rütter soceco
sozioökonomische forschung + beratung

rütter soceco ag
Weingartenstrasse 5
CH-8803 Rüschlikon
Tel. (+41) 044 724 27 70
Fax (+41) 044 724 22 78
info@ruetter-soceco.ch
www.ruetter-soceco.ch
Partner von:
senarclens, leu + partner ag

Exiobase as an instrument for the analysis of environmental impacts of economic activities

Report to the Swiss Federal Office for the Environment

Carsten Nathani & Pino Hellmüller

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1. Background and goal of this paper

Background

As a small open economy (SMOPEC), Switzerland is strongly and increasingly integrated into global value chains. Among other things, this is reflected in the fact that products consumed in Switzerland are often manufactured within cross-border and cross-industry value chains. In order to adequately analyze the environmental impacts caused within global value chains, various worldwide databases containing environmentally extended multiregional input-output (EE MRIO) tables have been compiled in the past years. One of these databases is *Exiobase*. Compared to other EE-MRIO databases (e.g. GTAP, WIOD, OECD), Exiobase is characterized by a high degree of sectoral detail and a large set of environmental indicators. For this reason, Exiobase seems to be the best choice among the EE-MRIO databases for detailed environmental analyses. However, EE-MRIO databases often exhibit specific strengths and weaknesses, which have to be considered when determining what database to use. Against this background, the Federal Office for the Environment (FOEN) has commissioned an analysis of the suitability of the Exiobase EE-MRIO database for environmental examinations for Switzerland.

Project Goals

The aim of this project is to address and answer the following questions:

- Structure of the Exiobase database: which countries, industries and environmental data are represented? Which environmental midpoint and endpoint indicators can be generated with the data?
- How do the published Exiobase versions 2 and 3 differ in terms of data sources and compilation methodology? Which data sources were evaluated when the database was created?
- How good is Switzerland represented in Exiobase, on the one hand with regard to economic data and on the other hand with regard to environmental data? Which data sources were evaluated in order to map Switzerland in Exiobase?
- To what extent can Exiobase be used to calculate Switzerland's consumption based greenhouse gas footprint? How do the so obtained results differ from those generated when using comparable databases and other approaches?

The rest of the paper is structured as follows: in section 3 the structure of the Exiobase database is presented. In section 3 we discuss the quality of the representation of Switzerland in Exiobase. Afterwards, in section 4 we briefly show the results for the global greenhouse gas footprint caused by Swiss final demand and exports obtained applying a combined approach based on the Swiss environmental extended IOT (CH EE-MRIOT) and Exiobase. We present our conclusions in section 5.

2. Structure of the Exiobase database

Exiobase is a database of EE MRIO tables that has been developed by a European research consortium[1] within the EU-Projects EXIOPOL[2] (Exiobase V.1), CREEA[3] (Exiobase V.2) and DESIRE[4] (Exiobase V.3) funded by the European Commission under the 6th (EXIOPOL) and 7th (CREEA and DESIRE) framework program. The objective of EXIOBASE is to provide a tool with high suitability for global environmental analysis, in particular for EU countries and its main trade partners (cp. Stadler et al., 2018).

In this section, we first explain the structure of the Exiobase EE MRIO. We then present the detailed categories (countries, industries, emissions etc.) in Exiobase. Subsequently we show which environmental footprints can be calculated making use of Exiobase. The section concludes with a comparison and discussion of the differences between V.2 and V.3 of Exiobase, as both show advantages and disadvantages. It strongly depends on the question addressed which version is recommendable to use.

2.1 About EE MRIO analysis and the Exiobase EE MRIO

EE MRIO analysis is a well-established method in the fields of applied economics to analyze global value chains as well as in environmental economics for the calculation of the environmental footprints of specific agents (e.g. the global greenhouse gas footprint caused by the household consumption in a specific country). Various EE-MRIO databases have been constructed to depict the global supply chains and the environmental impacts of production in the various countries (e.g. the OECD ICIO database, World Input-Output Database WIOD, GTAP, Exiobase).

Figure 2.1 shows the structure of the Exiobase EE-MRIOT. It consists of an economic core of multiregional input-output tables (MRIOT) and environmental extensions (EE). The MRIOT links several national input-output tables via trade flows at the level of industries / product groups.

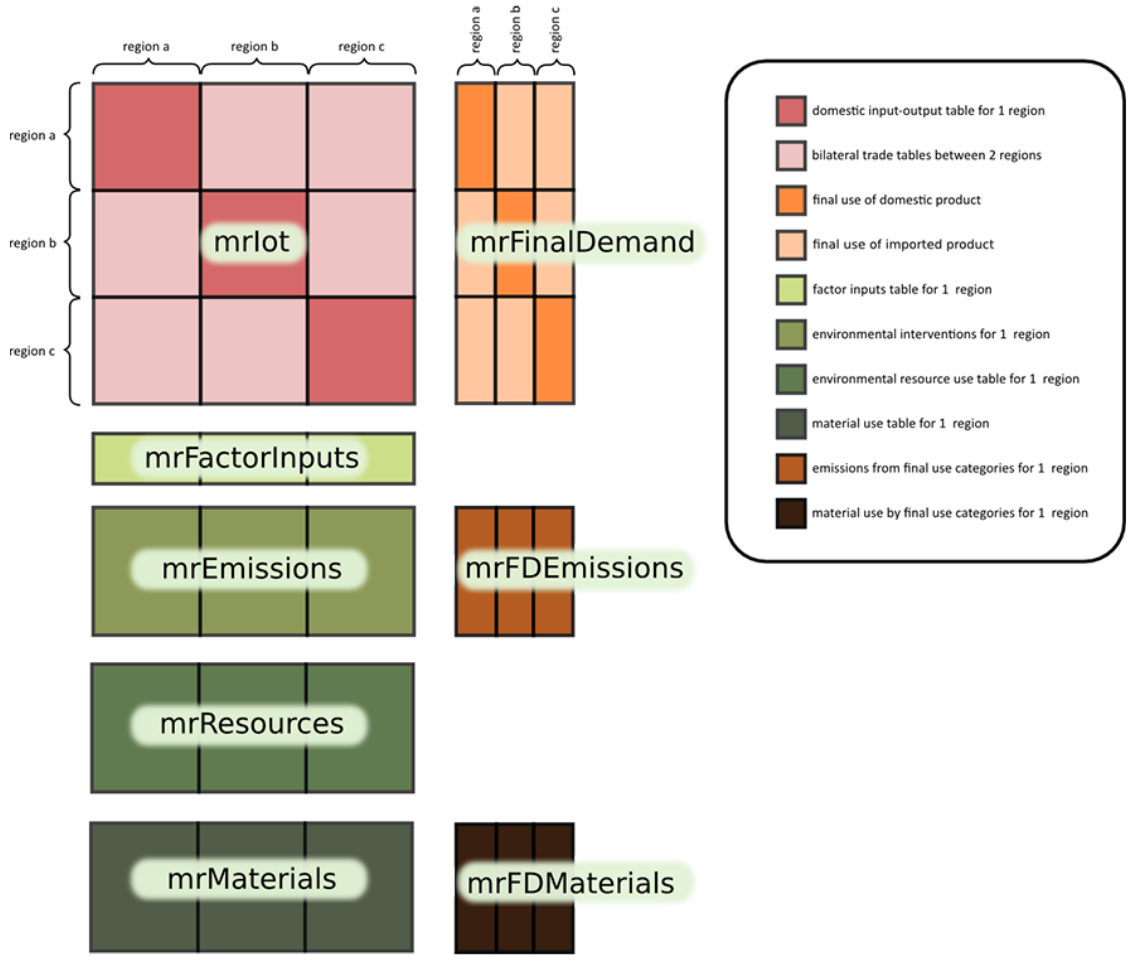
[1] Norwegian University of Science and Technology (NTNU), Netherlands Organization for Applied Scientific Research (TNO), The Sustainable Europe Research Institute (SERI), Universiteit Leiden: The Institute of Environmental Sciences (CML), The research group “Sustainable Resource Use” at the Institute for Ecological Economics at Vienna University of Economics and Business (WU) and 2.-0 LCA consultants.

[2] A New Environmental Accounting Framework Using **Ex**ternality Data and **I**nput-**O**utput Tools for **Pol**icy Analysis

[3] **C**ompiling and **R**efining **E**nvironmental and **E**conomic **A**ccounts

[4] **De**velopment of a **S**ystem of **I**ndicators for **R**esource **E**fficient Europe

Figure 2.1: Structure of an EE MRIO table



This linkages illustrates the flows of goods and services from every industry in every country to every industry (mrIOT in Figure 2.1) and final demand category (mrFinalDemand in Figure 2.1) in every country. Furthermore, the MRIOT comprises a set of factor inputs (mrFactorInputs in Figure 2.1) consisting of different value-added components as well as labor inputs for every industry / product group. The environmental extensions contain data on the direct environmental impacts of industries (mrEmissions, mrResources, mrMaterials in Figure 2.1) and final demand categories (mrFDEmissions, mrFDResources, mrFDMaterials in Figure 2.1).

Making use of input-output calculation methods (cf. e.g. Miller & Blair 2009) EE MRIO tables make it possible to estimate detailed economic impacts and consequently the environmental impact of the activities of specific agents.

2.2 Country and industry classifications in Exiobase

As mentioned in section 1, the Exiobase database was developed in three different EU-Projects and is accordingly available in three different Versions (V.1, V.2 and V.3). The third version is the most advanced and should therefore be preferred over the previous version. For instance, it is the only one containing a time series of tables, while the earlier versions only cover individual years. Nevertheless, the latest version also exhibits some weaknesses which do not occur in V.2 (cf. section 2.3). This is the reason why in some cases it might be worth considering using V.2 (or a combination of V.2 and V.3) instead of V.3, despite the above-mentioned limitations. That is why in the following classifications we focus on V.3, but mention the differences between V.3 and V.2.

