UPTEC W11 021

Examensarbete 30 hp
Juni 2011

Green growth?

A consumption perspective on Swedish environmental impact trends using input–output analysis

Grön tillväxt? Svensk miljöpåverkan ur ett konsumtionsperspektiv med tillämpning av input–output-analys

---

Mårten Berglund

Abstract

Green growth? A consumption perspective on Swedish environmental impact trends using input–output analysis

Mårten Berglund

Consumption-based environmental impact trends for the Swedish economy have been generated and analysed in order to determine their levels compared to official production-based data, and to determine whether or not the Swedish economy has decoupled growth in domestic final demand from worldwide environmental impact. Three energy resources (oil, coal and gas use, as well as their aggregate fossil fuel use) and seven emissions (CO_2, CH_4, N_2O, SO_2, NO_x, CO and NMVOC, as well as the aggregate CO_2 equivalents) were studied. An augmented single-regional input–output model has been deployed, with world average energy and emission intensities used for products produced abroad. A new method for updating input–output tables for years missing official input–output tables, was also developed. For each of the resources and the emissions, two time series were generated based on two different revisions of Swedish national accounts data, one for the period 1993–2003, the other for the period 2000–2005. The analysis uses a recently revised time series of environmental data from the Swedish environmental accounts, as well as recently published global environmental data from the IEA and from the EDGAR emissions database (all data from 2010 or later). An index decomposition analysis was also performed to detect the various components of the time series. For fossil fuels consumption-based data don't differ much from production-based data in total. For the greenhouse gases there is a clear increase (CO_2eq emissions increase approximately 20 % from 1993–2005, mainly driven by an increase in CH_4 emissions), resulting from increased emissions abroad due to the increased demand for imported products. This suggests Sweden has not decoupled economic growth from increasing greenhouse gas emissions – contrary to what the slightly decreasing official production-based UNFCCC data say. For the precursor gases (SO_2, NO_x, CO and NMVOC), emissions are generally decreasing, with the exception of SO_2 and NO_x which increase in the second time series. For all emissions studied, consumption-based data lie at much higher levels than the official production-based UNFCCC data. However, further research is needed regarding the resolution of the data of the energy use and the emissions generated abroad by the Swedish domestic final demand. Also, extension of the time series and of the environmental parameters to such things as material use is needed to find out with more certainty to what extent Swedish growth has been sustainable or not.

Keywords: Input–output analysis, emissions embodied in trade, environmental Kuznets curve, index decomposition analysis, green growth, IPAT equation, carbon footprint, consumption-based accounting, fossil fuels, greenhouse gases, atmospheric pollution, Sweden.

Global Energy Systems, Department of Physics and Astronomy,
Uppsala University, Box 516, SE-751 20 Uppsala, Sweden

ISSN 1401-5765

Referat

Grön tillväxt? Svensk miljöpåverkan ur ett konsumtionsperspektiv med tillämpning av input–output-analys

Mårten Berglund

I den här studien har konsumtionsbaserade tidsserier på svensk fossilbränsleanvändning och på svenska utsläpp av luftföroreningar tagits fram i avsikt att jämföra dessa med de officiella produktionsbaserade tidsserierna. Syftet har varit att avgöra om det svenska samhällets påverkan på resurser och miljö ur ett konsumtionsperspektiv har minskat eller ökat över tiden, och framförallt om en frikoppling har skett mellan den svenska ekonomiska tillväxten och den påverkan Sverige har på miljön i Sverige och utomlands. Tre fossila bränslen (olja, kol, gas samt aggregatet fossila bränslen) och sju luftföroreningar (CO_2, CH_4, N_2O, SO_2, NO_x, CO och NMVOC samt aggregatet CO_2-ekvivalenter) har analyserats. En enkelregional input–output-modell har tagits fram, utökad med globala medelintensiteter för den produktion som sker utanför Sverige. En ny metod har också utvecklats för att generera input–output-tabeller för år där officiella sådana tabeller saknas. För samtliga energiresurser och luftföroreningar, upprättades två stycken tidsserier, baserat på två olika revisioner av ekonomiska data från nationalräkenskaperna. Den första tidsserien täcker åren 1993–2003, och den andra åren 2000–2005. Miljödata togs från nyligen reviderade tidsserier från de svenska miljöräkenskaperna samt från IEA och den internationella luftföroreningsdatabasen EDGAR (alla data reviderade 2010 eller senare). En komponentanalys utfördes också, för att identifiera olika bidragande komponenter i tidsserierna. Vad gäller fossila bränslen i sin helhet, uppstår ingen markant skillnad mellan konsumtionsbaserade och produktionsbaserade data. Vad gäller växthusgaserna kan en klar ökning urskiljas (20 procents ökning av CO_2-ekvivalenter mellan 1993–2005; CH_4-utsläppen har där bidragit mest), vilket beror på stigande utsläpp utomlands orsakade av ökad efterfrågan på importerade produkter. Detta antyder att den svenska tillväxten ännu inte frikopplats från ökade utsläpp av växthusgaser, vilket står i motsats till den minskning i utsläpp som de officiella produktionsbaserade siffrorna från UNFCCC-rapporteringen redovisar. För övriga luftföroreningar (SO_2, NO_x, CO och NMVOC), sker i allmänhet en minskning, förutom för SO_2 och NO_x som ökar i den andra tidsserien. Samtliga luftföroreningar ligger vidare på en betydligt högre nivå jämfört med UNFCCC-rapporteringen. Mer detaljerade studier behövs dock på den energiförbrukning och de utsläpp som svensk slutlig användning för med sig utomlands. Tidsserierna behöver också förlängas och fler miljövariabler som t.ex. materialanvändningen behöver studeras för att kunna dra säkrare slutsatser kring i vilken utsträckning som den svenska tillväxten har varit hållbar eller ej.

Nyckelord: Input–output-analys, inbäddade utsläpp, miljö-Kuznetskurvan, komponentanalys, grön tillväxt, IPAT, kolavtryck, konsumtionsbaserad bokföring, fossila bränslen, växthusgaser, luftföroreningar, Sverige.

Globala energisystem, Institutionen för fysik och astronomi, Uppsala universitet, Box 516, 751 20 Uppsala

ISSN 1401-5765

Preface

This study is the result of a degree project within the Aquatic and Environmental Engineering Programme at Uppsala University. It has been performed at the Global Energy Systems group at the Department of Physics and Astronomy. Supervisor has been Kristofer Jakobsson, and reviewer has been professor Kjell Aleklett, both at the Global Energy Systems group.

At first I'd like to thank my professor Kjell Aleklett who approved my proposal for doing a study in the field of economic growth versus the environment within his group. The next thanks goes of course to my supervisor Kristofer Jakobsson, who just happened to possess a vast number of books in the subject of input–output analysis which again happened to be the main method used in this field – thanks for all interesting discussions and for your support, patience and all encouraging words during the project. I'd also like to thank Mikael Höök in the group for interesting discussions and help.

People outside the group who need special mention, are Anders Wadeskog, Ann-Marie Bråthén and Ida Björk at the environmental accounts and national accounts units of Statistics Sweden, who helped me a lot with the details of the input–output tables. Glen Peters at CICERO in Oslo gave me good introducing articles in the field of environmental input–output analysis and Pontus von Brömssen at Skandia Liv was helpful in checking some of the maths. I'd also like to direct a special thanks to the librarians at the university library, who purchased books and databases I've asked for, and for being generally helpful.

Finally, I'd like to thank my family and all friends who have been supporting me with encouraging talks and interesting discussions without which all my thoughts about this subject wouldn't have been much.

Mårten Berglund

Uppsala, June 2011

UPTEC W11 021, ISSN 1401-5765

Printed at the Department of Earth Sciences, Geotryckeriet, Uppsala university, Uppsala, 2011.

Populärvetenskaplig sammanfattning

I den här rapporten behandlas frågan om det är möjligt att leva i ett samhälle med ständig ekonomisk tillväxt[1] utan att samtidigt tära på naturresurser och miljö på ett ohållbart sätt. Många menar att det är dagens konsumtionssamhälle som är grundorsaken till våra miljöproblem, och att vi är tvungna att slå in på en annan väg om vi ska kunna rädda vår planet från utarmade resurser och ökade temperaturer.

En del menar å andra sidan att det är den ekonomiska tillväxten som gör att vi har råd att göra något åt miljöproblemen, och som skapar möjlighet att utveckla nya energitekniker och renare industrier. En del statistik över länders ekonomiska utveckling och deras miljötillstånd, visar till och med hur miljöproblemen i ett land visserligen till att börja med förvärras med stigande BNP, men efter en viss nivå tenderar dessa miljöproblem att avta ju högre landets BNP blir. Detta samband, som kan beskrivas med en kurva som tar formen av ett uppochnedvänt U, brukar kallas för miljö-Kuznetskurvan.

Detta resonemang går dock att problematisera ytterligare. Uppstår denna miljö-Kuznetskurva även när man tar hänsyn till den miljöpåverkan som ett land orsakar utomlands genom sin import? Kanske är det så att vår miljö på hemmaplan har kunnat bli bättre tack vare att vi har flyttat ut tung och smutsig industri till andra länder som nu producerar de produkter vi efterfrågar. När det gäller frågan om huruvida vår ekonomiska tillväxt och vår konsumtion är hållbar eller ej, så kan det inte vara rimligt att bara titta på den miljöpåverkan som uppkommer i Sverige, utan vi måste förstås ta reda på vilka konsekvenser denna konsumtion får på miljön i både Sverige och utomlands.

I den här rapporten är det just den svenska konsumtionens påverkan på miljön i både Sverige och utomlands som har analyserats. Ett centralt tema för rapporten är att de direkta miljöeffekterna som uppkommer av att ett företag tillverkar en produkt, inte är det enda intressanta. För att tillverka något så behöver ju ett företag köpa in andra produkter som har tillverkats någon annanstans (eventuellt utomlands till och med), och dessa produkter har i sin tur sina beståndsdelar som tillverkats någon annanstans, och så vidare. Och i varje sådant steg uppkommer miljöpåverkan. Att analysera denna tillverkningskedja är själva poängen med den metod som kallas för input–output-analys och som har använts för att ta fram resultaten i denna rapport.

Input–output-analysen är från början en ekonomisk metod, men när den tillämpas inom miljöområdet, så är den nära besläktad med livscykelanalysen. Skillnaden är att när livscykelanalysen tittar i detalj på den miljöpåverkan en viss specifik produkt orsakar genom hela sin livscykel, så tittar input–output-analysen på miljöpåverkan från en hel bransch, eller ett helt land.

---

[1] Med ekonomisk tillväxt i ett land, menar vi ökningen av det landets BNP, bruttonationalprodukten.

På sätt och vis kan därför denna rapport ses som en livscykelanalys över hela det svenska samhället. Det är dock inte bara *en* livscykelanalys, utan för att kunna se utvecklingen över tid för de miljöeffekter som denna rapport tar upp, så har upprepade sådana här livscykelanalyser utförts för varje år mellan 1993 till 2005. De miljöeffekter som studerats är användningen av fossila bränslen (olja, kol och gas), samt utsläppen av växthusgaser (koldioxid, metan och lustgas) och av svaveldioxid, kväveoxider, kolmonoxid och gruppen av föroreningar med så kallade flyktiga organiska ämnen (exklusive metan).

När man försöker ta reda på t.ex. vilka utsläpp som sker i Sverige eller utomlands i de olika stegen i den här tillverkningskedjan som nämndes tidigare, så är det – om man ska göra en analys över ett helt land – i stort sett omöjligt att samla in exakta uppgifter från alla företag om deras utsläpp. Istället baserar man beräkningarna på det ekonomiska värdet för de produkter som företagen producerar, samt de totala utsläppen för varje bransch. På så sätt får man fram en så kallad utsläppsintensitet, som beskriver ett för en viss bransch genomsnittligt värde på hur stora utsläppen är per krona producerad vara. Utsläppsintensiteten är så att säga kopplingen mellan de ekonomiska värdena i kronor, och de fysiska värdena i form av t.ex. kilo koldioxid. För att uppskatta de utsläpp som vår import orsakar utomlands, används också dessa utsläppsintensiteter, fast justerat mot ett världsgenomsnitt på grund av att Sverige har en mycket renare och mindre utsläppsintensiv industri än vad som är det normala i de länder som vår import tillverkas i.

