,38E+06	1,02E+06	-1,44E+07	1,79E+07
21 Extraction	2,11E+05	2,14E+03	8,37E+06	8,58E+03	1,45E+06	7,41E+05	5,02E+06	1,55E+07
22 Mining of uranium and thorium ores (12)	8,53E+04	7,82E+02	3,70E+06	4,71E+03	6,44E+05	2,90E+05	2,43E+06	6,53E+06
23 Mining of iron ores	4,72E+04	5,86E+02	3,10E+06	2,40E+03	3,78E+05	2,44E+05	5,79E+06	6,34E+06
24 Mining of copper ores and concentrates	2,81E+05	3,92E+03	1,18E+07	6,79E+03	1,61E+06	6,42E+05	4,32E+06	1,85E+07
25 Mining of nickel ores and concentrates	1,07E+03	3,72E+01	1,91E+05	1,20E+02	3,17E+04	1,23E+04	3,47E+05	4,01E+05
26 Mining of aluminium ores and concentrates	4,37E+04	7,86E+02	3,95E+06	2,13E+03	3,97E+05	3,18E+05	7,91E+06	8,32E+06
27 Mining of precious metal ores and concentrates	4,15E+04	9,05E+02	5,79E+06	1,68E+03	3,06E+05	3,85E+05	3,86E+06	8,39E+06
28 Mining of lead	1,52E+03	-6,64E+01	-6,17E+05	-1,80E+02	-1,28E+04	-3,59E+04	-6,85E+04	-9,34E+05
29 Mining of other non-ferrous metal ores and concentrates	-3,85E+02	-1,92E+00	9,84E+04	-5,29E+01	-3,15E+04	1,41E+03	5,91E+04	1,10E+04
30 Quarrying of stone	2,44E+05	3,38E+03	1,69E+07	1,51E+04	2,28E+06	1,35E+06	9,57E+06	2,95E+07
31 Quarrying of sand and clay	3,82E+05	4,81E+03	2,34E+07	1,99E+04	3,09E+06	1,84E+06	1,32E+07	4,12E+07
32 Mining of chemical and fertilizer minerals	1,87E+05	2,17E+03	1,33E+07	1,17E+04	1,78E+06	1,02E+06	1,94E+07	2,20E+07
33 Processing of meat	1,25E+07	1,51E+05	6,04E+09	5,43E+05	9,42E+07	1,95E+09	1,78E+09	9,83E+09

	External cost							
	Carcinogenic effects	Non-carcinogenic effects	Respiratory effects (inorganic)	Aquatic ecotoxicity	Terrestrial ecotoxicity	Terrestrial acidification /nutrification	Total Climate Change	Total
	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro
cattle								
34 Processing of meat pigs	1,31E+07	1,57E+05	9,49E+09	5,25E+05	9,21E+07	3,16E+09	1,08E+09	1,38E+10
35 Processing of meat poultry	2,68E+07	3,43E+05	4,83E+09	1,17E+06	2,06E+08	1,26E+09	1,37E+09	7,62E+09
36 Production of meat products nec	1,15E+07	1,37E+05	2,08E+09	5,53E+05	9,10E+07	5,44E+08	6,73E+08	3,37E+09
37 Processing vegetable oils and fats	5,96E+06	7,21E+04	8,03E+08	2,86E+05	6,58E+07	1,87E+08	4,74E+08	1,48E+09
38 Processing of dairy products	3,20E+07	4,00E+05	6,73E+09	1,17E+06	2,17E+08	1,82E+09	2,22E+09	1,10E+10
39 Processed rice	1,28E+06	8,52E+03	5,11E+07	4,77E+04	6,45E+06	7,34E+06	2,97E+07	9,22E+07
40 Sugar refining	5,33E+06	6,82E+04	4,10E+08	1,95E+05	4,30E+07	5,39E+07	2,05E+08	7,13E+08
41 Processing of Food products nec	2,77E+07	3,36E+05	3,80E+09	1,02E+06	2,01E+08	8,56E+08	1,47E+09	6,22E+09
42 Manufacture of beverages	5,29E+06	5,52E+04	3,57E+08	1,93E+05	3,40E+07	5,79E+07	1,82E+08	6,24E+08