In its most recent version (V.3.4), Exiobase covers the years from 1995 to 2011[5] and contains data covering 44 countries, including the EU 28 countries, other OECD countries (incl. Switzerland), large emerging countries and five aggregated world regions. Together, the regions considered account for about 90% of global domestic product (GDP). The database distinguishes 163 industries and 200 product groups, which is substantially more than other EE-MRIO databases offer. With regard to final demand, 7 categories per country are distinguished. Value added is differentiated into 12 subcategories and 14 types of labor inputs are listed for every industry / product group. Moreover, Exiobase contains data on 423 emissions, 14 resource types that are effectively land use types and 867 material groups that also include other resources, all differentiated by emitting/using industries and final demand category in every country.

This section describes and lists the detailed classifications of countries/regions, industries/product groups, final demand categories and factor inputs. For reasons of clarity, some tables are listed only in the annex.

2.2.1 Countries and Regions

The latest published version (V.3.4) of Exiobase covers the 44 countries and the 5 Rest-of-the-world regions presented in Table 2.1. Compared to the V.2, there was only a small change in terms of countries covered: Croatia as new EU member country was added.

Table 2.1: Countries and regions in Exiobase

Countries and regions						
No.	**Country code**	**Country name**	**Continent**	**UN region**	**Exiobase region code**	**Exiobase region name**
1	AT	Austria	Europe	Western Europe	WE	Europe
2	BE	Belgium	Europe	Western Europe	WE	Europe
3	BG	Bulgaria	Europe	Eastern Europe	WE	Europe
4	CY	Cyprus	Asia	Western Asia	WM	Middle East
5	CZ	Czech Republic	Europe	Eastern Europe	WE	Europe
6	DE	Germany	Europe	Western Europe	WE	Europe
7	DK	Denmark	Europe	Northern Europe	WE	Europe
8	EE	Estonia	Europe	Northern Europe	WE	Europe
9	ES	Spain	Europe	Southern Europe	WE	Europe
10	FI	Finland	Europe	Northern Europe	WE	Europe
11	FR	France	Europe	Western Europe	WE	Europe
12	GR	Greece	Europe	Southern Europe	WE	Europe
13	HR	Croatia	Europe	Southern Europe	WE	Europe
14	HU	Hungary	Europe	Eastern Europe	WE	Europe
15	IE	Ireland	Europe	Northern Europe	WE	Europe
16	IT	Italy	Europe	Southern Europe	WE	Europe
17	LT	Lithuania	Europe	Northern Europe	WE	Europe
18	LU	Luxembourg	Europe	Western Europe	WE	Europe
19	LV	Latvia	Europe	Northern Europe	WE	Europe
20	MT	Malta	Europe	Southern Europe	WE	Europe
21	NL	Netherlands	Europe	Western Europe	WE	Europe
22	PL	Poland	Europe	Eastern Europe	WE	Europe
23	PT	Portugal	Europe	Southern Europe	WE	Europe

[5] Exiobase V.2 covers only the base year 2007.

Countries and regions						
No.	**Country code**	**Country name**	**Continent**	**UN region**	**Exiobase region code**	**Exiobase region name**
24	RO	Romania	Europe	Eastern Europe	WE	Europe
25	SE	Sweden	Europe	Northern Europe	WE	Europe
26	SI	Slovenia	Europe	Southern Europe	WE	Europe
27	SK	Slovakia	Europe	Eastern Europe	WE	Europe
28	GB	United Kingdom	Europe	Northern Europe	WE	Europe
29	US	United States	America	Northern America	WL	America
30	JP	Japan	Asia	Eastern Asia	WA	Asia and Pacific
31	CN	China	Asia	Eastern Asia	WA	Asia and Pacific
32	CA	Canada	America	Northern America	WL	America
33	KR	South Korea	Asia	Eastern Asia	WA	Asia and Pacific
34	BR	Brazil	America	South America	WL	America
35	IN	India	Asia	Southern Asia	WA	Asia and Pacific
36	MX	Mexico	America	Central America	WL	America
37	RU	Russia	Europe	Eastern Europe	WE	Europe
38	AU	Australia	Oceania	Australia and New Zealand	WA	Asia and Pacific
39	CH	Switzerland	Europe	Western Europe	WE	Europe
40	TR	Turkey	Asia	Western Asia	WM	Middle East
41	TW	Taiwan	Asia	Eastern Asia	WA	Asia and Pacific
42	NO	Norway	Europe	Northern Europe	WE	Europe
43	ID	Indonesia	Asia	South-Eastern Asia	WA	Asia and Pacific
44	ZA	South Africa	Africa	Southern Africa	WF	Africa
45	WA	RoW Asia and Pacific	Asia, Oceania, Antarctica		WA	RoW Asia and Pacific
46	WL	RoW America	America		WL	RoW America
47	WE	RoW Europe	Europe		WE	RoW Europe
48	WF	RoW Africa	Africa		WF	RoW Africa
49	WM	RoW Middle East	Asia, Africa		WM	RoW Middle East

2.2.2 Industries and product groups

IO tables are mostly available in two different variations: industry by industry (ixi) tables and product by product (pxp) tables. In the ixi-tables, industries are chosen as defining unities. This has the advantage that the tables mostly rely on real survey data. The disadvantage is given by the fact, that firms in a specific industry may also produce goods or services, which in terms of product classification should be attributed to other industries with very different input structures. As a result, the input structures for the industries may be composed of a mixture of input structures of different goods. This problem is solved in the pxp-tables, where homogeneous (in terms of the products they produce) branches are constructed. However, for the creation of these homogenous branches, the assumption that a specific product always has the same input structure, independently of the industry it was produced in, has to be made. This does not necessarily have to be the case and can therefore also lead to distortions in terms of input structures. Whether the ixi or the pxp table is more suited for an analysis strongly depends on the specific circumstances and the questions addressed.

Exiobase V.3.4 distinguishes 163 industries and 200 product groups. In comparison to V.2, there have not been any changes. Since the industries (in terms of classification) are a slightly aggregated version of the product groups, at this point, we only show a detailed list of the product groups in Table 7.1 in the Annex.

Final demand categories

Exiobase distinguishes the 5 different final demand categories shown in Table 2.2. These do not vary across the different versions of Exiobase.

Table 2.2: Final demand categories in Exiobase

No.	Final demand category
1	Final consumption expenditure by households
2	Final consumption expenditure by non-profit organisations serving households (NPISH)
3	Final consumption expenditure by government
4	Gross fixed capital formation
5	Changes in inventories

Factor inputs (value added components and labor inputs)

Exiobase contains data that subsets the value added of each industry or product group into various components as shown in Table 2.3. Furthermore, it also includes information about the labor input differentiated by skill category and gender as exposed in Table 2.4. In the course of the ongoing Exiobase versions, these factor inputs have been slightly extended.

Table 2.3: Value added components in Exiobase

No.	Value added components	Unit
1	Taxes less subsidies on products purchased: Total	M.EUR
2	Other net taxes on production	M.EUR
3	Taxes on products purchased	M.EUR
4	Subsidies on products purchased	M.EUR
5	Compensation of employees; wages, salaries, & employers social contributions: High-skilled	M.EUR
6	Compensation of employees; wages, salaries, & employers social contributions: Low-skilled	M.EUR
7	Compensation of employees; wages, salaries, & employers social contributions: Medium-skilled	M.EUR
8	Compensation of employees; wages, salaries, & employers social contributions: Total	M.EUR
9	Operating surplus: Consumption of fixed capital	M.EUR
10	Operating surplus: Rents on land	M.EUR
11	Operating surplus: Royalties on resources	M.EUR
12	Operating surplus: Remaining net operating surplus	M.EUR

Table 2.4: Labor inputs in Exiobase

No.	Labor input	Unit
1	Employment: Low-skilled male	1000 p
2	Employment: Low-skilled female	1000 p
3	Employment: Medium-skilled male	1000 p
4	Employment: Medium-skilled female	1000 p

No.	Labor input	Unit
5	Employment: High-skilled male	1000 p
6	Employment: High-skilled female	1000 p
7	Employment hours: Low-skilled male	M.hr
8	Employment hours: Low-skilled female	M.hr
9	Employment hours: Medium-skilled male	M.hr
10	Employment hours: Medium-skilled female	M.hr
11	Employment hours: High-skilled male	M.hr
12	Employment hours: High-skilled female	M.hr
13	Employment: Vulnerable employment	1000 p
14	Employment hours: Vulnerable employment	M.hr

2.3 Economic data in Exiobase

The economic data in Exiobase relate to the multiregional input-output table that connects country input-output tables with bilateral trade data at the industry or product group level. Exiobase v2 provides an MRIOT for the year 2007, while Exiobase v3.4 provides MRIOTs for the years 1995 to 2011.