De mest intressanta resultaten i rapporten visar att gruppen av växthusgaser (koldioxid, lustgas och metan) har tillsammans ur ett konsumtionsperspektiv ökat med ca 20 procent mellan 1993 och 2005. Framförallt är det metanet som bidragit till denna ökning. Detta skiljer sig från de officiella siffror som Sverige rapporterar till FN:s klimatkonvention, där istället en liten minskning har skett under samma period. Ökningen hänger direkt ihop med vår ökande konsumtion, i synnerhet eftersom ökad konsumtion också innebär ökad import och därmed ökade utsläpp utomlands.

För samtliga luftföroreningar som ingick i studien gäller vidare att de ligger på en mycket högre nivå under hela perioden jämfört med de officiella siffrorna. Vissa resultat i studien är dock mer positiva, t.ex. har utsläppen av kolmonoxid under perioden minskat.

Slutsatsen som kan dras är att för Sveriges del så har den ekonomiska tillväxten än så länge inte kunnat förenas med minskande utsläpp från vår konsumtion, åtminstone inte i fallet med växthusgaser. Fler och noggrannare undersökningar behöver dock göras för att få fram säkrare samband mellan tillväxt och miljöpåverkan, t.ex. genom att även titta på andra miljöproblem som råvaruanvändningen och genereringen av avfall.

Contents

List of Figures

List of Tables

Chapter 1

Introduction

The consumption society and the economic system of today's world with its urge for continuous economic growth, has among many environmentalists and concerned citizens been pointed out as being the root cause to all environmental problems.

This is however not a trivial and undisputed fact since – as many economists has argued – when looking at various countries in the world, the richer the country, the less environmental problems the country has, at least to some extent. This relation is described by the so called environmental Kuznets curve: as a country develops it goes through a stage of deteriorating environment, which, after a sufficient level of development, starts to level off and eventually the environment in the country starts to improve.

However, such conclusions are based on measuring the environmental load only in that particular country. Going one step further, it is therefore reasonable to analyse that particular country's environmental pressure on the world as a whole, and find out if that load is increasing or decreasing with increasing prosperity. Only then could we more accurately determine if the consumption society of today – and in particular the economic growth – is associated with the environmental problems or not.

This study is an attempt to contribute to that project, by analysing the environmental pressure Sweden and its citizens impose on the world, and how that pressure is developing with time and economic level.

The most widely used method to examine the environmental effects of the consumption for a whole country, is environmental input–output analysis.[1] Input–output analysis is a powerful method used in economics to analyse the production needed upstream throughout the whole supply chain, to satisfy the consumption of some product or, collectively, some set of products. The environmental input–output analysis extends this to cover all the environmental pressure, e.g. emissions, occurring upstream throughout the whole supply chain, caused by some kind of consumption – including the emissions occurring abroad. It can be considered to be a sort of life cycle assessment, applicable to whole industries or whole countries.

---

[1] See Chapter 3.3 for studies.

This study can in that sense be regarded as a time series of life cycle assessments of Sweden as a whole country.[2]

1.1 Objective of the study

The primary objective of the study is to evaluate whether the environmental pressure that the Swedish consumption causes is increasing or decreasing with time and economic level. A secondary objective, motivated by climate change negotiations, is to examine the official figures of environmental pressure such as CO_2 that are allocated to Sweden compared to the environmental pressure Swedish consumption causes. Another secondary objective is to estimate the environmental pressure caused by consumption of different kinds of products, in order to see which type of consumption should be encouraged or discouraged.

1.2 Method, data and delimitations

To determine the environmental pressure caused upstream by Swedish consumption, an environmental input–output model of the Swedish economy is developed. The model developed is a single-regional input–output model, augmented with world average energy and emission intensities for the production occurring abroad. This means that the model, in theory, includes all emissions from the whole supply chain from the whole world, but with some assumptions, the most important being that the production structure for the world is approximated by the Swedish production structure, and that all emissions abroad have the same intensities, no matter where abroad they are produced.[3] When speaking about Swedish consumption here, we mean, in economic terminology, final demand less exports, i.e. public and private consumption, and investments, but not exports (however, investments in the exports industry have not been excluded).

The environmental pressure caused downstream after consumption, i.e. the pressure caused by use and disposal, is also part of the study.

Economic data come from the Swedish national accounts in two revisions, one for the period 1993–2003, the other for the period 2000–2005. Environmental data come from a newly revised time series from the Swedish environmental accounts covering 1993–2005; all environmental variables in the environmental accounts that refer to fossil fuels are used; all environmental variables in the environmental accounts that have its correspondence in the official UNFCCC emissions data have been used. Environmental data for the world are taken from recently published figures from the IEA, and from the international EDGAR emissions database, both

---

[2] This analogy is used by e.g. Hendrickson et al., 2006.

[3] World average intensities for the rest of the world could be accused for being quite a strong assumption, but in Chapter 4.3.3 it will be concluded that it is reasonable.

covering the period 1993–2005. World economic data to calculate world average intensities, come from the World Bank.

The environmental variables are the following:

- Fossil fuels: Oil, coal and gas use, and the aggregate fossil fuel use. Note that this is fossil fuel use, and not supply, i.e. transformation losses are not included.
- Emissions: CO_2, CH_4, N_2O, SO_2, NO_x, CO and NMVOC, and the aggregate CO_2 equivalents.

Environmental variables are plotted against time and against economic level. Economic level is final demand less exports per capita.

The purpose with the broad selection of environmental variables has been to give an overview only of the consumption-based development of these variables, encouraging more in-depth analysis of specific variables for future studies. Environmental variables not part of the study are for instance use of minerals, water use, overfishing, total oil consumption (only oil used for fuel is counted in this study, e.g. oil in plastics industry is not included), total energy consumption (including consumption of electricity), emissions of phosphorus and nitrogen to aquatic systems, emissions of persistent organic pollutants, and waste flows. Also, changes in emissions due to natural sinks like land use change and forestry, are not included. Environmental pressure, like emissions caused by the treatment of waste exported to other countries, is not included either. Another issue not included is the development of the Swedish ecological footprint, which would be a relevant issue to analyse in future research. See Chapter 6.4 for an overview of aspects not part of this study but which are suggested for further research.

1.3 Outline of the report

After this introduction, a background follows in Chapter 2 that dwells more deeply into the rationale and context of the study, analysing in more detail the debate about economic growth and environmental degradation. Chapter 3, gives the theoretical foundation of the environmental input–output analysis, as well as its foundation in the system of national accounts, and the environmental accounts. Chapter 4 describes in detail the method used in this study and Chapter 5 presents the results. In Chapter 6 the results and conclusions drawn from them are discussed, and an overview of the various outcomes of the whole study is presented; this chapter also concludes with suggestions for further research.

1.4 Supporting information and technical details

Homepage of the report: Supporting information, i.e. the whole Excel database with all calculations and results, can be found on the following web page: `http://www.fysast.uu.se/ges/en/marten-berglund`.

Email of the author: The author of the report can be contacted through e-mail at marten.berglund@physics.uu.se.

Browsing the report: It is possible to browse the PDF version of the report as a hypertext. Headings in the table of contents, literature references in footnotes and chapter references etc. are all clickable links. After clicking, to return to where you were, push Alt + left arrow. To go forwards again, push Alt + right arrow. The same applies to the blue links in the contents sheets of the Excel database. Many of the references in the reference list also have links attached which by clicking leads directly to the referred text on the Web (some texts may require subscription though).

Software: The report is written in LaTeX with the help of the LyX editor. Figures are drawn in Inkscape, and diagrams are made in MATLAB. The database is built in Microsoft Office Excel.

Chapter 2

Background

2.1 Analysing environmental problems

2.1.1 Ultimate versus proximate environmental problems

This master thesis has its origin in the quest for the ultimate environmental problem, and its corresponding solution. Talking about the ultimate environmental problem in this context, doesn't mean to assess which of the global environmental problems – whether it is climate change, oil depletion, water scarcity or overfishing, to name but a few – that is the most important environmental problem, but to find the ultimate causes behind these problems.[1] It is a question about to realize where the true problem causing all other environmental problems really lies, which, if solved, has the most power to solve all the actual environmental problems mankind faces.

This suggests that environmental problems exists at various levels. Suppose we have a sea with dead fish. Some would say the high concentration of aluminum ions in the sea is the environmental problem, others would say it is the sulfur deposition onto the sea that is the environmental problem, still others would say it is the industries and the transports producing the sulfur dioxide that is the environmental problem. All are in a sense right. The former are pointing to proximate environmental problems, the latter to ultimate environmental problems. Proximate problems have their corresponding proximate solutions (lake liming), ultimate problems their ultimate solutions (flue gas treatment, regulations). In this way environmental problems and their solutions can be organized into an ultimate–proximate spectrum.[2]

---

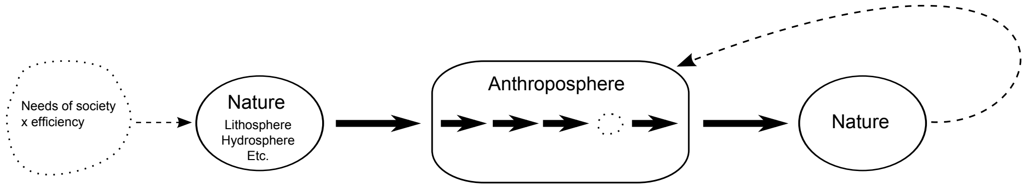
[1] The terms ultimate and proximate are here used in a new way, corresponding to a similar usage in biology, sociology and philosophy. See e.g. Campbell, 1996, and Mayr, 1961.

[2] See Meadows, 1999, for an excellent account of how to deal with environmental problems in a similar way, finding the solutions that has the most power to impose change. Daly and Farley, 2004, uses a similar approach, using an ends-means spectrum.

The ultimate–proximate spectrum of environmental problems should in this context be interpreted as a cause–effect chain. Environmental problems on lower levels have their causes on higher levels, and trying to solve an environmental problem through taking care of the direct proximate causes of the problem on a lower level, often mean to engage in suboptimization, leading to the problem disappearing in one place or appearance, popping up in an other place or appearance. This would be the case when there are other more ultimate causes, which will continue to create new environmental problems if not these ultimate causes are addressed. Thus, taking care of the proximate causes are often in vain – instead, solving environmental problems must be done upstream in the cause–effect chain.[3]

Looking into Figure 2.1 gives an illustration with examples from the area of climate change.[4] Going to the left in the figure, the ultimate causes of the environmental problem and its corresponding ultimate solutions are shown. Going to the right, the proximate causes of the environmental problem and its corresponding proximate solutions are shown. For instance, when the effects of climate change are inevitable, geoengineering or finally adaptation might be the only remaining measures available. More preferably would be to limit the withdrawal of fossil fuels, or ultimately, to reform the world economy, in order to prevent the effects of climate change to arise in the first place.

Even though the needs of society should be interpreted as an ultimate cause leftmost in the figure, they are at the same time a part of the society, shown as the dotted round figure inside the anthroposphere box. The needs of society[5] are there the main factor pulling products from the supply chain upstream, shown by the three arrows to the left inside the anthroposphere box.[6] The rightmost arrow in the anthroposphere box, denotes downstream effects after consumption, i.e. usage



Environmental problem:	Economic growth?	Resource depletion	Emissions, waste	Contamination	Impact on society
Examples:	The world economy	Peak oil	Burning of fossil fuels	CO_2eq > 450 ppm	Risen sea levels
Solution:	Green GDP? Performance economy? Steady-state economics?	Limit withdrawal Use recycled materials	Treatment, recycling	Geoengineering	Adaptation

Figure 2.1. Cause–effect chain of environmental problems.

---

[3] Robèrt, 2000, talks about upstream thinking in cause–effect chains.

[4] Though not exactly the same, Graedel and Allenby, 2010, use a similar approach for environmental problems in general.

[5] In economic terms this corresponds to the so called final demand, i.e. consumption in a general meaning.

[6] Though the final demand is the driving factor in this model, it should not be concluded that the consumers are the sole responsible. As e.g. Sanne, 2007, argues, the industry is in a great deal responsible for pushing consumers to buy their products. But yet, this is again ultimately driven by the eager to grow economically.

and disposal. All arrows denote a cause–effect relation, thick solid arrows denote a material flow as well.