43 Manufacture of fish products	3,06E+07	3,95E+05	2,06E+09	9,85E+05	2,12E+08	2,39E+08	1,03E+09	3,52E+09
44 Manufacture of tobacco products (16)	5,39E+06	6,67E+04	6,13E+08	2,09E+05	4,00E+07	1,37E+08	2,46E+08	1,02E+09
45 Manufacture of textiles (17)	1,90E+07	2,39E+05	1,38E+09	7,98E+05	1,44E+08	1,70E+08	8,58E+08	2,34E+09
46 Manufacture of wearing apparel; dressing and dyeing of fur (18)	2,48E+07	2,87E+05	1,61E+09	1,16E+06	1,92E+08	1,84E+08	1,05E+09	2,74E+09
47 Tanning and dressing of leather; manufacture of luggage	1,21E+07	1,52E+05	9,15E+08	4,50E+05	9,07E+07	1,40E+08	5,80E+08	1,57E+09
48 Manufacture of wood and of products of wood and cork	1,04E+07	1,49E+05	5,16E+08	2,98E+05	5,69E+07	2,98E+07	2,32E+08	8,27E+08
49 Manufacture of pulp	2,43E+07	3,77E+05	1,16E+09	5,02E+05	1,13E+08	6,70E+07	5,24E+08	1,87E+09
50 Publishing	3,32E+07	4,59E+05	1,95E+09	1,09E+06	1,91E+08	9,85E+07	7,71E+08	3,01E+09
51 Manufacture of coke oven products	2,78E+07	1,02E+05	3,04E+07	1,08E+05	1,55E+07	7,74E+05	1,44E+08	2,07E+08
52 Manufacture of motor spirit (gasoline)	3,01E+07	2,27E+05	9,32E+08	8,64E+05	1,39E+08	7,32E+07	9,35E+08	1,94E+09
53 Manufacture of kerosene	6,37E+05	4,76E+03	2,20E+07	2,39E+04	3,63E+06	1,91E+06	2,38E+07	4,97E+07
54 Manufacture of gas oils	6,30E+06	4,73E+04	1,93E+08	1,81E+05	2,96E+07	1,57E+07	1,88E+08	4,04E+08
55 Manufacture of fuel oils n.e.c.	4,32E+05	1,56E+04	6,50E+07	3,47E+04	1,38E+07	3,94E+06	1,98E+07	9,97E+07
56 Manufacture of petroleum gases and other gaseous hydrocarbons	1,27E+06	1,82E+04	7,63E+07	5,19E+04	1,42E+07	5,15E+06	4,17E+07	1,34E+08
57 Manufacture of other petroleum products	3,04E+05	1,35E+04	7,59E+07	3,14E+04	1,21E+07	4,24E+06	3,77E+07	1,29E+08
58 Processing of nuclear fuel	-5,27E+05	-2,97E+03	-1,07E+07	-1,51E+04	-2,23E+06	-7,76E+05	-6,61E+06	-2,04E+07
59 Manufacture of chemicals and chemical products (24)	7,43E+07	9,40E+05	4,71E+09	2,59E+06	5,47E+08	4,62E+08	2,37E+09	7,98E+09
60 Manufacture of rubber and plastic products (25)	1,62E+07	2,16E+05	8,97E+08	5,43E+05	1,14E+08	8,15E+07	4,99E+08	1,54E+09
61 Manufacture of glass and glass products	8,18E+06	1,13E+05	4,11E+08	2,23E+05	5,26E+07	2,62E+07	2,22E+08	7,02E+08

	External cost							
	Carcinogenic effects	Non-carcinogenic effects	Respiratory effects (inorganic)	Aquatic ecotoxicity	Terrestrial ecotoxicity	Terrestrial acidification /nutrification	Total Climate Change	Total
	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro
62 Manufacture of ceramic goods	7,00E+06	1,01E+05	2,94E+08	1,26E+05	3,93E+07	1,30E+07	1,53E+08	4,74E+08
63 Manufacture of bricks	2,13E+06	3,13E+04	1,00E+08	4,51E+04	1,38E+07	5,06E+06	5,18E+07	1,72E+08