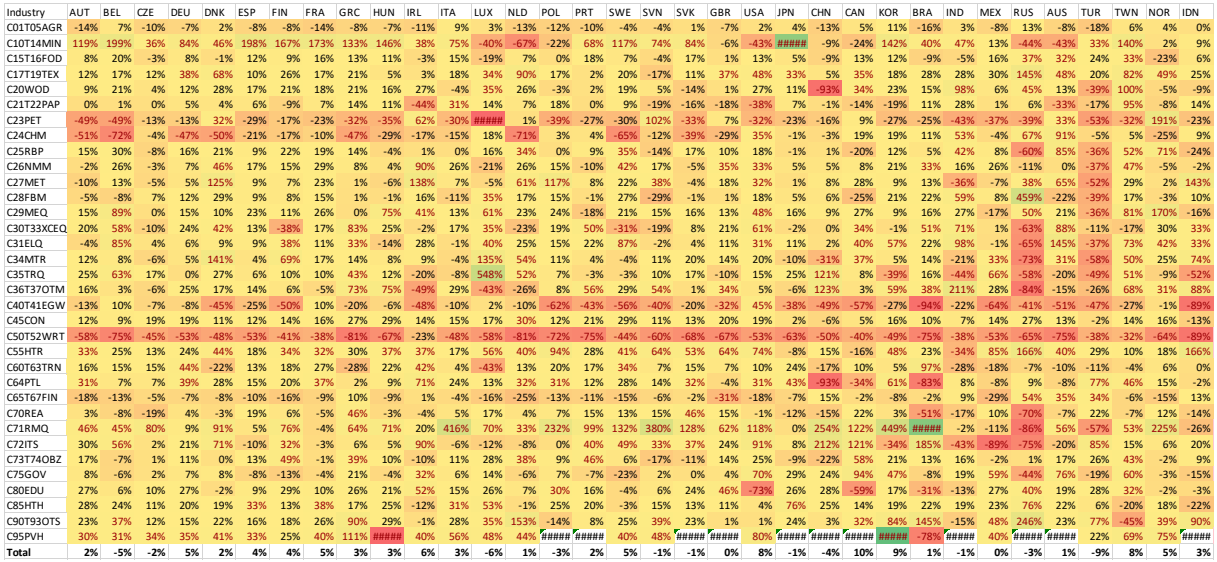
A comparison of industry gross production values between Exiobase v2 and v3.4 for the year 2007 showed substantial differences. We therefore compared the Exiobase data with data from the OECD MRIOT, that are supposed to be more close to the official statistics.

The following two heatmaps show the differences for 2007 between the Exiobase v2 and the OECD MRIOT and between the Exiobase v3.4 and the OECD MRIOT for the most important trade partners of Switzerland. With regard to the difference between Exiobase v2 and OECD MRIOT the results show that the deviations from the OECD data are small for European countries, medium for other OECD countries and rather large for non-OECD countries. This reflects the different uncertainty levels of economic data in the different world regions.

Figure 2: Heatmap of differences between Exiobase v2 and the OECD MRIOT for gross output in 2007 by industry and country

Industry	AUT	BEL	CZE	DEU	DNK	ESP	FIN	FRA	GRC	HUN	IRL	ITA	LUX	NLD	POL	PRT	SWE	SVN	SVK	GBR	USA	JPN	CHN	CAN	KOR	BRA	IND	MEX	RUS	AUS	TUR	TWN	NOR	IDN
C01T05AGR	-1%	0%	-4%	-1%	2%	0%	0%	0%	1%	2%	18%	-1%	0%	0%	0%	7%	0%	0%	13%	-2%	13%	-5%	-7%	0%	0%	0%	23%	9%	53%	-12%	51%	-3%	-1%	2%
C10T14MIN	-1%	0%	-4%	0%	0%	0%	0%	0%	-2%	2%	-10%	-1%	0%	0%	0%	-8%	0%	1%	13%	-1%	-44%	-2%	-7%	0%	4%	0%	-11%	-29%	6%	0%	-17%	-30%	-1%	12%
C15T16FOD	-1%	0%	-4%	0%	0%	0%	0%	0%	0%	2%	13%	-1%	0%	0%	-2%	6%	0%	-1%	13%	0%	8%	-6%	-6%	0%	-1%	0%	-3%	6%	63%	8%	22%	-7%	-1%	19%
C17T19TEX	-1%	0%	-4%	0%	0%	0%	0%	0%	-15%	2%	-38%	-1%	0%	0%	-4%	11%	0%	6%	13%	-2%	85%	-3%	4%	0%	-1%	0%	14%	39%	98%	8%	33%	-1%	-1%	31%
C20WOD	-1%	0%	-4%	0%	0%	0%	0%	0%	3%	2%	2%	-1%	0%	0%	1%	5%	0%	4%	13%	0%	20%	4%	-94%	0%	1%	0%	97%	17%	23%	-3%	-34%	3%	-1%	-1%
C21T22PAP	-1%	0%	-4%	0%	-1%	0%	0%	0%	-10%	2%	-9%	-1%	0%	0%	4%	9%	0%	0%	13%	-4%	-11%	2%	0%	-17%	-29%	0%	0%	2%	23%	-42%	2%	35%	-1%	16%
C23PET	-1%	0%	-4%	0%	0%	0%	0%	0%	9%	2%	42%	-1%	-100%	0%	-2%	16%	0%	0%	13%	0%	-51%	-30%	6%	0%	-14%	-12%	-47%	-27%	-29%	25%	-27%	-16%	47%	9%
C24CHM	0%	0%	-3%	2%	2%	2%	1%	2%	-15%	2%	-4%	1%	4%	1%	3%	5%	1%	0%	14%	2%	-9%	-17%	2%	1%	7%	11%	3%	-6%	63%	23%	10%	-19%	-31%	16%
C25RBP	-1%	0%	-4%	0%	0%	0%	0%	0%	-5%	2%	-26%	-1%	0%	0%	1%	4%	0%	5%	13%	-1%	14%	-18%	6%	0%	-1%	0%	-20%	-3%	-70%	88%	-30%	1%	0%	1%
C26NMM	-1%	-3%	-4%	-6%	-3%	-3%	-3%	-4%	-7%	0%	-7%	-4%	0%	-3%	-1%	-20%	-3%	-1%	11%	-7%	1%	-17%	4%	-2%	-1%	-2%	-15%	4%	-32%	1%	-34%	-4%	-6%	13%
C27MET	-1%	0%	-4%	0%	0%	0%	0%	0%	-11%	2%	-14%	-1%	0%	0%	-1%	2%	0%	1%	13%	-2%	-25%	-29%	8%	0%	-2%	0%	-49%	-35%	37%	53%	-51%	-14%	-1%	24%
C28FBM	-1%	0%	-4%	0%	1%	0%	0%	0%	-1%	2%	-20%	-1%	0%	0%	1%	-1%	0%	1%	13%	-2%	-1%	-11%	9%	0%	7%	0%	-13%	-1%	578%	-17%	-41%	-18%	-1%	11%
C29MEQ	-1%	0%	-4%	0%	-2%	0%	0%	0%	-10%	2%	10%	-1%	0%	0%	2%	-3%	0%	1%	13%	-1%	31%	-16%	5%	0%	-9%	-12%	-17%	-53%	59%	-4%	-34%	-3%	-1%	-25%
C30T33XCEQ	-1%	0%	-4%	0%	-3%	0%	0%	0%	17%	2%	-4%	-1%	0%	0%	0%	18%	-35%	-7%	13%	0%	48%	-15%	-3%	14%	-6%	18%	22%	-13%	-76%	-9%	6%	-21%	-1%	28%
C31ELQ	-1%	0%	-4%	0%	5%	0%	0%	0%	15%	2%	-6%	-1%	0%	0%	1%	2%	118%	-6%	13%	4%	-11%	32%	3%	0%	35%	0%	24%	-29%	-76%	103%	-44%	-3%	-1%	19%
C34MTR	-1%	0%	-4%	0%	0%	0%	0%	0%	24%	2%	-28%	-1%	0%	0%	1%	14%	0%	0%	13%	0%	28%	-20%	-33%	0%	-1%	0%	-30%	28%	-82%	10%	-56%	-5%	-1%	95%
C35TRQ	-1%	0%	-4%	0%	3%	0%	0%	0%	-12%	2%	-33%	-1%	0%	0%	-3%	-4%	0%	-13%	13%	0%	-11%	-7%	120%	0%	-20%	0%	-59%	52%	-72%	-27%	-60%	-15%	-1%	-48%
C36T37OTM	-1%	0%	-4%	0%	-1%	0%	0%	0%	15%	2%	-50%	-1%	0%	0%	2%	6%	0%	1%	13%	-1%	-14%	-28%	106%	-12%	21%	0%	46%	15%	-81%	-43%	-20%	-1%	-1%	35%
C40T41EGW	-1%	0%	-3%	0%	0%	0%	0%	0%	-7%	2%	-2%	-1%	0%	0%	0%	-12%	0%	0%	13%	2%	7%	-29%	-7%	0%	3%	-87%	29%	-16%	4%	-39%	40%	11%	-1%	18%
C45CON	-1%	0%	-4%	1%	0%	0%	0%	0%	-9%	2%	1%	-1%	0%	0%	0%	10%	0%	0%	13%	0%	9%	-3%	-7%	0%	-3%	0%	-32%	-10%	32%	-4%	-4%	-3%	-1%	3%
C50T52WRT	-1%	0%	-4%	0%	0%	0%	0%	0%	-3%	1%	-4%	-1%	0%	0%	0%	5%	0%	0%	13%	0%	4%	-8%	-29%	22%	-9%	-7%	-10%	-3%	40%	-11%	14%	10%	-1%	4%
C55HTR	-1%	0%	-4%	0%	0%	0%	0%	0%	3%	2%	29%	-1%	0%	0%	10%	5%	0%	0%	13%	-1%	14%	-19%	-9%	0%	0%	0%	-25%	19%	294%	11%	9%	-4%	-1%	27%
C60T63TRN	-1%	0%	-4%	0%	0%	0%	0%	0%	2%	2%	-9%	-1%	0%	0%	0%	-1%	0%	0%	13%	0%	-3%	6%	-3%	42%	-2%	67%	-4%	0%	15%	-7%	-4%	-4%	-1%	24%
C64PTL	-1%	0%	-4%	0%	0%	0%	0%	0%	-10%	2%	-8%	-1%	0%	0%	10%	7%	0%	0%	21%	0%	9%	-7%	-94%	-1%	2%	-87%	12%	-19%	45%	-13%	66%	-5%	-1%	-6%
C65T67FIN	-1%	0%	-4%	0%	0%	0%	0%	0%	-1%	2%	8%	-1%	0%	0%	0%	0%	0%	0%	13%	-15%	-12%	-14%	4%	-20%	-1%	0%	9%	-26%	202%	40%	49%	-9%	-1%	26%
C70REA	-1%	0%	-4%	1%	0%	0%	0%	0%	-1%	2%	-2%	-1%	0%	0%	1%	6%	0%	0%	13%	-2%	10%	-10%	-21%	12%	8%	-69%	-7%	8%	-87%	-20%	-13%	1%	-1%	8%
C71RMQ	-1%	0%	-4%	0%	1%	0%	0%	0%	6%	2%	-8%	-1%	0%	0%	7%	-2%	0%	0%	13%	-1%	92%	40%	263%	0%	385%	#####	-17%	-21%	-69%	-14%	-92%	52%	-1%	-43%
C72ITS	-1%	0%	-4%	0%	1%	0%	0%	0%	-20%	2%	57%	-1%	0%	0%	-4%	6%	0%	0%	13%	-2%	71%	9%	189%	49%	-14%	196%	-27%	-88%	-71%	-41%	9%	-3%	-1%	35%
C73T74OBZ	-1%	0%	-4%	0%	0%	0%	0%	0%	3%	2%	-18%	-1%	0%	0%	0%	0%	0%	0%	13%	-1%	8%	-7%	-29%	29%	27%	-8%	-4%	15%	-45%	-8%	7%	35%	-1%	26%
C75GOV	-1%	0%	-4%	0%	0%	3%	0%	0%	3%	2%	15%	-1%	0%	0%	0%	5%	0%	0%	13%	-1%	38%	-17%	-18%	0%	-1%	0%	-8%	8%	-56%	20%	28%	-5%	-1%	-42%
C80EDU	-1%	0%	-4%	2%	0%	3%	0%	0%	9%	2%	2%	-1%	0%	-6%	0%	12%	0%	0%	13%	-3%	-80%	31%	-7%	0%	0%	-28%	-14%	8%	-28%	-3%	5%	-6%	-1%	-40%
C85HTH	-1%	0%	-4%	-1%	0%	3%	0%	0%	10%	2%	-26%	-1%	0%	0%	0%	3%	0%	0%	13%	0%	3%	3%	-4%	6%	0%	3%	7%	4%	-11%	-9%	0%	-19%	-1%	-44%
C90T93OTS	-1%	0%	-4%	0%	0%	-8%	0%	0%	6%	1%	-20%	-1%	0%	9%	-18%	-9%	0%	0%	13%	-6%	-1%	24%	-8%	38%	101%	153%	-20%	72%	209%	19%	15%	-40%	-1%	97%
C95PVH	-1%	0%	-4%	0%	0%	4%	0%	1%	22%	-100%	-1%	-1%	0%	0%	#####	#####	0%	0%	#####	#####	-4%	#####	#####	#####	#####	-78%	#####	15%	#####	#####	-7%	-6%	-1%	#####
Total	-1%	0%	-4%	0%	0%	0%	0%	0%	-1%	1%	-1%	-1%	0%	0%	0%	4%	0%	0%	13%	-2%	3%	-8%	-4%	6%	2%	0%	-9%	-3%	22%	-3%	1%	-8%	-1%	11%