Accordingly, many researchers have suggested that the current economic system with its demand for continuous economic growth may be the ultimate cause to all other environmental problems.[7] Meadows goes even further upstream in the cause–effect chain talking about the current paradigm of thinking, and to reconsider what really matters in our lives.[8]

This leads us to the core of this study, which goes no further than to the level of the economic system. Its aim is to contribute to that project which tries to determine whether the economic system is the ultimate (so far) environmental problem or not. If it is concluded that the economic system is the ultimate environmental problem, other studies need to develop ultimate solutions to that problem. If, on the other hand, it is concluded that the economic system is not the ultimate environmental problem, we need to study other parts of the cause–effect chain.[9] This is important, since we must first try to obtain an accurate description of what is really the problem, before trying to find solutions.[10]

2.1.2 The consumption versus the production perspective

When we talk about the needs of society and the effects these needs cause, it is important that we take into consideration not only the direct effects these needs cause when producing the products needed, or the effects caused in just one particular country (like the effects on the Swedish territory), but also all the *upstream* effects caused throughout the supply chain.[11]

This can be understood by looking at Figure 2.2, which as an example shows the emissions of CO_2. The needs of society, e.g. the needs of the Swedish consumers (i.e. exclusive consumption abroad through exports) are there represented by the final consumption. The final consumption should be interpreted as a vector of various product groups consumed by ordinary people – an element in that vector could for instance be cars purchased and used for private purposes and not for use in the industry.

When a product is consumed at the final consumption stage, it has to be produced in the stage just before that, leading to emissions in that stage. But for that

---

[7] Meadows et al., 1972, Jackson, 2009, and Rockström and Wijkman, 2011, to name but a few. In works of Hornborg, theories from thermodynamics are used to argue for the society–biosphere system being a zero-sum game, and that technological development is in vain; see e.g. Hornborg, 1992, and Hornborg, 2010.

[8] Meadows, 1999.

[9] For instance Radetzki, 2010, Goklany, 2007, and Beckerman, 1992, propose that economic growth is an essential contributor to the solution of environmental problems.

[10] This, and some of the reasoning in the preceding paragraphs, is also discussed in Ariansen, 1993.

[11] E.g. Spangenberg and Lorek, 2002.

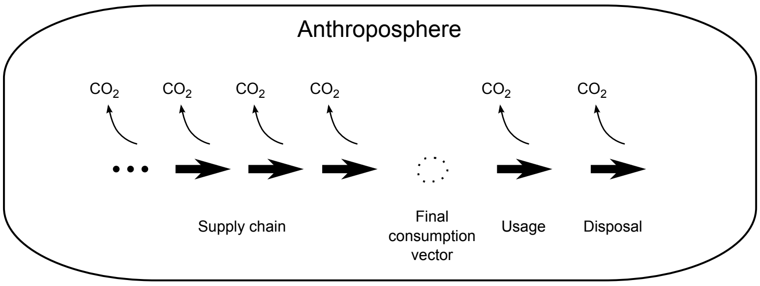


Figure 2.2. Environmental impact upstream and downstream the final consumption.

product to be produced, the producer needs to consume other products (through so called intermediate consumption, in contrast to final consumption) from the production stage just before that. And the products in that stage need in turn other products from the stage before that, and so on, all the way through the whole supply chain (the three dots leftmost in the figure indicates that this supply chain can be infinitely long). The total emissions occurring throughout the whole supply chain correspond to the emissions in the *consumption perspective*.[12] Calculating all the emissions occurring in the whole supply chain is done with the help of *input–output analysis*, which is the main method employed in this study.

For clarity in Figure 2.2, arrows indicating imports have not been drawn but should be considered implicit. That means that all arrows in the supply chain includes imports, and thus imports are included in the consumption perspective.

In Figure 2.2, the *downstream* effects are also shown. That is the effects occurring after the final consumption stage, i.e. effects during usage and disposal.[13] In life cycle assessments, upstream effects correspond to the production phase and downstream effects to the use and disposal phase, though in such studies only a specific product is analysed, and just a few steps of the supply chain are included. In this study all upstream and downstream effects are included for all products consumed by Swedish consumers.

In Figure 2.2, it is also possible to see the emissions occurring from a *production perspective*, i.e. emissions occurring in all phases shown in the figure, but only on the domestic territory, and no matter if domestic consumers or consumers abroad (exports) caused the emissions. Looking into the reporting done in Sweden, most statistics and analyses use a production perspective. That is for instance the case when it comes to the sixteen environmental quality objectives, which the Swedish parliament has agreed upon.[14]

In this study we will focus on the consumption perspective, including downstream effects, in order to determine all environmental impact caused by Swedish citizens.

---

[12] See e.g. Peters and Solli, 2010, Davis and Caldeira, 2010, Swedish EPA, 2010a, Wiedmann, 2009, Peters, 2008, Peters and Hertwich, 2008, and Rothman, 1998.

[13] OECD, 2001, uses downstream in this way.

[14] Though, in one of its latest report from the Environmental Objectives Council, the consumption perspective is briefly analysed for the first time – see Swedish EPA, 2010a. For further Swedish analyses using a consumption perspective, see Chapter 3.3.4.

2.1.3 The IPAT equation

As we have suggested above, it is the needs of the society – i.e. the consumption – that is to some extent the ultimate cause and the factor driving the environmental problems. Leftmost in Figure 2.1 this is expressed as the needs of society times the efficiency to fulfil these needs.

Let us examine this in more detail. To be more precise, the needs of the society could be said to be equal to the number of humans, times the need per human, times the efficiency by which the society fulfil these needs. This is exactly what the so called IPAT equation says,

$$I = P \times A \times T \tag{2.1}$$

which states that the environmental impact (I) equals the size of the population (P) times the affluence (A) of the population times a technology factor (T) denoting the efficiency by which that affluence is generated.[15]

Affluence is normally referring to GDP per capita or income per capita,[16] but we will according to what has been said before focus on the need per capita, expressed as the consumption per capita.[17] The technology factor, expressed as environmental impact per unit of GDP, e.g. CO_2 per GDP, will consequently be interpreted as CO_2 per unit of consumption. To refer to the technology factor as the efficiency factor is strictly speaking incorrect, since it rather measures the inefficiency. Further on we will refer to this factor as the intensity of the production or the consumption, i.e. how much resources needed or emissions emitted for the production or consumption of one unit.

Sometimes the intensity factor T, is further decomposed into an energy intensity factor T_e (joule per GDP) and a carbon intensity factor T_c (CO_2 per joule):[18]

$$I = P \times A \times T_e \times T_c \,, \tag{2.2}$$

or in the case of CO_2

$$CO_2 = Population \times GDP/cap \times J/GDP \times CO_2/J \,. \tag{2.3}$$

Thus, we now have a way to analyse various factors driving the environmental impact.

In Figure 2.3, an extended IPAT equation (corresponding to equation (2.2) and (2.3)) for the whole world is shown. There one can see that population growth and economic growth have been the driving factors, while the energy intensity of the

---

[15] The IPAT equation came up during an environmental debate in the beginning of the 1970s, see e.g. Ehrlich and Holdren, 1970 and 1971, and Commoner, 1972. For a critical analysis, see Dietz and Rosa, 1994.

[16] Income per capita, also expressed as GDI per capita, is approximately the same as GDP per capita – see Sandelin, 2005.

[17] This was also what Ehrlich and Holdren, 1970, used.

[18] This is then called the Kaya identity, see Davis and Caldeira, 2010.

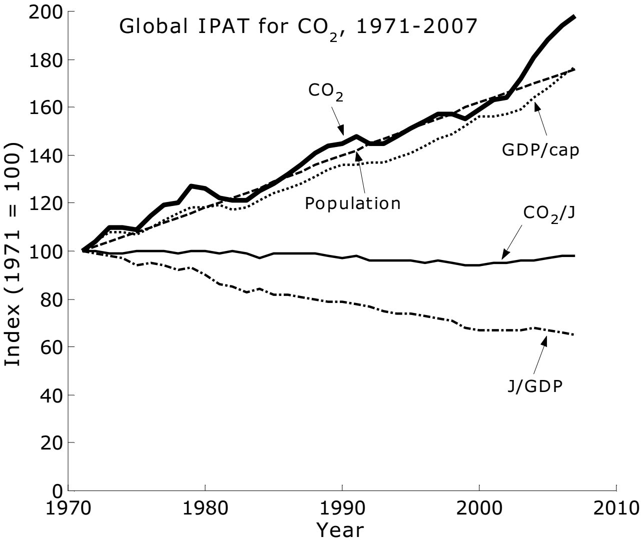


Figure 2.3. Global IPAT diagram for CO_2, extended with the energy intensity of the world economy. GDP are in constant 2000 US dollars. *Source*: Data from the World Bank, 2010.

world economy has had a restraining impact, though not even close to the degree population and economic growth have been increasing. Even though population growth is expected to decline and only grow an approximate 60 percentage points the coming 40 years,[19] if GDP/capita is growing linearly at the same rate as the latest 40 years (approximately 80 percentage points the coming 40 years), and if energy efficiency doesn't improve faster than it has done the latest 40 years, the prospects for decreasing CO_2 emissions in the near future look not so encouraging. However, the assumption that the variables in the IPAT equation are linear may not be realistic, and the future development may be much more uncertain.[20] But anyway, what is crucial here is if it possible to decrease the T factors at a faster rate than the P and A factors increase.

2.1.4 The rebound effect

Accordingly, looking at Figure 2.3 reveals that as the energy intensity of the world economy has declined, GDP/capita has increased still more, which consequently has lead to continued increasing CO_2 emissions. This may lead us to the conclusion that efficiency improvements always entail improved turnovers and thereby increased environmental pressure. This is the hypothesis behind the rebound effect – every efficiency improvement will lead to higher volumes, eating up some of the reduced resource demand that the efficiency improvements to begin with resulted in, or sometimes even has as a consequence that the total resources needed will in

---

[19] UN, 2011.

[20] E.g. Victor, 2008, points out that the factors in IPAT depend on each other, and that the impact is dependent also on the composition of the GDP.

fact increase.[21,22] Even though the rebound effect may not arise as a logical consequence of improved efficiency, awareness of its existence among policy makers and in industry is crucial if the absolute environmental pressure are to be decreased.[23]

The rebound effect can be direct or indirect.[24] Direct effects are increased consumption of a product, due to the decreased energy intensity of that product. Indirect effects happen when increased efficiency leads to lower prices and in turn more space for consuming other products.

An important limitation of many environmental systems analysis tools like the life cycle assessment methodology or environmental management systems,[25] is that they focus mainly on the environmental impact per unit of product, and tends to disregard the volume effect.[26] Similar conclusions are drawn in a couple of studies by Alfredsson[27] where the positive effect of "green consumption" is shown to be eaten up by the growth in income. Consequently, looking at the IPAT equation and considering the rebound effect, is utterly important when evaluating environmental performance.

2.1.5 The environmental Kuznets curve hypothesis

Now, let's turn our attention to the I and A factors in the IPAT equation. That is, let's look at how the environmental impact relates to the growth in the GDP per capita. It turns out that for many pollutants in the richer world, the relationship has an inverted u-shaped form: as the country develops the environmental degradation *in that country* increases until a certain point when the environmental degradation starts to decrease. This is the hypothesis of the environmental Kuznets curve (EKC).

The name origins from the economist Kuznets, who in the 1950s wrote a paper suggesting that as a country develops it goes through a stage of increasing income inequality which after a sufficient level of development is reached, turns to an increasing income equality.[28] In the environmental analogy to this Kuznets curve, environmental degradation is substituted for income inequality.

In Figure 2.4 a schematic diagram of an EKC is shown. The y axis normally refers to environmental degradation inside the particular country of study, and the x

---

[21] Also known as the Jevons paradox from the 19th century British economist William Stanley Jevons, or the Khazzoom-Brookes postulate See Herring and Sorrell, 2009. See Jevons, 1866, for the original work.

[22] Tsao et al., 2010, attracted much attention by asserting that when LED lamps become more prevailing in society, total energy demand probably will increase.

[23] See von Weizsäcker et al., 2009, and Herring and Sorrell, 2009, for suggestions of how to prevent the rebound effect.

[24] Swedish EPA, 2006, and Herring and Sorrell, 2009.

[25] See Finnveden and Moberg, 2005 for a good overview of environmental systems analysis tools. An attempt to organize various environmental systems analysis tools is also done in The Natural Step framework presented in Robèrt, 2000, and Robèrt et al., 2002.

[26] See Axelsson and Marcus, 2008, regarding environmental management systems.

[27] Alfredsson, 2002 and 2004.

[28] Kuznets, 1955.