64 Manufacture of cement	4,56E+06	6,69E+04	2,49E+08	1,22E+05	3,02E+07	1,30E+07	2,59E+08	5,49E+08
65 Manufacture of other non-metallic mineral products n.e.c.	4,11E+06	8,11E+04	1,64E+08	1,28E+05	2,85E+07	9,87E+06	9,50E+07	2,87E+08
66 Manufacture of basic iron and steel and of ferro-alloys and first products thereof	3,17E+07	4,86E+05	4,61E+08	5,64E+05	2,62E+08	2,52E+07	6,42E+08	1,36E+09
67 Precious metals production	5,43E+05	4,65E+03	1,47E+07	1,51E+04	3,09E+06	8,03E+05	1,00E+07	2,52E+07
68 Aluminium production	6,27E+06	6,00E+04	7,12E+07	6,48E+04	8,84E+06	3,93E+06	4,93E+07	1,29E+08
69 Lead	1,58E+07	7,75E+04	5,33E+07	1,64E+05	6,23E+07	3,43E+06	2,77E+07	1,61E+08
70 Copper production	2,69E+07	2,14E+04	5,74E+07	2,18E+06	2,21E+08	3,68E+06	3,13E+07	3,38E+08
71 Other non-ferrous metal production	8,68E+05	5,44E+03	1,27E+07	3,19E+04	5,50E+06	8,08E+05	8,20E+06	2,72E+07
72 Casting of metals	3,61E+05	3,22E+03	1,11E+07	1,48E+04	2,26E+06	7,77E+05	1,76E+07	1,86E+07
73 Manufacture of fabricated metal products	8,87E+07	1,07E+06	1,96E+09	2,74E+06	6,60E+08	1,32E+08	1,67E+09	4,34E+09
74 Manufacture of machinery and equipment n.e.c. (29)	1,64E+08	1,88E+06	4,32E+09	5,98E+06	1,25E+09	3,20E+08	3,26E+09	9,02E+09
75 Manufacture of office machinery and computers (30)	3,34E+07	2,89E+05	1,12E+09	1,71E+06	2,51E+08	8,76E+07	6,99E+08	2,10E+09
76 Manufacture of electrical machinery and apparatus n.e.c. (31)	6,39E+07	4,47E+05	1,18E+09	3,05E+06	4,55E+08	8,50E+07	8,04E+08	2,48E+09
77 Manufacture of radio	5,75E+07	4,70E+05	1,65E+09	2,32E+06	3,81E+08	1,25E+08	1,03E+09	3,05E+09
78 Manufacture of medical	3,41E+07	3,38E+05	1,12E+09	1,35E+06	2,41E+08	7,62E+07	6,07E+08	2,05E+09
79 Manufacture of motor vehicles	2,44E+08	2,71E+06	6,88E+09	8,48E+06	1,78E+09	4,89E+08	4,77E+09	1,37E+10
80 Manufacture of other transport equipment (35)	4,98E+07	5,57E+05	1,52E+09	1,94E+06	3,67E+08	1,02E+08	9,62E+08	2,97E+09
81 Manufacture of furniture; manufacturing n.e.c. (36)	8,11E+07	8,91E+05	2,82E+09	2,32E+06	5,16E+08	2,02E+08	1,93E+09	4,99E+09
82 Recycling of metal waste and scrap	2,99E+06	2,39E+04	5,73E+07	7,72E+04	1,46E+07	3,50E+06	2,93E+07	1,06E+08
83 Recycling of non-metal waste and scrap	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
84 Production of electricity by coal	8,63E+07	2,64E+06	1,90E+10	2,67E+06	5,10E+08	1,19E+09	6,64E+09	2,73E+10
85 Production of electricity by gas	7,55E+06	3,11E+05	1,17E+09	5,16E+05	1,51E+08	1,54E+08	2,15E+09	3,60E+09
86 Production of electricity by nuclear	1,30E+06	1,36E+04	5,60E+07	4,87E+04	8,63E+06	4,49E+06	3,36E+07	1,02E+08
87 Production of electricity by hydro	1,37E+06	2,80E+04	1,44E+08	5,39E+04	1,28E+07	1,04E+07	7,76E+07	2,44E+08