Figure 3: Heatmap of differences between Exiobase v3.4 and the OECD MRIOT for gross output in 2007 by industry and country



Industry	AUT	BEL	CZE	DEU	DNK	ESP	FIN	FRA	GRC	HUN	IRL	ITA	LUX	NLD	POL	PRT	SWE	SVN	SVK	GBR	USA	JPN	CHN	CAN	KOR	BRA	IND	MEX	RUS	AUS	TUR	TWN	NOR	IDN
C01T05AGR	-14%	7%	-10%	-7%	2%	-8%	-8%	-14%	-8%	-7%	-11%	9%	3%	-13%	-12%	-10%	-4%	-4%	1%	-7%	2%	4%	-13%	5%	11%	-16%	3%	-8%	13%	-8%	-18%	6%	4%	0%
C10T14MIN	119%	199%	36%	84%	46%	198%	167%	173%	133%	146%	38%	75%	-40%	-67%	-22%	68%	117%	74%	84%	-6%	-43%	#####	-9%	-24%	142%	40%	47%	13%	-44%	-43%	33%	140%	2%	9%
C15T16FOD	8%	20%	-3%	8%	-1%	12%	9%	16%	13%	11%	-3%	15%	-19%	7%	0%	18%	7%	-4%	17%	1%	13%	5%	-9%	13%	12%	-9%	-5%	16%	37%	32%	24%	33%	-23%	6%
C17T19TEX	12%	17%	12%	38%	68%	10%	26%	17%	21%	5%	3%	18%	34%	90%	17%	2%	20%	-17%	11%	37%	48%	33%	5%	35%	18%	28%	28%	30%	145%	48%	20%	82%	49%	25%
C20WOD	9%	21%	4%	12%	28%	17%	21%	18%	21%	16%	27%	-4%	35%	26%	-3%	2%	19%	5%	-14%	1%	27%	11%	-93%	34%	23%	15%	98%	6%	45%	13%	-39%	100%	-5%	-9%
C21T22PAP	0%	1%	0%	5%	4%	6%	-9%	7%	14%	11%	-44%	31%	14%	7%	18%	0%	9%	-19%	-16%	-18%	-38%	7%	-1%	-14%	-19%	11%	28%	1%	6%	-33%	-17%	95%	-8%	14%
C23PET	-49%	-49%	-13%	-13%	32%	-29%	-17%	-23%	-32%	-35%	62%	-30%	#####	1%	-39%	-27%	-30%	102%	-33%	7%	-32%	-23%	-16%	9%	-27%	-25%	-43%	-37%	-39%	33%	-53%	-32%	191%	-23%
C24CHM	-51%	-72%	-4%	-47%	-50%	-21%	-17%	-10%	-47%	-29%	-17%	-15%	18%	-71%	3%	4%	-65%	-12%	-39%	-29%	35%	-1%	-3%	19%	19%	11%	53%	-4%	67%	91%	-5%	5%	-25%	9%
C25RBP	15%	30%	-8%	16%	21%	9%	22%	19%	14%	-4%	1%	0%	16%	34%	0%	9%	35%	-14%	17%	10%	18%	-1%	1%	-20%	12%	5%	42%	8%	-60%	85%	-36%	52%	71%	-24%
C26NMM	-2%	26%	-3%	7%	46%	17%	15%	29%	8%	4%	90%	26%	-21%	26%	15%	-10%	42%	17%	-5%	35%	33%	5%	5%	8%	21%	33%	16%	26%	-11%	0%	-37%	47%	-5%	-2%
C27MET	-10%	13%	-5%	5%	125%	9%	7%	23%	1%	-6%	138%	7%	-5%	61%	117%	8%	22%	38%	-4%	18%	32%	1%	8%	28%	9%	13%	-36%	-7%	38%	65%	-52%	29%	2%	143%
C28FBM	-5%	-8%	7%	12%	29%	9%	8%	15%	1%	-1%	16%	-11%	35%	17%	15%	-1%	27%	-29%	-1%	1%	18%	5%	6%	-25%	21%	22%	59%	8%	459%	-22%	-39%	17%	-3%	10%
C29MEQ	15%	89%	0%	15%	10%	23%	11%	26%	0%	75%	41%	13%	61%	23%	24%	-18%	21%	15%	16%	13%	48%	16%	9%	27%	9%	16%	27%	-17%	50%	21%	-36%	81%	170%	-16%
C30T33XCEQ	20%	58%	-10%	24%	42%	13%	-38%	17%	83%	25%	-2%	17%	35%	-23%	19%	50%	-31%	-19%	8%	21%	61%	-2%	0%	34%	-1%	51%	71%	1%	-63%	88%	-11%	-17%	30%	33%
C31ELQ	-4%	85%	4%	6%	9%	9%	38%	11%	33%	-14%	28%	-1%	40%	25%	15%	22%	87%	-2%	4%	11%	31%	11%	2%	40%	57%	22%	98%	-1%	-65%	145%	-37%	73%	42%	33%
C34MTR	12%	8%	-6%	5%	141%	4%	69%	17%	14%	8%	9%	-4%	135%	54%	11%	4%	-4%	11%	20%	14%	20%	-10%	-31%	37%	5%	14%	-21%	33%	-73%	31%	-58%	50%	25%	74%
C35TRQ	25%	63%	17%	0%	27%	6%	10%	10%	43%	12%	-20%	-8%	548%	52%	7%	-3%	-3%	10%	17%	-10%	15%	25%	121%	8%	-39%	16%	-44%	66%	-58%	-20%	-49%	51%	-9%	-52%
C36T37OTM	16%	3%	-6%	25%	17%	14%	6%	-5%	73%	75%	-49%	29%	-43%	-26%	8%	56%	29%	54%	1%	34%	5%	-6%	123%	3%	59%	38%	211%	28%	-84%	-15%	-26%	68%	31%	88%
C40T41EGW	-13%	10%	-7%	-8%	-45%	-25%	-50%	10%	-20%	-6%	-48%	-10%	2%	-10%	-62%	-43%	-56%	-40%	-20%	-32%	45%	-38%	-49%	-57%	-27%	-94%	-22%	-64%	-41%	-51%	-47%	-27%	-1%	-89%
C45CON	12%	9%	19%	19%	11%	12%	14%	16%	27%	29%	14%	15%	17%	30%	12%	21%	29%	11%	13%	20%	19%	2%	-6%	5%	16%	10%	7%	14%	27%	13%	-2%	14%	16%	-13%
C50T52WRT	-58%	-75%	-45%	-53%	-48%	-53%	-41%	-38%	-81%	-67%	-23%	-48%	-58%	-81%	-72%	-75%	-44%	-60%	-68%	-67%	-53%	-63%	-50%	-40%	-49%	-75%	-38%	-53%	-65%	-75%	-38%	-32%	-64%	-89%
C55HTR	33%	25%	13%	24%	44%	18%	34%	32%	30%	37%	37%	17%	56%	40%	94%	28%	41%	64%	53%	64%	74%	-8%	15%	-16%	48%	23%	-34%	85%	166%	40%	29%	10%	18%	166%
C60T63TRN	16%	15%	15%	44%	-22%	13%	18%	27%	-28%	22%	42%	4%	-43%	13%	20%	17%	34%	7%	15%	7%	10%	24%	-17%	10%	5%	97%	-28%	-18%	-7%	-10%	-11%	-4%	6%	0%
C64PTL	31%	7%	7%	39%	28%	15%	20%	37%	2%	9%	71%	24%	13%	32%	31%	12%	28%	14%	32%	-4%	31%	43%	-93%	-34%	61%	-83%	8%	-8%	9%	-8%	77%	46%	15%	-2%
C65T67FIN	-18%	-13%	-5%	-7%	-8%	-10%	-16%	-9%	10%	-9%	1%	-4%	-16%	-25%	-13%	-11%	-15%	-6%	-2%	-31%	-18%	-7%	15%	-2%	-8%	-2%	9%	-29%	54%	35%	34%	-6%	-15%	13%
C70REA	3%	-8%	-19%	4%	-3%	19%	6%	-5%	46%	-3%	-4%	5%	17%	4%	7%	15%	13%	15%	46%	15%	-1%	-12%	-15%	22%	3%	-51%	-17%	10%	-70%	-7%	22%	-7%	12%	-14%
C71RMQ	46%	45%	80%	9%	91%	5%	76%	-4%	64%	71%	20%	416%	70%	33%	232%	99%	132%	380%	128%	62%	118%	0%	254%	122%	449%	#####	-2%	-11%	-86%	56%	-57%	53%	225%	-26%
C72ITS	30%	56%	2%	21%	71%	-10%	32%	-3%	6%	5%	90%	-6%	-12%	-8%	0%	40%	49%	33%	37%	24%	91%	8%	212%	121%	-34%	185%	-43%	-89%	-75%	-20%	85%	15%	6%	20%
C73T74OBZ	17%	-7%	1%	11%	0%	13%	49%	-1%	39%	10%	-10%	11%	28%	38%	9%	46%	6%	-17%	-11%	14%	25%	-9%	-22%	58%	21%	13%	16%	-2%	1%	17%	26%	43%	-2%	9%
C75GOV	8%	-6%	2%	7%	8%	-8%	-13%	-4%	21%	-4%	32%	6%	14%	-6%	7%	-7%	-23%	2%	0%	4%	70%	29%	24%	94%	47%	-8%	19%	59%	-44%	76%	-19%	60%	-3%	-15%
C80EDU	27%	6%	10%	27%	-2%	9%	29%	10%	26%	21%	52%	15%	26%	7%	30%	16%	-4%	6%	24%	46%	-73%	26%	28%	-59%	17%	-31%	-13%	27%	40%	19%	28%	32%	-2%	-3%
C85HTH	28%	24%	11%	20%	19%	33%	13%	38%	17%	25%	-12%	31%	53%	-1%	25%	20%	-3%	15%	13%	11%	4%	76%	25%	14%	19%	22%	19%	23%	76%	22%	6%	-20%	18%	-22%
C90T93OTS	23%	37%	12%	15%	22%	16%	18%	26%	90%	29%	-1%	28%	35%	153%	-14%	8%	25%	39%	23%	1%	1%	24%	3%	32%	84%	145%	-15%	48%	246%	23%	77%	-45%	39%	90%
C95PVH	30%	31%	34%	35%	41%	33%	25%	40%	111%	#####	40%	56%	48%	44%	#####	#####	40%	48%	#####	#####	80%	#####	#####	#####	#####	-78%	#####	40%	#####	#####	22%	69%	75%	#####
Total	2%	-5%	-2%	5%	2%	4%	4%	5%	3%	3%	6%	3%	-6%	1%	-3%	2%	5%	-1%	-1%	0%	8%	-1%	-4%	10%	9%	1%	-1%	0%	-3%	1%	-9%	8%	5%	3%