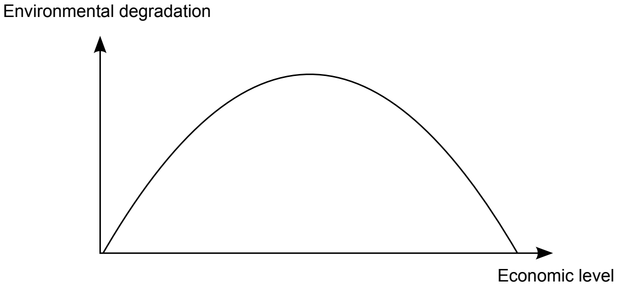


Figure 2.4. Schematic diagram of an environmental Kuznets curve.

axis to the GDP per capita or income per capita. However, in this study we will contrast this with the environmental degradation all over the world caused by the consumption in a particular country, plotted against consumption per capita (or more precisely, against domestic final demand per capita).

Statistical studies like the ones used for testing the hypothesis of the EKC, come in two different shapes: *cross-sectional studies* and *longitudinal studies*.[29] In the context of EKCs, cross-sectional studies, are most often cross-country studies, i.e. these studies plot these countries' environmental performance against these countries' GDP/capita. However, in some cross-sectional EKC studies, analysis is performed with consumption groups divided by level of income, in order to determine how the environmental impact varies with level of income.[30] Longitudinal studies on the other hand, analyse time series data of environmental performance for a given country or region; this is the kind of study that has been performed for this report.

The first studies of EKCs came in the beginning of the 1990s and analysed both various emissions and natural resource uses as functions of income per capita.[31] The results were that most emissions and resource uses actually declined with level of income per capita, except for waste generation and CO_2. Although mixed results have been dominating the EKC studies, the general picture is that local pollutants tend to follow an EKC pattern, while global environmental problems like CO_2 emissions tend to have an ever increasing trend with income per capita. The Swedish situation looks similar,[32] though in Sweden there is some support for CO_2 also declining, with a longitudinal study by Kander even showing a typical EKC pattern.[33] However, important to remember, these studies don't consider the environmental degradation caused abroad by the domestic consumption.

The mechanisms explaining the EKC pattern could be of three sorts.[34] Firstly, as an economy grows beyond a certain stage, the demand for more service oriented products begins to dominate. Secondly, wealthier countries can afford to

---

[29] Compare Andersson et al., 2007.

[30] E.g. Roca and Serrano, 2007.

[31] See Grossman and Krueger, 1991, and Shafik and Bandyopadhyay, 1992. For a comprehensive survey up to 1997, see Kågeson, 1997. For a recent literature survey, see Carson, 2010.

[32] See for instance Johansson and Kriström, 2007 for SO_2.

[33] Kander, 2002, and Kander and Lindmark, 2006.

[34] Adopted from Galeotti, 2003.

spend more money on cleaner technologies and more efficient ones. Thirdly, as the average income of the individuals in a country increases, they become more environmentally aware, and the country as a whole starts to introduce environmental legislation and environmental policies.

Another factor explaining the EKC pattern – which is also one of the main critiques that has been delivered – is the possibility that environmental performance has been improved due to the fact that products from more heavy and dirty industries are being imported from abroad.[35] In the literature, this is sometimes covered under the term the pollution haven hypothesis or carbon leakage.[36] Weber and Peters conclude that although there is little support for industries moving to countries with less strict environmental legislation, due to stricter environmental policies at home, several studies suggest parts of the increasing consumption is met by production abroad, consequently leading to higher emissions generated abroad.[37]

This takes us back to what was concluded in Chapter 2.1.2 regarding the consumption versus the production perspective. If the purpose is to determine if our economy has been able to grow without any negative consequences on the environment, we must take into account all the environmental impact caused by the economy, or caused by the consumption of our economy, within and outside our borders. Accordingly, diagrams showing the relationship between environmental impact and GDP or consumption, must show the consumption-based environmental impact for being meaningful.[38] Thus, in this study, the purpose is to generate consumption-based such diagrams.

2.1.6 Green growth and decoupling

In this context, the concept of green growth and decoupling is fundamental, that is when the growth in GDP or income is decoupled from the growth in natural resource use or the growth in emissions.[39] Decoupling could be relative or absolute.[40] Relative decoupling means that the emission intensity of an economy is not anymore rising with rising income. For the world economy this has already happened with the energy intensity, as was shown in Figure 2.3. Though this measure could be interesting in some types of analyses,[41] as, again, Figure 2.3 showed, the overall emissions were still on the rise. Therefore, absolute decoupling is in this

---

[35] See for instance Arrow et al., 1995, Stern et al., 1996, and Rothman, 1998.

[36] See Fullerton, 2006, and Weber and Peters, 2009. Carbon leakage is the carbon leaking from e.g. Annex B countries to non-Annex B countries, due to undertakings the country has signed under the Kyoto protocol.

[37] This is sometimes referred to as "weak carbon leakage" or demand-driven displacement, in contrast to "strong carbon leakage" or policy-induced displacement. See Peters and Solli, 2010, and Weber and Peters, 2009.

[38] This was the main conclusion in Rothman, 1998, and also commented in the EKC survey by Carson, 2010.

[39] Victor, 2010, The Natural Edge Project, 2008, Azar et al., 2002, and OECD, 2002.

[40] OECD, 2002.

[41] E.g. Kander, 2002, focuses on relative measures.

context a more relevant measure, i.e. a situation when the economy grows at the same time as the emissions are constant or decreasing.[42]

However, absolute decoupling is not good enough. Obviously, if CO_2 emissions continue to be high, while neither increasing or decreasing, this is not enough as we need to lower our CO_2 emissions. This reasoning can go even further, saying that not even when the emissions are decreasing it is good enough, because we are still increasing the accumulated levels of CO_2 in the atmosphere as long as the emissions are higher than the natural sustainable uptake in the biosphere, even though we're then on the right track. Not before the emissions actually are negative, we're coming somewhere.

2.2 Stocks and flows in economic-ecological systems

2.2.1 The mass balance of the society

When we have been talking about environmental degradation in the preceding sections, we have been a little bit unclear of what exactly we are referring to. Do we refer to the level of how much the environment in total have been degraded, i.e. the level of remaining resources in a resource pool and the level of accumulated pollutants in the biosphere, in other words, the stocks? Or do we refer to the ongoing process of environmental degradation, i.e. the flows of extracted resources and the flows of emitted pollutants?[43]

It is important to distinguish between these two – the stocks and the flows – as was shown in the section above about decoupling: it is not good enough to reach a constant level of CO_2 flow into the atmosphere, since integrating this flow over time, yields an increasing stock of carbon content in the atmosphere. A similar reasoning is essential in the debate on oil depletion and peak oil: peak oil is not about the oil resources running out, but about how and when the flow of oil from these resources will reach its maximum.[44]

Consequently, analysing only the flows gives us an incomplete picture. However, measuring the level of the stocks could have its complications, since e.g. lagging mechanisms in natural systems like buffering, will make it hard to see the true levels. Therefore, most EKC studies analyse flows, but there are exceptions, as one of the first EKC studies also analysed the total accumulated deforestation.[45] In our study, only the flows are studied.[46]

---

[42] This is also emphasized in Azar et al., 2002.

[43] This conceptual model is described in many places, like Graedel and Allenby, 2010, and Daly and Farley, 2004. In Kågeson, 1997, these concepts can be considered included in the pressure–state–response model presented there.

[44] Aleklett and Campbell, 2003.

[45] Shafik and Bandyopadhyay, 1992.

[46] The distinction between stocks and flows in EKC studies is also made in Carson, 2010.

To get a more comprehensive picture of the stocks and flows between the society – the anthroposphere – and the nature, we will elaborate Figure 2.1 a bit, focusing on the anthroposphere box and its closest interactions – see Figure 2.5.[47] In this figure, the levels of the resource stocks, like oil and fossil water, are shown to the left. These resource stocks decrease as they flow into the anthroposphere. If not accumulated in the anthroposphere, they transform and flow out of the anthroposphere as emissions or waste, eventually increasing the levels of various stocks in nature to the right in the figure, like the carbon stock in the atmosphere.

The mass balance of the society in the figure can be expressed as

$$R = \frac{dA}{dt} + E \ , \tag{2.4}$$

where R means the resource use inflow, $\frac{dA}{dt}$ the rate of change of mass in the anthroposphere, and E is the outflow of emissions.[48] Accordingly, as can be noted by Figure 2.5 and equation (2.4), environmental problems can be divided into two groups, depending on if they belong to the inflow side, or the outflow side.

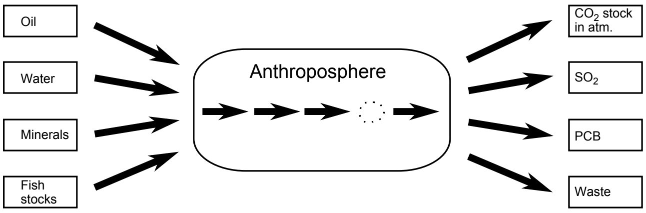


Figure 2.5. Simplified model of the societal mass balance.

2.2.2 The production–consumption "mass balance"

Stocks and flows are also fundamental in economics,[49] and a "mass balance" of the economy can be expressed in a similar way, which fits into the overall mass balance shown in Figure 2.5. We're now referring to a balance between production and consumption, or to be more precise, between the value of the supply of products, and the value of the use of products.

Looking into Figure 2.5, and recalling the interpretation of the arrows inside the anthroposphere box, the three arrows to the left in that box represent the production side, and the small dotted circle the consumption side (the rightmost arrow is disregarded for the moment). If the production side is to include production from abroad as well, i.e. the imports, and the consumption side is to include the

---

[47] A model like this one is one of the main components in the field of industrial ecology, where the "metabolism" of the society is studied. See e.g. Graedel and Allenby, 2010. A similar figure is also presented in Statistics Sweden, 2002a.

[48] See Graedel and Allenby, 2010, for a similar version. This is ultimately based on the law of conservation of mass.

[49] UN et al., 1993.

investments made, and the foreign consumption abroad of domestic products, i.e. the exports, the following supply–use balance can be put forward:[50]

$$GDP + Imports = Consumption + Gross\ investments + Exports\ . \tag{2.5}$$

The production–consumption "mass balance" equation corresponding to equation (2.4) then becomes

$$GDP + I = \frac{dS}{dt} + D + C + E\ , \tag{2.6}$$

where GDP here should be interpreted as the production flow, I is the flow of imports, $\frac{dS}{dt}$ is net investments, i.e. the rate of net change in the capital stock, D is the depreciation flow, i.e. the decrease in the existing capital stock, C is the consumption flow, and E is the flow of exports.

This balance can now be concluded in a similar figure like Figure 2.5 – see Figure 2.6. Note though, that here, in the use of supplies going to gross investments, it is only the depreciation part that is an outflow – the rest (net investments) is accumulated in the capital stock. This is depicted in the figure by the small arrows inside the capital stock box, showing that gross investments can be divided into a depreciation part and a net investments part. I.e. an initial decrease in the capital stock through depreciation, will possibly turn into a net increase in the capital stock when the gross investments been added.

Even though this is a balance of values, and not of masses, its resemblance to the societal mass balance will be of interest in this study. Further on, value flows and stocks are often the only proxies available for determining the mass flows and stocks, since data on economic values are much more readily available. To convert values to masses, *intensities* are the fundamental tool applied, e.g. CO_2 emitted per dollar's worth of produced products.

It is important to note in Figure 2.6, that GDP is a flow, and is not equal to the wealth of the society, here corresponding to the capital stock. Increasing GDP, i.e. economic growth, doesn't mean to increase the wealth of the society. In fact,

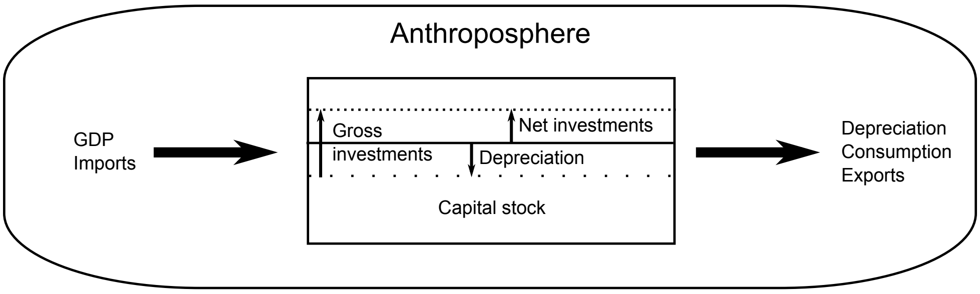


Figure 2.6. Balance of supply and use – the production–consumption "mass balance".