88 Production of electricity by wind	6,47E+04	4,94E+02	1,83E+06	1,88E+03	3,55E+05	1,54E+05	1,09E+06	3,42E+06
89 Production of electricity nec	1,77E+07	9,50E+05	3,29E+09	1,72E+06	6,91E+08	2,20E+08	1,43E+09	5,63E+09

	External cost							
	Carcinogenic effects	Non-carcinogenic effects	Respiratory effects (inorganic)	Aquatic ecotoxicity	Terrestrial ecotoxicity	Terrestrial acidification /nutrification	Total Climate Change	Total
	Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro
90 Transmission of electricity	1,29E+06	2,26E+04	1,17E+08	5,11E+04	1,07E+07	8,48E+06	5,79E+07	1,94E+08
91 Distribution and trade of electricity	6,36E+06	1,18E+05	6,26E+08	2,63E+05	5,55E+07	4,47E+07	3,08E+08	1,02E+09
92 Manufacture of gas; distribution of gaseous fuels through mains	5,16E+06	7,27E+04	3,21E+08	2,20E+05	4,17E+07	2,35E+07	1,79E+08	5,58E+08
93 Steam and hot water supply	6,96E+06	2,69E+05	1,45E+09	3,99E+05	1,17E+08	9,53E+07	6,98E+08	2,35E+09
94 Collection	1,04E+07	9,92E+04	4,14E+08	2,45E+05	5,23E+07	3,01E+07	2,23E+08	7,22E+08
95 Construction (45)	3,46E+08	4,28E+06	1,50E+10	1,39E+07	2,64E+09	1,04E+09	9,87E+09	2,83E+10
96 Sale	5,40E+07	4,96E+05	1,85E+09	1,94E+06	3,19E+08	1,53E+08	1,03E+09	3,35E+09
97 Retail sale of automotive fuel	5,36E+06	5,79E+04	6,19E+08	2,86E+05	4,08E+07	9,78E+06	1,50E+08	8,18E+08
98 Wholesale trade and commission trade	7,72E+07	8,41E+05	5,14E+09	5,15E+06	7,06E+08	5,34E+08	2,33E+09	8,69E+09
99 Retail trade	1,00E+08	1,13E+06	6,39E+09	4,97E+06	7,28E+08	7,11E+08	2,92E+09	1,07E+10
100 Hotels and restaurants (55)	1,02E+08	1,15E+06	1,07E+10	3,91E+06	6,90E+08	2,24E+09	4,33E+09	1,77E+10
101 Transport via railways	3,94E+06	5,32E+04	4,87E+08	3,15E+05	4,04E+07	5,76E+07	2,31E+08	8,03E+08
102 Other land transport	2,87E+07	4,21E+05	4,42E+09	4,22E+06	4,21E+08	2,60E+08	1,21E+09	6,21E+09
103 Transport via pipelines	2,30E+06	3,13E+04	1,89E+08	2,06E+05	2,37E+07	1,70E+07	1,26E+08	3,42E+08
104 Sea and coastal water transport	1,47E+07	6,06E+04	3,65E+08	1,11E+06	1,17E+08	3,63E+07	1,07E+09	1,63E+09
105 Inland water transport	1,58E+08	9,54E+04	1,51E+09	1,33E+07	1,27E+09	1,82E+08	2,34E+08	3,38E+09
106 Air transport (62)	1,42E+07	1,42E+05	1,31E+09	9,28E+05	1,18E+08	1,69E+08	2,82E+09	4,66E+09
107 Supporting and auxiliary transport activities; activities of travel agencies (63)	1,98E+07	2,45E+05	1,72E+09	2,58E+06	2,68E+08	1,59E+08	7,64E+08	2,92E+09
108 Post and telecommunications (64)	2,20E+07	3,12E+05	1,90E+09	2,47E+06	2,75E+08	1,68E+08	7,93E+08	3,13E+09
109 Financial intermediation	1,46E+07	1,48E+05	7,14E+08	5,89E+05	8,95E+07	6,30E+07	3,81E+08	1,25E+09