With regard to the difference between Exiobase v3.4 and OECD MRIOT the results show that the deviations from the OECD data are significantly larger compared to the Exiobase v2 data. This also holds for European and other OECD countries, which are the main Swiss trade partners. The reasons for the larger deviations are unclear. We therefore conclude that the economic data in Exiobase v2 are more suited for analysis of environmental footprints than the data in Exiobase v3.4.

2.4 Environmental data in Exiobase

Environmental data in Exiobase are structured in three groups:

- emissions
- resources, i.a. land use types and
- materials, that include the classical resources.

Emissions

Exiobase includes the 33 different emission types shown in Table 2.5. However, these are further differentiated by environmental medium, “combustion / non-combustion” and various processes (only in V.3). In the course of the ongoing versions of Exiobase, the set of emissions remained unaltered, however the degree of differentiation increased steadily.

Table 2.5: Emission types in Exiobase

No.	Emission symbol	Emission name
1	CO2	Carbon dioxide
2	CH4	Methane
3	N2O	Nitrous oxide
4	SOx	Sulfur oxide
5	NOx	Nitrogen oxide
6	NH3	Ammonia

No.	Emission symbol	Emission name
7	CO	Carbon monoxide
8	B(a)P	Benzo(a)pyrene
9	B(b)F	Benzo(b)fluoranthene
10	B(k)F	Benzo(k)fluoranthene
11	C22H12	Indeno[1,2,3-cd]pyren]
12	PAH	Polycyclic aromatic hydrocarbon
13	PCBs	Polychlorinated biphenyl
14	PCDD_F	Polychlorinated dibenzodioxins
15	HCB	Hexachlorobenzene
16	NMVOC	Non-methane volatile organic compound
17	PM10	particulate matter 10 micrometers or less in diameter
18	PM2.5	particulate matter 2.5 micrometers or less in diameter
19	TSP	Trisodium phosphate
20	As	Arsenic
21	Cd	Cadmium
22	Cr	Chromium
23	Cu	Copper
24	Hg	Mercury
25	Ni	Nickel
26	Pb	Lead
27	Se	Selenium
28	Zn	Zinc
29	SF6	Sulfur hexafluoride
30	HFC	Hydrofluorocarbon
31	PFC	Perfluorinated compound
32	N	Nitrogen
33	P	Phosphorus

Resources (land use)

Exiobase Version 3.4 includes the 14 different types of land uses per industry or product group shown in Table 2.6. The categories “Used Other land – Wood fuel” and “Infrastructure land” were newly added in Exiobase V.3 and were not part of V.2 yet.

In Exiobase V.2 land use for animal farming obviously was not allocated to the animal farming industries but to “other crops”. Thus land use of animal farming is substantially underestimated in Exiobase V.2. In Exiobase V.3.4 this allocation of land use to animal farming industries has been included, which makes Exiobase V3.4 a better choice for the analysis of land use impacts than Exiobase V2.

Table 2.6: Resources (land use types) in Exiobase

Resources (land use)			
No.	**Name**	**Comp**	**Unit**
1	Land use - Arable Land - Rice	nature	km2
2	Land use - Arable Land - Wheat	nature	km2
3	Land use - Arable Land - Other cereals	nature	km2
4	Land use - Arable Land - Vegetables, fruits, nuts	nature	km2
5	Land use - Arable Land - Oil crops	nature	km2
6	Land use - Arable Land - Sugar crops	nature	km2
7	Land use - Arable Land - fibers	nature	km2
8	Land use - Arable Land - Other crops	nature	km2
9	Land use - Arable Land - Fodder crops	nature	km2
10	Land use - Permanent pasture	nature	km2
11	Used Forest Land - Industrial roundwood	nature	km2
12	Used Forest Land - Wood fuel	nature	km2
13	Used Other land - Woodfuel	nature	km2
14	Infrastructure Land	nature	km2

Materials

Exiobase V.3.4 contains a set of 867 specific material use/supply categories, which can all be attributed to one of the 9 groups presented in Table 2.7. These material use/supply groups are already included in Exiobase V.2, however they are less differentiated than in V.3 On the other hand, Exiobase V.3 contains less differentiation regarding energy carriers.