---

[50] See e.g. Eklund, 2004. Statistics Sweden calls this the balance of resources, a term not used in the international terminology though – Statistics Sweden, 2011a.

it could very well involve the decreased value of the wealth through depreciation (value destroyed), since GDP includes gross investments, which in turn include depreciation. Furthermore, the wealth of the society is not only the economic capital stock depicted in Figure 2.6, but also the natural capital stock resources, as depicted in Figure 2.5. In this sense, a sustainable society is a society where these boxes in Figure 2.5 and 2.6 are not decreasing. The concept of a green GDP comprehends these aspects, and will be discussed further on in this report.

2.3 Problems–solutions: concluding remarks

2.3.1 Economic growth: Problem, solution or neither

We began this chapter by discussing ultimate and proximate environmental problems, asking ourselves if economic growth and the growth in consumption is an ultimate cause to most other environmental problems. This study belongs to that grand project which tries to find answers to that central question. When the results of that project begin to crystallize, other projects follow concentrating on the solutions to the problems the former project has pointed out. In that sense, this study belongs to the problem formulation side of the environmental problems–solutions dichotomy.

Here it is of interest to structure the various possible outcomes of this research a little bit. What we have seems to be three possibilities:

1. Economic growth causes the environmental problems. Stopping economic growth is the solution.
2. Economic growth doesn't cause the environmental problems. However, economic growth does neither solve the environmental problems.
3. Economic growth solves the environmental problems.

However, finding clear and concise causal relationships like these, could be a delicate task. Just because B happens after A, doesn't mean that B happens as a necessary consequence of A. Something else, C, may have happened at the same time without our notice, which really caused B to happen.[51] In other words, correlation does not in itself imply causation.[52]

Moreover, if we refer to the IPAT equation, growth may result in better technology (decreased intensity and thus a decreased T factor), but may at the same time increase the scale even more (an increased A factor). Consequently, growth could be the cause behind increased environmental impact, and at the same time causing

---

[51] Compare Hume, 1739.

[52] However, it is possible to analyse causal relationships like these using e.g. Granger causality. See Granger, 1969, and for applications regarding economic growth versus energy use, see e.g. Cleveland et al., 2000, and Ozturk, 2010.

this impact to be not as high. In other words, growth could simultaneously both cause and solve the environmental problems – a combination of point one and three above.

The degree to which growth contributes in decreasing intensity will not be analysed in this study. Here we will only try to determine whether or not economic growth – in particular growth in domestic final demand – has been a driving force in increasing environmental impact. This will be done by a simplified decomposition analysis.[53]

2.3.2 An overview of solutions

To sum up this chapter, we will still give a brief overview of the solution side of the environmental problems–solutions dichotomy, solutions discussed in the literature and the public debate. In this context, solutions to environmental problems can be divided into three groups:

- BUSINESS AS USUAL: Doing nothing beyond the normal, economic growth will solve all our problems.
- NATURAL CAPITALISM:[54] This group can, as a suggestion, be further subdivided into the following groups:
  - Ordinary environmental politics: Green investments, green subsidies, carbon taxes and similar taxes on natural resource uses.[55]
  - Green GDP: Allow a green GDP – or more correctly speaking, a green NDP[56] – to grow, if it takes into account the depreciation of natural capital, which has been assigned appropriate economic values.[57]
  - Performance economy: Build a market economy based on the sales of functions instead of the sales of products, giving incentives for companies to cut down the use of resources instead of making profits on the waste of resources.[58]
- STEADY-STATE ECONOMICS: Transform the current economic system to an economy not built upon the principle of economic growth, and possibly downscale the current economy to a sustainable level.[59]

---

[53] See Chapter 3.3.3 for details about the so called index decomposition analysis used in this study. Whether growth contributes to decreased intensity can be analysed in a structural decomposition analysis, which will be suggested for future research.

[54] The term comes from Hawken et al., 1999, and subsequently used by many authors, like Robèrt et al., 2002, and von Weizsäcker et al., 2009. Here I use it in a broad sense for all market friendly solutions trying to solve the environmental problems.

[55] See UNEP, 2011 for a recent and optimistic investigation.

[56] Net Domestic Product, i.e. GDP minus depreciation.

[57] E.g. SOU, 1991:37, Simon and Proops, 2000.

[58] This is an idea suggested in e.g. Stahel, 2010, and Stahel, 2007, and supported by many, for instance in Rockström and Wijkman, 2011.

[59] Jackson, 2009, Victor, 2008, and Daly and Farley, 2004, among others. See Malmaeus, 2011, for a model applied to the Swedish economy.

Chapter 3

Methodological framework

In this chapter we will go into the details behind the methods enabling a consumption perspective on a country's environmental pressure. That means to lay the foundations for the methodology of environmental input–output analysis upon which the consumption-based accounting approach normally is based. We will start off with the national accounts, in which the input–output tables have their origin, continuing with the environmental counterpart to the national accounts namely the environmental accounts. After that follows the environmental input–output analysis, which has its roots in the input–output tables of the national accounts and the environmental data from the environmental accounts.

Chapter 3.1 and 3.2 dealing with the compilation of data from the national accounts and the environmental accounts, can be skimmed through or skipped for the reader who wants to get straight to the methodology of the environmental input–output analysis described in Chapter 3.3. Furthermore, the purpose of this chapter is merely to give an overview of the methodology used in this area of research, whereas the detailed method used in the study follows in Chapter 4.

3.1 The national accounts

The national accounts of a country is an accounting system for the flows and stocks within a whole nation. It is similar to the accounting system of a company, but for the national accounts, it's about accounts on the country level. The national accounts comprises not just the economy of the government or the public sector, but all the economic actors in an economy – accordingly the industry and the households are included as well, and also the economical transactions with the rest of the world.[1]

The system of national accounts (SNA) is an international standard with its origin within the UN system, recommending how the statistical offices of the member

---

[1] For more details, see e.g. Sandelin, 2005, and SOU, 2002:118.

countries are to perform their national accounting. The standard has been developed through a couple of revisions since the first version in the 1950s,[2] and the latest revisions are the 1993 SNA[3] and the recently published 2008 SNA.[4] EU has developed a more detailed standard, based on the last international standard 1993 SNA, called the ESA 1995,[5] and this is what the Swedish national accounts still uses.[6]

The national accounts can be regarded as a collection of overlapping accounts. One of the most important economical statistics produced from the national accounts, is the GDP. Another important product of the national accounts, are the supply and use tables (SUTs), and the input–output tables (IOTs), which are of particular interest for this study.[7]

In the following sections, we will explain the SUTs, and how they are used to generate the IOT which in turn forms the basis for the matrices used in input–output analysis. To be able to follow the reasoning, it is recommended to study the SUTs and the IOT for Sweden 2005 in Appendix E. For the matrix algebra used, see Appendix C.

3.1.1 The supply table

The supply table corresponds to the supply side in the balance of supply and use depicted in Figure 2.6. Compared with Figure 2.6, the supply table describes not only the total flow of supplies, but gives also a sectoral resolution of this supply flow. Additionally, the supply table includes both supply going to the industry and to the final consumers.

The supply table is principally made up of a product x industry table – called the make matrix – of products produced by the domestic economy, and an imports column of products produced abroad. In the make matrix, each column represents an industry, and each such column consists of the various products produced within that industry, with one product group on each row in that column. If we denote the make matrix as $\boldsymbol{S}$, this can be expressed as s_{ij} being the production of product i made by industry j.

Appended to the make matrix and the imports column in the supply table are also a column describing the conversion from basic prices to market prices,[8] and total columns. See Appendix E for the supply table for the Swedish economy in 2005.

---

[2] SOU, 2002:118.

[3] UN et al., 1993.

[4] UN et al., 2008.

[5] EC, 1996.

[6] Statistics Sweden, 2010.

[7] Details about the SUTs and the IOT and the conversion from the SUTs to the IOT are found in Miller and Blair, 2009, Eurostat, 2008, UN, 1999, and UN et al., 1993. The following text are mostly based on these sources.

[8] Basic prices are the values which the industries receive. Market prices, are the prices which the purchasers pay, which include taxes less subsidies on the products, money that the producer wont receive. See Statistics Sweden, 2010.

3.1.2 The use table

The use table corresponds to the use side of the balance of supply and use depicted in Figure 2.6. As in the supply table, the use table extends the description of the economy depicted in that figure, by giving a sectoral resolution of that use flow. But the use table doesn't only describe the uses going to final consumption as in Figure 2.6, but also all the use of products going to the industry. This corresponds to the intermediate use higher up in the supply chain depicted to the left in Figure 2.2 – this will be described in more detail further down. For an example of a use table, see Appendix E with the use table for the Swedish economy in 2005.

The use table is made up of two main tables, a product x industry table on the left hand side – called the intermediate matrix of the use table, or just the use matrix – and a final demand table on the right hand side. The former have, as in the make matrix in the supply table, columns denoting the various industries in a country. However, here the columns doesn't consist of the products produced by each industry, but the products *used* as inputs by each industry for the industry to be able to produce its products. This is sometimes called the *production recipe* for that industry to produce its products. If we denote the use matrix as $\boldsymbol{U}$ we can, as in the corresponding case for $\boldsymbol{S}$ in the supply table, refer to u_{ij} as the product i used as input in industry j.

However, the industries do not only use products as inputs, but also labor force and profits to the owners of the industries. This is shown in the row below the use matrix, as a row of value added. Value added is the difference between what the industry earns when selling their products and the costs the industry have to pay for products used as inputs.

Note that the column totals of the use matrix including the value added row, equals the column totals in the make matrix of the supply table. That is just because a particular industry's total cost for inputs (including input of labor force and profits to the owners), equals exactly, at least in theory, the total revenues the industry receives when selling their products.

The right hand side of the use table consists of the final demand table, divided in columns for the various types of final demand. This calls for an explanation of the distinction between intermediate and final demand. Looking back into Figure 2.2 once again, the arrows to the left represent the supply chain upstream from the consumer. This means that industries buy products from one and each other in a supply chain, which downstream ends at the final consumers, i.e. the final demanders (the small dotted circle in Figure 2.2).[9] The final consumers is final in the sense that they don't use what they buy for production, but for own purposes. The intermediate consumers on the other hand, are industries buying products for the purpose of production.

Accordingly, looking for instance at the agricultural row in the use table, the cells to the left in that row (the cells belonging to the intermediate matrix) represent

---

[9] Final consumer, final demander or final user are all used interchangeably in this text.

what the various industries purchase of agricultural products, i.e. the intermediate demand of agricultural products. The cells to the right (the cells belonging to the final demand table) represent what the final users purchase of agricultural products.

The final demand is further subdivided into consumption (which could be private or public), investments and exports. Investments can be regarded as long term consumption which will later on be used in the production (e.g. buildings and machines).[10] Exports can be regarded as consumption made by actors abroad (the rest of the world).

The Swedish use table in Appendix E is in market prices. This makes sense, since the industry or the final user are, so to speak, not interested in whether the money for purchasing products goes to the state as taxes, or to the producer of the products. However, it would also be reasonable to separate the taxes less subsides part of all the costs an industry (or a final user category) have, by putting these taxes less subsidies on a separate row in the industry's column. Then we would end up with a use table in basic prices and that is in fact how the input–output table normally is presented – see the following section for details.

3.1.3 The input–output table

The input–output table (IOT) can on the whole be regarded as a use table, but instead of having industries as intermediate consumers in the columns of the intermediate use matrix, the IOT have products as the intermediate consumers. This may sound strange, but it is quite reasonable to imagine products as having inputs in order to be produced. It is also an essential part of the subsequent input–output analysis that the intermediate matrix in the IOT is a product x product matrix, of reasons that will be explained further on. See Appendix E for the Swedish IOT in 2005.

The terms input and output may need some further clarification. The *inputs* of a product are the products and the labor force needed for its production – for a given product, these inputs are shown on separate rows in that product's column. It's not just the inputs needed for one unit of that product, but the total inputs needed to produce all products of that kind during one year (which in the case of agricultural products in Sweden 2005 totals a value of 38 billion SEK). The inputs correspond to what is used by different users or consumers, intermediate or final. In that sense, the inputs correspond to the use side of the balance of supply and use depicted in Figure 2.6 (although in that figure intermediate uses have been stripped and only final uses are shown, not all uses).