110 Insurance and pension funding	2,29E+07	2,24E+05	1,07E+09	9,23E+05	1,39E+08	9,53E+07	5,69E+08	1,88E+09
111 Activities auxiliary to financial intermediation (67)	1,18E+07	5,77E+04	1,23E+08	1,63E+05	2,27E+07	1,07E+07	8,24E+07	2,57E+08
112 Real estate activities (70)	1,04E+08	1,03E+06	4,71E+09	2,69E+06	5,29E+08	3,53E+08	2,43E+09	8,04E+09
113 Renting of machinery and equipment without operator and of personal and household goods (71)	3,17E+06	3,91E+04	1,98E+08	2,18E+05	2,86E+07	1,76E+07	1,07E+08	3,51E+08
114 Computer and related activities (72)	1,31E+07	1,39E+05	6,74E+08	5,75E+05	9,04E+07	6,19E+07	3,59E+08	1,19E+09
115 Research and development (73)	7,22E+06	8,09E+04	4,09E+08	3,05E+05	7,27E+07	3,29E+07	2,67E+08	7,82E+08
116 Other business activities (74)	1,72E+07	2,00E+05	1,02E+09	9,56E+05	1,35E+08	9,32E+07	5,00E+08	1,76E+09
117 Public administration and defence; compulsory social security (75)	1,96E+08	1,52E+06	6,52E+09	5,36E+06	9,59E+08	6,22E+08	3,59E+09	1,17E+10
118 Education (80)	4,41E+07	5,52E+05	3,12E+09	1,64E+06	3,00E+08	3,15E+08	1,45E+09	5,17E+09
119 Health and social work (85)	1,28E+08	1,27E+06	6,82E+09	3,84E+06	7,28E+08	8,11E+08	3,26E+09	1,16E+10

		External cost							
		Carcinogenic effects	Non-carcinogenic effects	Respiratory effects (inorganic)	Aquatic ecotoxicity	Terrestrial ecotoxicity	Terrestrial acidification /nutrification	Total Climate Change	Total
		Euro	Euro	Euro	Euro	Euro	Euro	Euro	Euro
120	Collection and treatment of sewage	1,80E+07	5,67E+04	1,44E+08	1,63E+05	3,69E+07	1,33E+07	1,26E+08	3,36E+08
121	Collection of waste	2,83E+07	1,19E+05	3,67E+08	4,06E+05	7,84E+07	3,49E+07	3,16E+08	8,19E+08
122	Incineration of waste	3,98E+08	7,87E+05	3,02E+08	1,11E+06	5,00E+08	3,63E+07	7,40E+07	1,31E+09
123	Landfill of waste	8,53E+06	3,17E+04	8,88E+07	1,08E+05	2,12E+07	8,64E+06	9,97E+08	1,11E+09
124	Sanitation	1,38E+07	5,27E+04	1,62E+08	1,90E+05	3,59E+07	1,46E+07	1,14E+08	3,36E+08
125	Activities of membership organisation n.e.c. (91)	7,59E+06	1,12E+05	6,59E+08	5,87E+05	7,50E+07	6,24E+07	2,93E+08	1,08E+09
126	Recreational	3,32E+07	4,23E+05	2,41E+09	2,32E+06	3,02E+08	2,63E+08	1,13E+09	4,10E+09
127	Other service activities (93)	1,50E+07	1,57E+05	8,77E+08	6,90E+05	1,00E+08	8,42E+07	3,96E+08	1,45E+09
128	Private households with employed persons (95)	6,20E+05	1,87E+04	1,25E+08	1,90E+05	1,66E+07	1,05E+07	3,88E+07	1,91E+08
129	Extra-territorial organizations and bodies	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
130	direct	1,78E+09	2,72E+07	1,93E+11	1,06E+08	1,04E+10	3,66E+09	2,53E+10	2,34E+11
	Sum	5,39E+09	6,38E+07	3,89E+11	2,42E+08	3,40E+10	3,06E+10	1,22E+11	5,75E+11