Table 2.7: Material types in Exiobase

No.	Material category	Comments
1	Nature Inputs	
2	Emission Relevant Energy Carrier	
3	Energy Carrier Supply	
4	Energy Carrier Use	Substantially less energy carriers in Exiobase V.3.4 than in Exiobase V.2.
5	Domestic Extraction Used	
6	Unused Domestic Extraction	
7	Water Consumption Green	Green water footprint is water from precipitation that is stored in the root zone of the soil and evaporated, transpired or incorporated by plants. It is particularly relevant for agricultural, horticultural and forestry products.
8	Water Consumption Blue	Blue water footprint is water that has been sourced from surface or groundwater resources and is either evaporated, incorporated into a product or taken from one body of water and returned to another, or

No.	Material category	Comments
		returned at a different time. Irrigated agriculture, industry and domestic water use can each have a blue water footprint.
9	Water Withdrawal Blue	

Midpoint indicators

By combining the environmental data in Exiobase with specific characterization factors, a set of 4 different environmental footprints (midpoint indicators) can be calculated for every industry / product and every final demand category in every country. This section contains an overview of the midpoint indicators that can be calculated with Exiobase.

Greenhouse gas footprint

The climate change effect of greenhouse gases is expressed by the Global Warming Potential (GWP) according to the 4th Assessment Report of the Intergovernmental Panel on Climate Change (expressed in kg CO2-equivalents according to IPCC 2007). The indicator covers the so-called “Kyoto-Substances” CO2, CH4, N2O, PFC, HFC, SF6 and NF3. The climate-impacting ozone-depleting substances regulated by the Montreal Protocol are not included.

Biodiversity footprint

Land use is one of the major causes of loss of biodiversity and species. The indicator “potential species loss from land use” (Chaudhary et al. 2016) quantifies the damage potential of land use on biodiversity. The indicator quantifies the loss of species in amphibians, reptiles, birds, mammals and plants by the use of arable land, permanent crops, pasture, intensively used forest, extensively used forest and urban areas. The indicator weighs endemic species higher than species that are common. Species loss is determined in relation to the biodiversity of the natural state of the area in the region concerned. The indicator aggregates the regional loss of common species and the global loss of endemic species into “globally lost species”. By that, the indicator aggregates differing impact intensities into a common unit, similar to the unit “kg CO2-equivalents” used to aggregate greenhouse gas emissions (see above). The biodiversity footprint is expressed in equivalents of potentially globally lost species per million species (micro PDF·a). The indicator covers only a small share of all endangered species listed on the “red list”.

Eutrophication footprint

The release of nitrogen into the environment causes a wide range of problems. The most obvious of these is marine eutrophication ("over-fertilization" of the Oceans): The eutrophication footprint quantifies the amount of nitrogen that potentially enters the oceans through the emission of nitrogen compounds in water, air and soil and thus may contribute to over-fertilization (Goedkoop et al. 2009). Nitrogen quantities are taken into account according to their marine eutrophication potential (kg N-equivalents).

Water footprint

The water footprint describes the extent to which a Swiss industry uses the global freshwater resources, taking into account the prevailing water scarcity in the production regions. The water footprint is quantified using the water scarcity indicator AWARE, recommended by the UNEP SETAC Life Cycle Initiative (Boulay et al. 2017). The AWARE indicator is based on the assumption that decreasing water availability in a region increases the likelihood that other users will be deprived in their access to water. The indicator quantifies the available water quantity per catchment area by subtracting the water requirements of humans and ecosystems from the amount of naturally available water.

Air pollution footprint

Air pollution and in particular fine particles have a major impact on human health and well-being. Thus the air pollution footprint is characterized with primary and secondary particles and the associated effects on human health, such as respiratory diseases (Goedkoop et al. 2009). The emissions of the particulate matter precursors NOX, SO2 and NH3 are converted to kg PM10-equivalents according to their potential to form particulate matter.

3. The representation of Switzerland in Exiobase

The development of the time series of detailed EE MRIO tables in Exiobase V.3.4 is documented in Stadler et al. (2018) and its supporting information (cf. Stadler et al. 2018, p. 505). The monetary parts (MRIOTs) are based on national Supply and Use Tables (SUTs), which are linked via international trade flows. The Environmental parts are based on various international data sources like e.g. FAO Statistics for Land use (For details cf. Stadler et al., 2018).

The SUTs, the Exiobase consortium used to integrate Switzerland into Exiobase, are the official tables for the years 2001, 2005 and 2008 published by the Federal Statistical Office (FSO) and not the more detailed Swiss IOT estimated by Rütter Soceco for 2008 in a recent project funded by the Swiss National Science Foundation (Nathani et al. 2016). The latter took into account a major revision of the Swiss national accounts (SNA) in 2012 that was based on improved value added statistics and led to significant changes of industries' gross production and gross value added. These economic changes are not represented in the official Swiss IOT 2008 that reflects the statistical situation before the SNA revision.

Table 3.1 provides a comparison of the gross production values (GPV) in the Swiss EE-IOT and the representation of Swiss industries in EXIOBASE and shows substantial differences for several industries. Even though some of the differences may reflect classification or conceptual differences, the results suggest that the Swiss IOT has partially been altered in a substantial way in the course of the Exiobase construction. For this reason, we recommend using a combination of the Swiss EE-IOT and Exiobase rather than only Exiobase for analyses in the Swiss context.

Table 3.1: Gross production values of industries in Exiobase compared to those of the Swiss EE-IOT 2008

Nace Rev. 1.1	Industry name	CH EE IOT: GPV 2008, Mio. CHF	EXIOBASE V.3.4: GPV 2008, Mio. CHF	EXIOBASE V.2.2.2: GPV 2007, Mio. CHF	EXIOBASE V.3.4: Deviation to CH EE IOT, %	EXIOBASE V.3.4: Deviation to CH EE IOT, %
01_01	Cattle and milk farming	4'851	6'236	5'914	28.6%	21.9%
01_02	Cereals farming	867	938	821	8.2%	-5.4%
01_03	Landscape services	2'463	0	0	-100.0%	-100.0%
01_04	Farming of oil seeds	138	179	107	29.4%	-22.7%
01_05	Other agriculture	0	0	0		
01_06	Other animal agriculture.	202	424	249	109.8%	23.1%
01_07	Other crops agriculture nec.	1'259	233	560	-81.5%	-55.5%
01_08	Pigs farming	1'182	1'730	1'404	46.4%	18.8%
01_09	Poultry farming	422	673	579	59.5%	37.1%
01_10	Cultivation of sugar	194	265	254	36.1%	30.9%
01_11	Cultivation of vegetables, fruits & nuts	2'044	2'926	2'431	43.2%	19.0%
02	Forestry	1'095	1'013	930	-7.5%	-15.1%
05	Fishing	38	87	32	128.2%	-16.4%
10t14	Mining and Quarrying	2'088	3'975	1'707	90.3%	-18.3%
15_01	Manufacture of beverages	2'599	5'503	3'557	111.7%	36.9%

Nace Rev. 1.1	Industry name	CH EE IOT: GPV 2008, Mio. CHF	EXIOBASE V.3.4: GPV 2008, Mio. CHF	EXIOBASE V.2.2.2: GPV 2007, Mio. CHF	EXIOBASE V.3.4: Deviation to CH EE IOT, %	EXIOBASE V.3.4: Deviation to CH EE IOT, %
15_02	Manufacture of dairy products	6'917	3'817	3'548	-44.8%	-48.7%
15_03	Manufacture of fish products	80	164	76	104.0%	-4.9%
15_04	Processing of meat	5'457	596	163	-89.1%	-97.0%
15_05	Processing of food nec.	13'489	20'964	16'985	55.4%	25.9%
15_06	Sugar refining	338	48	65	-85.9%	-80.9%
15_07	Processing of vegetable oils and fats	591	253	681	-57.2%	15.3%
17	Manufacture of textiles	2'274	3'550	2'264	56.1%	-0.4%
18	Manufacture of wearing apparel	1'193	2'503	1'154	109.8%	-3.2%
19	Manufacture of leatherware	608	783	396	28.7%	-34.8%
20	Wood and wood products	8'483	22'359	7'789	163.6%	-8.2%
21	Manufacture of Pulp & paper	4'693	6'416	4'321	36.7%	-7.9%
22	Publishing & printing	10'399	11'782	8'831	13.3%	-15.1%
23_01	Coke and ref. petroleum industry	5'077	9'740	9'048	91.8%	78.2%
23_02	Nuclear fuels industry	0	27	14		
24	Chemical industry	76'770	61'559	54'673	-19.8%	-28.8%
25	Rubber & plastic industry	9'050	10'166	7'824	12.3%	-13.6%
26	Oth. non-metallic minerals industry	6'359	7'423	5'046	16.7%	-20.6%
27	Basic metals industry	7'944	8'961	5'526	12.8%	-30.4%
28	Metal Products industry	22'600	24'820	19'001	9.8%	-15.9%
29	Machinery & equipment industry	36'942	46'258	32'700	25.2%	-11.5%
30	Office machinery & computer industry	892	2'680	1'468	200.4%	64.6%
31	Electrical machinery	21'952	18'778	14'762	-14.5%	-32.8%
32	Radio, televison & communication equipment industry	10'935	9'789	7'286	-10.5%	-33.4%
33	Precision instrumentation	47'756	44'739	35'421	-6.3%	-25.8%
34	Vehicles industry	2'029	3'954	1'967	94.9%	-3.1%
35	Other transport equipment	6'471	7'948	5'084	22.8%	-21.4%
36	Furniture & other manufacturing	5'788	10'539	5'838	82.1%	0.9%
37	Recycling	2'588	2'159	1'742	-16.6%	-32.7%
40_01	Energy distribution	33'934	8'852	7'508	-73.9%	-77.9%
40_02	Prod. of electricity from fossil fuels	11	236	138	2076.4%	1172.0%
40_03	Gas industry	3'855	2'919	1'862	-24.3%	-51.7%
40_04	Hydropower industry	2'412	8'119	7'037	236.7%	191.8%
40_05	Nuclear power industry	1'238	6'036	5'264	387.5%	325.2%
40_06	Public heat industry	401	45	1	-88.8%	-99.7%
40_07	Prod. of electricity from wind and PV	7	37	7	414.0%	-1.0%
40_08	Production of electricity from wood energy	5	616	415	12318.6%	8276.5%
41	Collection, purification and dist. of water	1'431	5'820	4'981	306.6%	248.0%
45	Construction	60'409	69'616	50'529	15.2%	-16.4%
50	Sale & maintenance of motor vehicles, sale of automotive fuel	13'402	13'806	9'916	3.0%	-26.0%
51	Wholesale trade	123'412	38'221	45'356	-69.0%	-63.2%
52	Retail trade	28'371	29'738	34'954	4.8%	23.2%
55	Hotels & restaurants	23'582	32'649	20'651	38.5%	-12.4%
60_01	Land transport	16'028	16'517	11'005	3.1%	-31.3%
60_02	Pipeline transport	154	402	553	160.8%	258.9%
60_03	Railway transport	8'583	5'998	4'040	-30.1%	-52.9%
61	Water transport	11'393	6'769	4'632	-40.6%	-59.3%
62	Air transport	7'590	7'872	5'258	3.7%	-30.7%