The *outputs* of a product are the different uses (intermediate as well as final) which that particular product is distributed to. I.e. for a given product these outputs are shown in separate columns on that product's row. The output corresponds to

---

[10] This has implications for the input–output analysis, see later sections.

what is supplied, i.e. to the supply side in Figure 2.6 (although supply going to intermediate uses has been stripped from that figure).

Total inputs for all products are consequently found in a separate row below the intermediate matrix of the IOT. Total outputs for all products are found in a separate column, to the right of the final demand table of the IOT.

Conversion of the use table to the IOT

To generate the IOT, mainly two methods are available depending on two different assumptions. These assumptions deal with how the industries are converted to so called homogeneous industries, i.e. imaginary industries producing only one product each. These homogeneous industries will correspond to the product columns in the IOT. In this study, we will use the *industry technology assumption*, which means that when the conversion from the use table to the IOT is done, it is assumed that each industry uses the same input structure (i.e. the same production recipe), for all kind of products that industry produce.[11]

When it comes to the question of market prices and basic prices, the following text works for both cases to the extent that the resulting IOT then is expressed in basic prices or market prices, respectively. Though, to be able to use the IOT for input–output analysis, it must be in basic prices.

The conversion is done in the following way:[12] Firstly, we will make use of the supply table and the make matrix there within, denoted as $\boldsymbol{S}$. We start off by constructing a coefficient matrix of the make matrix called $\boldsymbol{S}_c$ by dividing all the cells in $\boldsymbol{S}$ with the column total from the column which that cell belongs to. If we denote the row of column totals as $\boldsymbol{x}_{ind}$, this procedure can be expressed as[13]

$$\boldsymbol{S}_c = \boldsymbol{S}\hat{\boldsymbol{x}}_{ind}^{-1} \quad \text{or} \quad (s_{ij}^c) = (s_{ij}/x_j^{ind})\,. \tag{3.1}$$

This means that each row, denoting a product, in a column, denoting an industry, of $\boldsymbol{S}_c$, is referring to the share of that product's value to the total production value of that industry. Or in other words, s_{ij}^c represents the share of the value of product i to the total production value of industry j.

The next step is the actual conversion, i.e. the transformation of the intermediate matrix in the use table to the intermediate matrix in the IOT. This is done by multiplying the intermediate matrix $\boldsymbol{U}$ from the use table, by the transpose of $\boldsymbol{S}_c$,

$$\boldsymbol{F} = \boldsymbol{U}\boldsymbol{S}_c'\,, \tag{3.2}$$

where $\boldsymbol{F}$ is the intermediate matrix of the IOT. In $\boldsymbol{F}$, element f_{ij} refers to the total inputs per year of product i needed for the total production of products of type j.

---

[11] The other common assumption used, is the commodity technology assumption, which states that the same input structure is used for the same kind of product, whatever industry is producing that product.

[12] This procedure is done in about the same way in Eurostat, 2008.

[13] See Appendix C for an explanation of these kinds of operations.

How can this be understood? If one recalls the definition of matrix multiplication, when the $\boldsymbol{U}$ matrix is multiplied by the first column of $\boldsymbol{S}'_c$, it means that the input structure (i.e. the column) of the agricultural industry is multiplied by the share of agricultural products produced in the agricultural industry, plus, the input structure of the forest industry multiplied by the share of agricultural products produced in the forest industry, and so on. This procedure is repeated until we add up to the first column in $\boldsymbol{F}$ which consequently holds the generated input structure for all agricultural products produced, whatever industry produced them. The same procedure is then followed for the other columns in $\boldsymbol{S}'_c$ when $\boldsymbol{U}$ are multiplied by them.

Now we're done with the intermediate matrix $\boldsymbol{F}$ of the IOT. The final demand table – which, when its columns are added together, form the vector $\boldsymbol{y}$ – of the IOT is just the same as the final demand table of the use table, so all in all, we now have completed the conversion of the use table to an IOT.

Dealing with imports

As yet, the use table and the corresponding IOT, haven't included any information about the use of imports. The production recipe each industry or each product possesses, should be understood as the inputs needed in total, no matter if the inputs are purchased domestically or from abroad as imports. When performing the conversion to an IOT, the procedure explained above is the most easy task. The challenging part is to assess the domestic part and the imports part of all the cells in the IOT, a job done primarily by the national accounts offices based on extra trade data and qualified assessments. Since this is a quite demanding task, IOTs are normally not produced on a yearly basis – in Sweden it is done every five years.[14]

When the domestic–imports divide is done, the resulting IOT can be regarded as a table in three layers: the domestic layer, the imports layer, and the domestic plus imports layer. In the IOT in Appendix E these layers are all present directly by presenting every cell as a domestic value + an imports value.

Updating IOTs

Since, as we said above, constructing IOTs are a quite resource demanding task and therefore is not done on a yearly basis, a number of various techniques have been developed to do the updating of IOTs automatically. These techniques are more or less based on extrapolating the information in an original IOT to the missing years, while at the same time calibrating the totals against the known totals of the missing years.[15] In this study a variation of these techniques have been developed, which takes advantage of the information of imports shares from the original IOT – see Chapter 4.2.2 for details.

---

[14] Statistics Sweden, 2011a.

[15] See Eurostat, 2008, for a good overview.

Physical IOTs

As was mentioned in Chapter 2, the rationale behind using monetary flows for estimating physical flows, is the fact that monetary values are much more readily available. The monetary flows can then be regarded as proxies for the physical flows, provided the correct conversions are done between price and e.g. mass. The normal way to do this, which will be explained in the following sections, is to do the calculations as far as possible in monetary values, and then finish by converting with help of intensities. E.g. the total required production in the whole supply chain for some kind of final consumption is first calculated monetarily, and then this value is converted to a physical value.

Another possibility, which would be possible if more physical data was available, would be to directly use physical IOTs, where assessments of the physical inputs used for producing products are made. Some interesting research has been done on this,[16] but the prevailing method is still to use the former method described in the preceding paragraph.

3.2 The environmental accounts

In the previous sections we have been talking about the national accounts, and analysed their most important products for this study, the supply and use tables, and the input–output tables. Appended to the system of national accounts, are also so called satellite accounts, which are not a completely integrated part of the national accounts, but still are developed in order to be able to use them together with the national accounts to as high a degree as possible. The environmental accounts is such a satellite accounting system.

In the SNA 1993 the use of satellite accounts, in particular environmental accounts, was introduced. In 1993, UN also came with its first publication dealing with a system of integrated environmental and economic accounting, SEEA 1993,[17] which now has been updated to the SEEA 2003.[18]

In Sweden the environmental accounts system has its origin in the Commission for Environmental Accounting appointed in 1990,[19] leading to the establishment of the environmental accounts in Sweden, which have been in use since 1993. In Sweden, Statistics Sweden, the National Institute of Economic Research, and the Swedish Environmental Protection Agency have been responsible for the environmental accounting.

---

[16] In Stahmer, 2000, not only a physical IOT is constructed but also a time IOT. Daly, 1968, constructs a physical IOT where not only inputs and outputs from and to the biosphere is included, but also the input and output flows within the biosphere (less the society). See also Weisz and Duchin, 2006.

[17] UN, 1993.

[18] UN et al., 2003.

[19] SOU, 1991:37.

The main purpose of the environmental accounting system is to organize statistics on environmental data (e.g. resource flows and emissions flows) in a way that make these data compatible with the national accounts. That means to classify environmental data into the same industrial categories as used by the national accounts, in order to be able to compare economical and environmental performance of the various industries of a country (e.g. calculate emission intensities). Earlier environmental statistics have not done this. This work goes under the heading physical environmental accounts, and in Sweden this is the responsibility of Statistics Sweden.[20]

Other important purposes of the environmental accounting system, is to try to valuate natural resources, and to develop a green GDP. This is called the monetary environmental accounts, and in Sweden the National Institute of Economic Research has the responsibility for this work.[21]

3.2.1 Integrating national and environmental accounts

Statistics from the national accounts and from the environmental accounts can be presented in an integrated matrix form, as seen in Figure 3.1. This is sometimes called a NAMEA (National Accounting Matrix with Environmental Accounts).[22] Figure 3.1 consists of the input–output table, extended with an environmental matrix shown below (the two boxes in the lowermost part of the figure).[23]

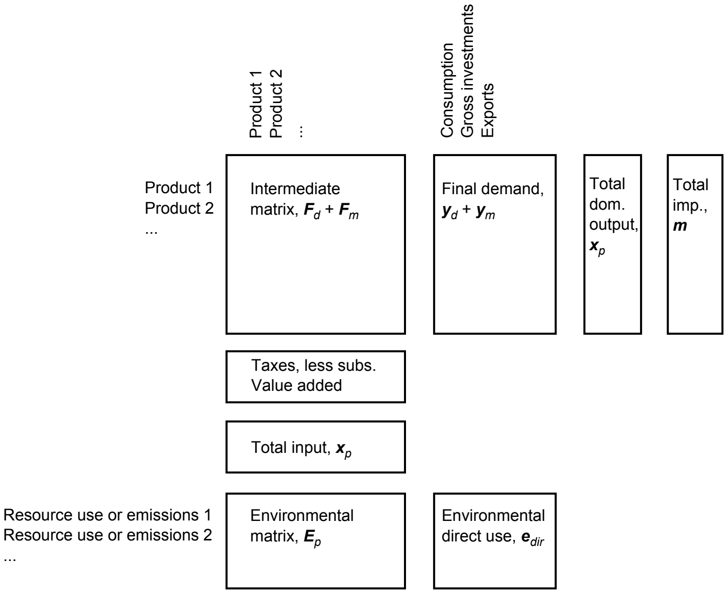


Figure 3.1. The structure of economic and environmental data into one framework, a NAMEA. *Source*: Based on Statistics Sweden, 2000.

---

[20] SOU, 1991:37, Statistics Sweden, 2002a, and Peters, 2008.

[21] SOU, 1991:37, and Statistics Sweden, 2002a.

[22] UN et al., 2003.

[23] Based on Statistics Sweden, 2000.

Some notes regarding Figure 3.1 are needed. The environmental direct use $\boldsymbol{e}_{dir}$ below the final demand box, consists of the resource use and emissions generated in the usage phase of the products, i.e. downstream after consumption. That is energy use and emissions occurring e.g. for heating of housing and transports. All downstream environmental impact is however not part of $\boldsymbol{e}_{dir}$; environmental impact during the disposal phase is instead considered impact happening upstream in the waste industry, whose products are waste services.

Furthermore, to be more theoretical consistent, resource uses ought to be the only environmental parameters shown below the intermediate matrix, since these can be regarded as inputs. Analogously, the emissions ought to be found to the right of the table, as outputs. However this is not the case, since in practice, the environmental matrix $\boldsymbol{E}_p$ is one continuous table in the environmental accounts. Also, it would be hard to show the direct emissions from final users in that way, as there is no output row for final users.[24] It is also possible to interpret emissions as resources – for instance the emissions of CO_2 can be considered being a use of the carbon absorption capacity resource of the atmosphere – so in that sense it is reasonable to have all environmental parameters as inputs.

3.2.2 Environmental data per industry and per product

In Figure 3.1, the environmental matrix $\boldsymbol{E}_p$ consists of rows representing energy uses and emissions, and columns representing products using these energy resources or emitting these emissions. I.e. e^p_{ij} is the energy use type or emission type i used or emitted by product j. However, since the original environmental data in the environmental accounts is presented per industry in a corresponding matrix $\boldsymbol{E}_{ind}$, we need to convert this matrix first in order to get $\boldsymbol{E}_p$. This is done in a way that resembles the conversion of the use table to an IOT.[25]

To get $\boldsymbol{E}_p$, we postmultiply $\boldsymbol{E}_{ind}$ by $\boldsymbol{S}'_c$ as is done in the following:

$$\boldsymbol{E}_p = \boldsymbol{E}_{ind}\boldsymbol{S}'_c\,. \tag{3.3}$$

This can be understood in the same manner as in the SUT–IOT conversion. That is, the first column in $\boldsymbol{E}_p$ is generated by taking the emissions column from the agricultural industry in $\boldsymbol{E}_{ind}$ multiplied by the production share of agricultural products in the agricultural industry (i.e. the first element of the first column of $\boldsymbol{S}'_c$), plus the emissions column from the forest industry in $\boldsymbol{E}_{ind}$ multiplied by the production share of agricultural products in the forest industry (i.e. the second element of the first column of $\boldsymbol{S}'_c$), and so on, until we have all the emissions that the agricultural products generate. The other columns of $\boldsymbol{E}_p$ are generated analogously.

---

[24] Although, Daly, 1968, designs a households row corresponding to the final consumption column, and is in this way able to construct physical inputs and physical outputs in this more consistent way.

[25] Östblom, 1998, does this in an equivalent way.

3.3 Environmental input–output analysis

Until this point, we have described how the data used in environmental input–output analysis are organized and collected, by the use of economic data from the national accounts and the use of environmental data from the environmental accounts. The result of this organization is summarized in Figure 3.1. Even though some of the data went through some processing – e.g. when the conversion to the input–output table (IOT) was done, and when the environmental data per industry were converted to environmental data per product – a regular analysis has not really been done yet. That is the task for the following sections, which will go into the details of the input–output analysis and its environmental extension.

The input–output analysis method was developed by the economist Wassily Leontief,[26] and earned him the Nobel Prize in economics in 1973.[27] Since 1988 the International Input–Output Association is active and responsible for e.g. the scientific journal Economic Systems Research, specialized in research about input–output analysis.[28]

3.3.1 Foundations of the input–output analysis

Domestic production and the Leontief inverse

We will start off with the pure economic part of the input–output analysis, by firstly returning to the input–output table from the national accounts.[29] Looking at the domestic part of the IOT, this table can mathematically be expressed as

$$\boldsymbol{F}_d \boldsymbol{i} + \boldsymbol{y}_d = \boldsymbol{x}_p \,, \tag{3.4}$$

where $\boldsymbol{F}_d$ is the domestic part of the intermediate matrix of the IOT, $\boldsymbol{i}$ is a unit vector, $\boldsymbol{y}_d$ is the domestic part of the final demand, and $\boldsymbol{x}_p$ is the total output, i.e. the total value of the various products produced over a year.

For the sake of the analysis, we're now interested in expressing the intermediate matrix $\boldsymbol{F}_d$ as a coefficient matrix, i.e. the domestic inputs expressed as shares of total input (or as shares of total output, since total input equals total output). Or, in other words, the value of the various domestic inputs per dollar's worth of produced output. This gives us the matrix

$$\boldsymbol{A}_d = \boldsymbol{F}_d \hat{\boldsymbol{x}}_p^{-1} \,, \tag{3.5}$$

called the matrix of technical coefficients, where each of the elements $a_{ij}^d = f_{ij}^d / x_j^p$ expresses the value of domestic product i needed as input per dollar's worth of

---

[26] First presented in Leontief, 1941.

[27] Another Nobel Prize in economics for the work in the IOA field was given to Richard Stone in 1984. See UN, 1999.

[28] IIOA, 2011.

[29] This follows more or less the text of Miller and Blair, 2009, and UN, 1999.

produced output of product j. This matrix describes the industry structure of a nation for a given year as regards domestic production, and it is assumed to be fixed, i.e. the relations between the industries are assumed not to change. This is reasonable if not too many years have past, or the production volume of the economy has not changed substantially. Concretely speaking, this means that we can multiply $\boldsymbol{A}_d$ with any vector of products we want to be produced, and the resulting vector will correctly show all the direct inputs needed to produce those products. In other words, linearity is assumed since any vector of products we want to be produced, use the same industry structure.

Now it also becomes clear that the intermediate matrix in the use table need be converted to the product x product intermediate matrix in the IOT, in order to make it possible to multiply the $\boldsymbol{A}_d$ matrix with a product vector in a meaningful way. From the above and from what follows below, it is also evident that the IOT must be in basic prices, so that $\boldsymbol{A}_d$ only reflects the pure inputs needed, excluding taxes (e.g. inputs of inputs would otherwise be valued too high, since also the tax part would have inputs, which is not the case).

Now, with the help of equation (3.5), it is possible to express equation (3.4) in the following way:

$$\boldsymbol{A}_d\boldsymbol{x}_p + \boldsymbol{y}_d = \boldsymbol{x}_p\,. \tag{3.6}$$

Rearranging gives us

$$\boldsymbol{x}_p = (\boldsymbol{I} - \boldsymbol{A}_d)^{-1}\boldsymbol{y}_d \tag{3.7}$$

which means that if $\boldsymbol{A}_d$ is fixed, the total output $\boldsymbol{x}_p$ can be considered a function of the final demand $\boldsymbol{y}_d$ which can be chosen arbitrarily.[30] In other words, equation (3.7) expresses the total domestic output needed throughout the whole supply chain to satisfy the final demand $\boldsymbol{y}_d$.

How can we understand that equation (3.7) describes the production needed throughout the whole supply chain more intuitively? Imagine that the products $\boldsymbol{y}_d$ are consumed. The direct production needed to satisfy this consumption will then be just $\boldsymbol{y}_d$, or let us express it as $\boldsymbol{I}\boldsymbol{y}_d = \boldsymbol{y}_d$. What products are needed indirectly to be able to produce $\boldsymbol{y}_d$? Now, look back to what the matrix $\boldsymbol{A}_d$ meant: every column in $\boldsymbol{A}_d$ describes the inputs needed per dollar's worth of produce. So if we take $\boldsymbol{A}_d$ and postmultiply it by $\boldsymbol{y}_d$, we would, remembering how matrix multiplication is defined, actually get the total inputs needed to be able to produce all the products in the vector $\boldsymbol{y}_d$. So the vector $\boldsymbol{A}_d\boldsymbol{y}_d$ expresses the production needed in this step of the supply chain to produce $\boldsymbol{y}_d$. But how much production is needed in the next step – to produce $\boldsymbol{A}_d\boldsymbol{y}_d$, what will the inputs be then? Remember now that $\boldsymbol{A}_d\boldsymbol{y}_d$ is the new consumption vector, and we will now see how much inputs are needed to be able to satisfy the consumption $\boldsymbol{A}_d\boldsymbol{y}_d$. That is obtained by once again postmultiplying $\boldsymbol{A}_d$, this time by $\boldsymbol{A}_d\boldsymbol{y}_d$, which gives us the production $\boldsymbol{A}_d^2\boldsymbol{y}_d$ in this step of the supply chain.

---

[30] Even though an arbitrarily chosen final demand $\boldsymbol{y}_d$ differs from the fixed final demand $\boldsymbol{y}_d$ of the IOT in equation (3.4) we will use the same notation. Analogously with the output $\boldsymbol{x}_p$.

This procedure can be repeated infinitely, and if we add together all this production produced in each step in the supply chain, as explained above, we will get the total production needed to satisfy the consumption $\boldsymbol{y}_d$ as

$$(\boldsymbol{I} + \boldsymbol{A}_d + \boldsymbol{A}_d^2 + \boldsymbol{A}_d^3 + \ldots + \boldsymbol{A}_d^n)\, \boldsymbol{y}_d = \boldsymbol{x}_p\,. \tag{3.8}$$

Now, can this infinite series inside the parenthesis on the left hand side of equation (3.8) be expressed in a more convenient way? As a matter of fact it can. If we premultiply the parenthesis with $(\boldsymbol{I} - \boldsymbol{A}_d)$ we get[31]

$$\begin{aligned}(\boldsymbol{I} - \boldsymbol{A}_d)(\boldsymbol{I} + \boldsymbol{A}_d + \boldsymbol{A}_d^2 + \ldots + \boldsymbol{A}_d^n) &= (\boldsymbol{I} + \boldsymbol{A}_d + \boldsymbol{A}_d^2 + \ldots + \boldsymbol{A}_d^n) \\ &- (\boldsymbol{A}_d + \boldsymbol{A}_d^2 + \boldsymbol{A}_d^3 + \ldots + \boldsymbol{A}_d^{n+1}) \\ (\boldsymbol{I} - \boldsymbol{A}_d)(\boldsymbol{I} + \boldsymbol{A}_d + \boldsymbol{A}_d^2 + \ldots + \boldsymbol{A}_d^n) &= \boldsymbol{I} - \boldsymbol{A}_d^{n+1} = \boldsymbol{I}\,, n \to \infty \\ (\boldsymbol{I} + \boldsymbol{A}_d + \boldsymbol{A}_d^2 + \ldots + \boldsymbol{A}_d^n) &= (\boldsymbol{I} - \boldsymbol{A}_d)^{-1}\,,\end{aligned} \tag{3.9}$$

assumed that $\boldsymbol{A}_d^{n+1} \to \boldsymbol{0}$, as $n \to \infty$.[32]

So equation (3.8) can actually be expressed as

$$\boldsymbol{x}_p = (\boldsymbol{I} - \boldsymbol{A}_d)^{-1}\boldsymbol{y}_d\,, \tag{3.10}$$

and that is the same result as was obtained in equation (3.7) which means that the interpretation of the supply chain offered by the reasoning behind equations (3.8) and (3.9) must be correct. The infinite series $\boldsymbol{I} + \boldsymbol{A}_d + \boldsymbol{A}_d^2 + \ldots$ is the *power series approximation* of $(\boldsymbol{I} - \boldsymbol{A}_d)^{-1}$ and is known as a power series, or more specifically, as a geometric series,[33] here in matrix form.

In other words, an arbitrary final demand $\boldsymbol{y}_d$ results – directly and indirectly throughout the whole supply chain – in the total production that amounts to $\boldsymbol{x}_p$. As was indicated earlier, this is true under the assumption that the input structure given by $\boldsymbol{A}_d$ is fixed and exactly the same wherever we are in the supply chain, and whatever production is produced in the various steps of the supply chain.

The matrix $(\boldsymbol{I} - \boldsymbol{A}_d)^{-1}$ is the so called *Leontief inverse*, and we will from now on denote this as $\boldsymbol{L}_d = (\boldsymbol{I} - \boldsymbol{A}_d)^{-1}$. Looking at equation (3.8) and (3.10) carefully, $\boldsymbol{L}_d$ can be regarded as a matrix composed of an infinite number of layers, each layer representing each of the terms in the power series approximation $\boldsymbol{I} + \boldsymbol{A}_d + \boldsymbol{A}_d^2 + \ldots$. This yields us an interpretation of the elements in $\boldsymbol{L}_d$, where a column represents all the direct and indirect production needed to satisfy the consumption of one dollar of the product which that column represents, with the required production per product on the various rows in that column. Or, in other words, l_{ij}^d is the total direct and indirect production of product i to satisfy the consumption per dollar's worth of product j.

---

[31] See Miller and Blair, 2009. This result can also be achieved by going backwards from the standard Maclaurin series of $(1 - x)^{-1}$ – see Adams, 1995.

[32] This is plausible, since all elements in $\boldsymbol{A}_d$ are less than 1. However, a formal proof is presented in Appendix D.

[33] Adams, 1995.

Total production including trade

In the previous section, we only discussed the required production produced domestically to satisfy some kind of final demand of domestic products. In this section we will also discuss the required production produced abroad to satisfy the total final demand. In consumption-based accounting studies related to environmental pressure, there are in essence two methods when calculating the production abroad needed to satisfy final demand – single-regional input–output (SRIO) analysis and multi-regional input–output (MRIO) analysis.[34] We will briefly describe both of them below, and also examine the production needed domestically for the exports part of the final demand. But first, we will start off with some general considerations regarding imports in input–output analysis.

If we are to include the imports part of the IOT, it is possible – as we did in equation (3.4) for the domestic part – to express the IOT mathematically as

$$(\boldsymbol{F}_d + \boldsymbol{F}_m)\boldsymbol{i} + (\boldsymbol{y}_d + \boldsymbol{y}_m) = \boldsymbol{x}_p + \boldsymbol{m}\,, \tag{3.11}$$

where $\boldsymbol{F}_m$ is the imports to the industry, $\boldsymbol{y}_m$ the imports to the final consumers (i.e. the final demand of imports), and $\boldsymbol{m}$ is the total imports with $\boldsymbol{m} = \boldsymbol{F}_m\boldsymbol{i}+\boldsymbol{y}_m$.