Nace Rev. 1.1	Industry name	CH EE IOT: GPV 2008, Mio. CHF	EXIOBASE V.3.4: GPV 2008, Mio. CHF	EXIOBASE V.2.2.2: GPV 2007, Mio. CHF	EXIOBASE V.3.4: Deviation to CH EE IOT, %	EXIOBASE V.3.4: Deviation to CH EE IOT, %
63	Auxiliary transport activities, travel angencies	18'547	27'462	15'751	48.1%	-15.1%
64	Post & telecommunications	22'984	32'396	22'530	41.0%	-2.0%
65	Financial intermediation	69'767	85'861	74'094	23.1%	6.2%
66	Insurance & pension funding	37'250	28'234	20'062	-24.2%	-46.1%
70x97	Real estate activities & private households	70'412	75'295	57'517	6.9%	-18.3%
71	Renting of machinery and equipment	10'903	16'590	10'946	52.2%	0.4%
72	Computer and related activities	19'455	22'972	15'272	18.1%	-21.5%
73	Research and development	16'341	12'605	8'742	-22.9%	-46.5%
74	Other business activities	65'851	81'171	51'764	23.3%	-21.4%
75	Public administration & defence	31'912	29'231	25'529	-8.4%	-20.0%
80	Education	33'322	32'870	26'446	-1.4%	-20.6%
85	Health & social work	53'414	68'027	45'194	27.4%	-15.4%
90_01	Other sewage and refuse disposal	6'653	2'750	1'450	-58.7%	-78.2%
90_02	Refuse incineration	277	5'387	3'543	1843.2%	1178.0%
91	Membership organizations	7'498	11'841	4'217	57.9%	-43.8%
92	Recreational, cultural and sporting activities	12'085	19'862	12'136	64.4%	0.4%
93	Other services	3'301	5'143	3'940	55.8%	19.4%
95	Households with domestic staff	1'974	1'202	593	-39.1%	-70.0%
	Total	**1'156'852**	**1'184'653**	**889'645**	**2.4%**	**-23.1%**

4. Calculation of the Swiss greenhouse gas footprint with Exiobase

As stated in chapter 3, the swiss IOT in Exiobase differs substantially from the Swiss EE-IOT. Hence, we recommend using a combination of the Swiss EE-IOT and Exiobase to calculate the global environmental greenhouse gas footprint caused by Swiss final demand and Swiss exports instead of only Exiobase. In an exemplary way we calculated the environmental impacts caused in Switzerland with the Swiss EE-IOT and those caused abroad with Exiobase. With the considerations in section 2.3 in mind, we have used the economic tables in Exiobase V2.2.2 and the environmental tables from Exiobase V.3.4. The following calculation steps were taken:

- Starting with the Swiss final demand and exports, the total output and gross value added induced in all Swiss industries are calculated with the Swiss EE-IOT.
- The environmental impacts in Swiss industries are then determined by multiplying the output with industry-specific environmental impact coefficients as reported in the Swiss EE-IOT.
- The calculation also yields the imports by product group that are induced due to Swiss final demand and Swiss exports. These imports are then distributed to source countries. For this, a table of product-group specific country shares was developed, distributing imported product groups to source countries. The table was derived from the Swiss foreign trade statistics (for source countries of goods), the Swiss balance of payments and the OECD-WTO Balanced Trade in Services Statistics (for source countries of services). The table distinguishes between imported product groups used for intermediate consumption and for final consumption.

- The imports by product group and source country are then fed into Exiobase, which is used to calculate the total output in all industries in all countries induced by these imports and the total environmental impacts caused by these foreign production activities.

Table 4.1 shows an aggregation of the obtained results (column 1) and compares them to the greenhouse gas footprints caused by Swiss final demand and exports, obtained with other methodological approaches (cf. Nathani, Frischknecht 2019). The comparison shows that the obtained greenhouse gas footprint caused by Swiss final demand is substantially higher than those obtained by applying the TRAIL (+9%), the IO-TRAIL (+19%) and the FSO (+12) method, while it is almost identical to the greenhouse gas footprint obtained using the OECD-MRIO approach. The picture changes somewhat when turning one's attention to the greenhouse gas footprint caused by Swiss exports: the obtained footprint is higher than the one obtained by applying the TRAIL (+50%), the IO-TRAIL (+13%) and the OECD-MRIO (+ 54%) methods, whereas it is lower than the greenhouse gas footprint obtained by applying the FSO method (-11%).

For both the final demand as well as the export induced greenhouse gas footprint the same pattern is observable: while the greenhouse gas footprint caused in Switzerland is similar for almost all calculation methods, the greenhouse gas footprint caused abroad differs strongly among the different calculation methods. More in-depth analysis is needed to explain the differences between the different methods.

Table 4.1: Comparison of the greenhouse gas footprint caused by swiss final demand and swiss exports calculated with different methods

Causing activity	Swiss EE-IOT + Exiobase (EE-MRIO)	TRAIL	IO-TRAIL	FSO	OECD-MRIO
Emission through domestic final demand	122'095	111'183	102'915	108'908	122'011
Direct Emissions households	19'224	20'653	20'478	20'652	20'478
Domestic emissions (industries)	21'120		20'935	23'166	20'403
Import related Emissions	81'751		61'502	65'090	81'130
Intermediate imports	35'291		32'271		31'965
Final use imports	46'460		29'232		49'164
Emissions through Exports	78'164	51'881	69'320	87'449	50'861
Domestic emissions (industries)	14'882		14'787	12'406	15'367
Import related Emissions	63'282		54'534	75'043	35'494
Intermediate imports	48'822		41'634		35'494
Final use imports	14'460		12'899		

Source: Calculations Rütter Soceco; Nathani, Frischknecht (2019)

5. Conclusions

Our analysis of the Exiobase data shows that in principal Exiobase is a valuable data base for estimating environmental impacts of economic activities across industry and country borders. A large amount of international economic and environmental data has been processed into the format of an environmentally extended multiregional input-output table. Our analysis of the representation of Swiss economic data in Exiobase has revealed large deviations from the official statistical data and from comparable

values in the Swiss EE-IOT 2008. The Swiss data appear to have been significantly altered in the process of creating the MRIOT. We therefore recommend to use the Swiss EE-IOT 2008 for the analysis of the environmental impact of economic activities in Switzerland instead of Exiobase. Exiobase can be used to calculate the import related environmental impacts. With regard to the existing Exiobase versions 2.2.2 and 3.4 we recommend to use the MRIOT from the version 2.2.2 since the economic data in that version show less deviations from the comparable data in the OECD MRIOT than the economic data in Exiobase version 3.4. The OECD MRIOT serves us as a benchmark, since we assume it to be relatively close to the official country statistical data. With regard to the environmental data in Exiobase we see significant differences between the data in version 2.2.2 and in version 3.4. This is partly due to progress in data availability between the publication dates of the two Exiobase versions. It is partly also due to the choices made in the compilation process of Exiobase 3.4, where a larger priority has been given to data sources that allow to construct time series. We recommend to use the environmental data in Exiobase version 3.4, since the use of more recent and advanced data sources appears to have improved the data base (e.g. with regard to land use, see above).

When the aim is to calculate environmental footprints of Swiss production or consumption we recommend to combine the Swiss EE-IOT with Exiobase in the fashion explained in chapter 4. In such a combination the Swiss EE-IOT is used for the calculation of environmental impacts in Switzerland and Exiobase is used for the calculation of environmental impacts induced by Swiss economic activities in foreign countries. This allows to exploit the respective strengths of the two databases and to improve overall results.

6. References

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7. Annex

Table 7.1: Product groups in Exiobase

Product groups		
Nbr	**Product group name**	**Product group code (Nace Rev. 1.1)**
1	Paddy rice	p01.a
2	Wheat	p01.b
3	Cereal grains nec	p01.c
4	Vegetables, fruit, nuts	p01.d
5	Oil seeds	p01.e
6	Sugar cane, sugar beet	p01.f
7	Plant-based fibers	p01.g
8	Crops nec	p01.h
9	Cattle	p01.i
10	Pigs	p01.j
11	Poultry	p01.k
12	Meat animals nec	p01.l
13	Animal products nec	p01.m
14	Raw milk	p01.n
15	Wool, silk-worm cocoons	p01.o
16	Manure (conventional treatment)	p01.w.1
17	Manure (biogas treatment)	p01.w.2
18	Products of forestry, logging and related services (02)	p02
19	Fish and other fishing products; services incidental of fishing (05)	p05
20	Anthracite	p10.a
21	Coking Coal	p10.b
22	Other Bituminous Coal	p10.c
23	Sub-Bituminous Coal	p10.d
24	Patent Fuel	p10.e
25	Lignite/Brown Coal	p10.f
26	BKB/Peat Briquettes	p10.g
27	Peat	p10.h
28	Crude petroleum and services related to crude oil extraction, excluding surveying	p11.a
29	Natural gas and services related to natural gas extraction, excluding surveying	p11.b
30	Natural Gas Liquids	p11.b.1
31	Other Hydrocarbons	p11.c
32	Uranium and thorium ores (12)	p12
33	Iron ores	p13.1
34	Copper ores and concentrates	p13.20.11
35	Nickel ores and concentrates	p13.20.12
36	Aluminium ores and concentrates	p13.20.13
37	Precious metal ores and concentrates	p13.20.14
38	Lead, zinc and tin ores and concentrates	p13.20.15
39	Other non-ferrous metal ores and concentrates	p13.20.16
40	Stone	p14.1
41	Sand and clay	p14.2
42	Chemical and fertilizer minerals, salt and other mining and quarrying products nec	p14.3
43	Products of meat cattle	p15.a
44	Products of meat pigs	p15.b
45	Products of meat poultry	p15.c
46	Meat products nec	p15.d
47	products of Vegetable oils and fats	p15.e
48	Dairy products	p15.f

Product groups		
Nbr	**Product group name**	**Product group code (Nace Rev. 1.1)**
49	Processed rice	p15.g
50	Sugar	p15.h
51	Food products nec	p15.i
52	Beverages	p15.j
53	Fish products	p15.k
54	Tobacco products (16)	p16
55	Textiles (17)	p17
56	Wearing apparel; furs (18)	p18
57	Leather and leather products (19)	p19
58	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials (20)	p20
59	Wood material for treatment, Re-processing of secondary wood material into new wood material	p20.w
60	Pulp	p21.1
61	Secondary paper for treatment, Re-processing of secondary paper into new pulp	p21.w.1
62	Paper and paper products	p21.2
63	Printed matter and recorded media (22)	p22
64	Coke Oven Coke	p23.1.a
65	Gas Coke	p23.1.b
66	Coal Tar	p23.1.c
67	Motor Gasoline	p23.20.a
68	Aviation Gasoline	p23.20.b
69	Gasoline Type Jet Fuel	p23.20.c
70	Kerosene Type Jet Fuel	p23.20.d
71	Kerosene	p23.20.e
72	Gas/Diesel Oil	p23.20.f
73	Heavy Fuel Oil	p23.20.g
74	Refinery Gas	p23.20.h
75	Liquefied Petroleum Gases (LPG)	p23.20.i
76	Refinery Feedstocks	p23.20.j
77	Ethane	p23.20.k
78	Naphtha	p23.20.l
79	White Spirit & SBP	p23.20.m
80	Lubricants	p23.20.n
81	Bitumen	p23.20.o
82	Paraffin Waxes	p23.20.p
83	Petroleum Coke	p23.20.q
84	Non-specified Petroleum Products	p23.20.r
85	Nuclear fuel	p23.3
86	Plastics, basic	p24.a
87	Secondary plastic for treatment, Re-processing of secondary plastic into new plastic	p24.a.w
88	N-fertiliser	p24.b
89	P- and other fertiliser	p24.c
90	Chemicals nec	p24.d
91	Charcoal	p24.e
92	Additives/Blending Components	p24.f
93	Biogasoline	p24.g
94	Biodiesels	p24.h
95	Other Liquid Biofuels	p24.i
96	Rubber and plastic products (25)	p25
97	Glass and glass products	p26.a
98	Secondary glass for treatment, Re-processing of secondary glass into new glass	p26.a.w
99	Ceramic goods	p26.b

Product groups		
Nbr	**Product group name**	**Product group code (Nace Rev. 1.1)**
100	Bricks, tiles and construction products, in baked clay	p26.c
101	Cement, lime and plaster	p26.d
102	Ash for treatment, Re-processing of ash into clinker	p26.d.w
103	Other non-metallic mineral products	p26.e
104	Basic iron and steel and of ferro-alloys and first products thereof	p27.a
105	Secondary steel for treatment, Re-processing of secondary steel into new steel	p27.a.w
106	Precious metals	p27.41
107	Secondary precious metals for treatment, Re-processing of secondary precious metals into new precious metals	p27.41.w
108	Aluminium and aluminium products	p27.42
109	Secondary aluminium for treatment, Re-processing of secondary aluminium into new aluminium	p27.42.w
110	Lead, zinc and tin and products thereof	p27.43
111	Secondary lead for treatment, Re-processing of secondary lead into new lead	p27.43.w
112	Copper products	p27.44
113	Secondary copper for treatment, Re-processing of secondary copper into new copper	p27.44.w
114	Other non-ferrous metal products	p27.45
115	Secondary other non-ferrous metals for treatment, Re-processing of secondary other non-ferrous metals into new other non-ferrous metals	p27.45.w
116	Foundry work services	p27.5
117	Fabricated metal products, except machinery and equipment (28)	p28
118	Machinery and equipment nec (29)	p29
119	Office machinery and computers (30)	p30
120	Electrical machinery and apparatus nec (31)	p31
121	Radio, television and communication equipment and apparatus (32)	p32
122	Medical, precision and optical instruments, watches and clocks (33)	p33
123	Motor vehicles, trailers and semi-trailers (34)	p34
124	Other transport equipment (35)	p35
125	Furniture; other manufactured goods nec (36)	p36
126	Secondary raw materials	p37
127	Bottles for treatment, Recycling of bottles by direct reuse	p37.w.1
128	Electricity by coal	p40.11.a
129	Electricity by gas	p40.11.b
130	Electricity by nuclear	p40.11.c
131	Electricity by hydro	p40.11.d
132	Electricity by wind	p40.11.e
133	Electricity by petroleum and other oil derivatives	p40.11.f
134	Electricity by biomass and waste	p40.11.g
135	Electricity by solar photovoltaic	p40.11.h
136	Electricity by solar thermal	p40.11.i
137	Electricity by tide, wave, ocean	p40.11.j
138	Electricity by Geothermal	p40.11.k
139	Electricity nec	p40.11.l
140	Transmission services of electricity	p40.12
141	Distribution and trade services of electricity	p40.13
142	Coke oven gas	p40.2.a
143	Blast Furnace Gas	p40.2.b
144	Oxygen Steel Furnace Gas	p40.2.c
145	Gas Works Gas	p40.2.d
146	Biogas	p40.2.e
147	Distribution services of gaseous fuels through mains	p40.2.1
148	Steam and hot water supply services	p40.3
149	Collected and purified water, distribution services of water (41)	p41

Product groups		
Nbr	**Product group name**	**Product group code (Nace Rev. 1.1)**
150	Construction work (45)	p45
151	Secondary construction material for treatment, Re-processing of secondary construction material into aggregates	p45.w
152	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessoiries	p50.a
153	Retail trade services of motor fuel	p50.b
154	Wholesale trade and commission trade services, except of motor vehicles and motorcycles (51)	p51
155	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods (52)	p52
156	Hotel and restaurant services (55)	p55
157	Railway transportation services	p60.1
158	Other land transportation services	p60.2
159	Transportation services via pipelines	p60.3
160	Sea and coastal water transportation services	p61.1
161	Inland water transportation services	p61.2
162	Air transport services (62)	p62
163	Supporting and auxiliary transport services; travel agency services (63)	p63
164	Post and telecommunication services (64)	p64
165	Financial intermediation services, except insurance and pension funding services (65)	p65
166	Insurance and pension funding services, except compulsory social security services (66)	p66
167	Services auxiliary to financial intermediation (67)	p67
168	Real estate services (70)	p70
169	Renting services of machinery and equipment without operator and of personal and household goods (71)	p71
170	Computer and related services (72)	p72
171	Research and development services (73)	p73
172	Other business services (74)	p74
173	Public administration and defence services; compulsory social security services (75)	p75
174	Education services (80)	p80
175	Health and social work services (85)	p85
176	Food waste for treatment: incineration	p90.1.a
177	Paper waste for treatment: incineration	p90.1.b
178	Plastic waste for treatment: incineration	p90.1.c
179	Intert/metal waste for treatment: incineration	p90.1.d
180	Textiles waste for treatment: incineration	p90.1.e
181	Wood waste for treatment: incineration	p90.1.f
182	Oil/hazardous waste for treatment: incineration	p90.1.g
183	Food waste for treatment: biogasification and land application	p90.2.a
184	Paper waste for treatment: biogasification and land application	p90.2.b
185	Sewage sludge for treatment: biogasification and land application	p90.2.c
186	Food waste for treatment: composting and land application	p90.3.a
187	Paper and wood waste for treatment: composting and land application	p90.3.b
188	Food waste for treatment: waste water treatment	p90.4.a
189	Other waste for treatment: waste water treatment	p90.4.b
190	Food waste for treatment: landfill	p90.5.a
191	Paper for treatment: landfill	p90.5.b
192	Plastic waste for treatment: landfill	p90.5.c
193	Inert/metal/hazardous waste for treatment: landfill	p90.5.d
194	Textiles waste for treatment: landfill	p90.5.e
195	Wood waste for treatment: landfill	p90.5.f
196	Membership organisation services nec (91)	p91
197	Recreational, cultural and sporting services (92)	p92

Product groups		
Nbr	**Product group name**	**Product group code (Nace Rev. 1.1)**
198	Other services (93)	p93
199	Private households with employed persons (95)	p95
200	Extra-territorial organizations and bodies	p99