This means that the matrix of technical coefficients really should be expressed as

$$\boldsymbol{A}_{tot} = \boldsymbol{A}_d + \boldsymbol{A}_m = (\boldsymbol{F}_d + \boldsymbol{F}_m)\hat{\boldsymbol{x}}_p^{-1} \tag{3.12}$$

in order to properly describe the production recipes used in the production of all the products, i.e. a production recipe including both domestic and imported inputs. Thus, $a_{ij}^{tot} = (f_{ij}^d + f_{ij}^m)/x_j^p$, represents the total direct input (domestic and imported) of product i needed in the production of product j. Combining equation (3.11) and (3.12) means that the total IOT can be expressed as[35]

$$(\boldsymbol{A}_d + \boldsymbol{A}_m)\boldsymbol{x}_p + (\boldsymbol{y}_d + \boldsymbol{y}_m) = \boldsymbol{x}_p + \boldsymbol{m}\,. \tag{3.13}$$

To obtain $\boldsymbol{A}_{tot}$ it is important not to divide the cells in $\boldsymbol{F}_{tot}$ ($= \boldsymbol{F}_d + \boldsymbol{F}_m$), e.g. cell f_{ij}^{tot}, with the total supply of product j in the vector $(\boldsymbol{x}_p + \boldsymbol{m})$ even though $(\boldsymbol{x}_p + \boldsymbol{m})$ is the vector of row sums of the whole IOT described by equation (3.13). In other words, $a_{ij}^{tot} \neq f_{ij}^{tot}/(x_j^p + m_j)$. This is because the domestic products' input shares (even though imports are included in those input shares) should still be in relation to the domestic products' output, not in relation to the products' supply (which includes imports of already produced products). The latter would yield a matrix which is not describing the domestic industry structure or the domestic industries' production recipes. In the IOT in Appendix E, this corresponds to dividing by 38 billion SEK and not 52 billion SEK in the agricultural products column.[36]

---

[34] Wiedmann, 2009.

[35] UN, 1999.

[36] This is discussed in e.g. Östblom, 1980, and Bergman, 1977. If information of the domestic–imports proportions was insufficient in the IOT, this would not be a trivial fact.

Single-regional input–output analysis SRIO analyses include the rest of the world (ROW) by assuming it has the same technological structure as the modelled country, e.g. as the Swedish technological structure. That means that the required production to produce the imported products is calculated by using the technical coefficients matrix of the modelled country. This is a quite strong assumption, since the inputs needed to produce a certain product in other countries could differ quite substantially. But when using SRIO modelling, it is the only option available.

Various SRIO analyses use various approaches to the ROW.[37] Some studies with the purpose of only analysing domestic effects of the consumption, does accordingly not include the effects abroad at all. Some studies use $\boldsymbol{A}_d$ to model ROW, other $\boldsymbol{A}_{tot} = \boldsymbol{A}_d + \boldsymbol{A}_m$, which would be the most correct method, since $\boldsymbol{A}_d$ doesn't describe the total direct inputs needed in the production recipes.

To express mathematically the production needed throughout the whole supply chain domestically and abroad to satisfy the total final demand $\boldsymbol{y}_d + \boldsymbol{y}_m$ – given that the ROW is approximated by $\boldsymbol{A}_{tot}$ – the power series approximation of the Leontief inverse is helpful. In Figure 3.2 this is visualized as a binary tree. In the top of the tree, final demand, $\boldsymbol{y}_{tot}$, is first divided into a domestic part, $\boldsymbol{y}_d$, and an imported part, $\boldsymbol{y}_m$. The domestic branch to the left is then further divided into domestic production, $\boldsymbol{A}_d\boldsymbol{y}_d$, and imported production, $\boldsymbol{A}_m\boldsymbol{y}_d$. For the imported branch to the right, the same is done, however the division in $\boldsymbol{A}_d\boldsymbol{y}_m$ and $\boldsymbol{A}_m\boldsymbol{y}_m$ is really not needed, since we're already abroad.

The total production caused by $\boldsymbol{y}_{tot}$ is the sum of all nodes in the whole tree, which can be expressed as $\boldsymbol{L}_{tot}\boldsymbol{y}_{tot} = (\boldsymbol{I} + \boldsymbol{A}_{tot} + \boldsymbol{A}_{tot}^2 + \ldots)\boldsymbol{y}_{tot}$. The production occurring domestically due to $\boldsymbol{y}_{tot}$ is the sum of all nodes on the left edge of the whole tree, in other words $\boldsymbol{L}_d\boldsymbol{y}_d = (\boldsymbol{I} + \boldsymbol{A}_d + \boldsymbol{A}_d^2 + \ldots)\boldsymbol{y}_d$. The production occurring abroad is accordingly the sum of the whole tree, less the left edge, i.e. $\boldsymbol{L}_{tot}\boldsymbol{y}_{tot} - \boldsymbol{L}_d\boldsymbol{y}_d$.[38] Note that in all these sums, the top node of the tree is always excluded, since it is already counted at the second level of the tree.

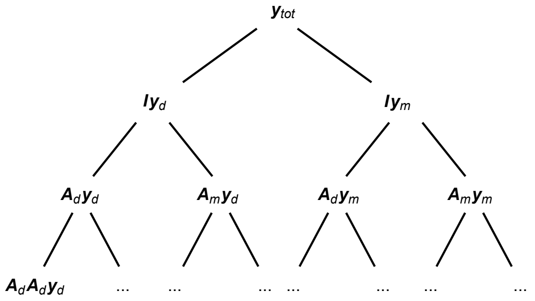


Figure 3.2. Binary tree describing production occurring domestically and abroad in the whole supply chain to satisfy final demand of domestic and imported products.

---

[37] See e.g. Lenzen, 1998, Östblom, 1998, Machado et al., 2001, and Lindmark, 2001.

[38] This result is also used in Finnveden et al., 2007.

Accordingly, this gives us a way of separating the required production occurring domestically and abroad. That separation will be used in this study when domestical and ROW production will be attributed different resource use and emission intensities. However, imports that has been exported from the modelled country further back in the supply chain will then wrongly be included in the ROW part – so called *feedback effects* – which implies that the higher ROW intensities will be used on a slightly too big share of the total production $\boldsymbol{L}_{tot}\boldsymbol{y}_{tot}$.

Multi-regional input–output analysis In MRIO studies, the $\boldsymbol{A}$ matrices of the trading countries in the ROW are known to some extent; also known is the distribution of imports over the countries exporting to the model country.[39]

Mainly two methods are used in MRIO analysis.[40] The first, the unidirectional trade model, separates the imports vector $\boldsymbol{m}$ into different imports vectors, one for each trading partner who is exporting products to us. These vectors $\boldsymbol{m}_i$ for various countries i, are subsequently premultiplied by the exporting countries' $\boldsymbol{A}_d$ matrices. In this way the production needed for the imports to be produced inside the trading countries are included, but not the production these trading countries in their turn need from their trading countries.

The second MRIO method, the multidirectional trade model, takes care of this, as it in theory uses all trading countries' $\boldsymbol{A}$ matrices, and information about how they trade. This is implemented by setting up a block matrix of $\boldsymbol{A}$ matrices, so that for every country, the $\boldsymbol{A}_m$ matrix for that country is divided into separate $\boldsymbol{A}_m$ matrices for each country they are in turn importing from. These models also take care of the feedback effects resulting from exports exported to one country, which after being processed, are imported back to the first country.[41] The multidirectional MRIO model has been implemented in the GTAP database[42] which a number of studies have been using.[43]

Exports In consumption-based accounting studies, the purpose is to reallocate the responsibility of the production to the citizens of the country causing that production. Therefore, exports, i.e. production caused domestically due to the consumption done by actors in the rest of the world, should not be part of the modelled country's required production. Accordingly, final demand $\boldsymbol{y}_{tot}$ should exclude exports. We will denote this as $\boldsymbol{y}_{tot}^{nexp}$.

---

[39] Weber and Matthews, 2007, distinguishes these as the two major types of data needed in MRIO models.

[40] Lenzen et al., 2004, Peters and Hertwich, 2009.

[41] de Haan, 2002, and Peters and Hertwich, 2009.

[42] GTAP, 2011.

[43] E.g. Peters et al., 2011, Peters and Solli, 2010, and Davis and Caldeira, 2010. See Wiedmann, 2009, for an overview.

3.3.2 Environmental extension to input–output analysis

We have now discussed the methods to determine the total production needed upstream all throughout the supply chain, domestically as well as abroad, to satisfy the total final demand in a country. Now we're heading for the main goal in the analysis, and that is to see what environmental repercussions that production causes – the consumption perspective on environmental impact. That is the subject of the environmental extension to the input–output analysis (environmental IOA).[44] See Chapter 2.1.2 and Figure 2.2 for the rationale behind this subject.

To translate flows of production from the IOA to flows of masses in the environmental IOA, the environmental intensities of production is utilized (see discussion in Chapter 2.2.2). E.g. the amount of CO_2 emitted per dollar's worth of some type of product is calculated. In Chapter 3.2, we learned that through the environmental accounts, the total flows of resource uses and emissions generated in the various industries were collected in an environmental matrix called $\boldsymbol{E}_{ind}$. This matrix was transformed to the matrix $\boldsymbol{E}_p$ in order to see the resource uses or emissions per total production of a certain product, during a year. To get the corresponding environmental intensity matrix $\boldsymbol{E}_i$, all resource use or emission types in a column of $\boldsymbol{E}_p$ is divided by the corresponding production value of that product to which that column refers, i.e.

$$\boldsymbol{E}_i = \boldsymbol{E}_p \hat{\boldsymbol{x}}_p^{-1} \,. \tag{3.14}$$

Thus, an element e^i_{ij} in $\boldsymbol{E}_i$ refers to the resource use intensity or emission intensity of resource use or emission type i in the production of product j.[45]

Having generated $\boldsymbol{E}_i$ means that it is possible to calculate the consumption-based resource uses and emissions for multiple resource use or emission types all at once, in a single matrix multiplication. This is done, postmultiplying $\boldsymbol{E}_i$ by the required production from some final demand, as expressed in equation (3.10), i.e.

$$\boldsymbol{e}_c = \boldsymbol{E}_i \boldsymbol{L} \boldsymbol{y} \,, \tag{3.15}$$

where $\boldsymbol{e}_c$ is a column vector denoting the consumption-based environmental impact, with e^c_i referring to the amount of resource use or emissions of type i generated through the whole supply chain, caused by the final demand of all products.[46] Equation (3.15) is the central equation of the environmental IOA used in this study.

In some SRIO studies,[47] $\boldsymbol{L}_d$ is used for $\boldsymbol{L}$ and $\boldsymbol{y}_d$ is used for $\boldsymbol{y}$, meaning that the domestic causes of final demand (inclusive exports) are analysed (impact on ROW

---

[44] See Leontief, 1970, for one of the first accounts of the subject. Miller and Blair, 2009, gives an overview. See e.g. SEI, 2010, and SEI et al., 2009, for current and recent projects using environmental IOA.

[45] Östblom, 1998, is doing this in a similar way.

[46] See Miller and Blair, 2009. However, as is pointed out by Miller and Blair, caution must be done when calculating energy use in this way, if both primary and secondary energy uses are calculated. Blair, 2011, confirms though, that when using only primary energy uses (as is done in this study), equation (3.15) is correct.

[47] E.g. Östblom, 1998.

not included). Some other studies use $\boldsymbol{L}_{tot}$ (or $\boldsymbol{L}_d$) and $\boldsymbol{y}_{tot}^{nexp}$ or similar approaches, in order to analyse the worldwide causes of the domestic final demand (exclusive exports).[48]

In unidirectional MRIO studies, $\boldsymbol{e}_c$ in equation (3.15) is calculated for every exporting country from which the modelled country are importing, with country-specific intensities and Leontief inverses ($\boldsymbol{E}_i$ and $\boldsymbol{L}$) and different $\boldsymbol{y}$'s (denoting imports) depending on country; then all these country-specific $\boldsymbol{e}_c$ vectors are summed together.[49] In multidirectional MRIO studies a block matrix is applied as mentioned earlier, and every country are assigned country-specific intensities.[50]

In many consumption-based studies, downstream effects are also part of the analysis by including the direct use $\boldsymbol{e}_{dir}$ in equation (3.15), thereby considering resource use and emissions in the usage phase as well.[51,52] Downstream effects in the disposal phase are already a part of the analysis upstream, since these effects can be considered included in the consumption of waste services from the waste industry.

LCA versus IOA

Since environmental IOA through its Leontief inverse, determines the environmental pressure caused throughout the whole supply chain, without any theoretical system boundary, it could be used together with ordinary life cycle assessments (LCAs). LCAs are still superior when it comes to determine the environmental impact early in the supply chain of some specific product, since the analyses done there are pretty detailed. However, it is impossible to extend the process tree of an LCA for ever, since the data demands become to high. Therefore, IOA can be used to cover up the rest of the process tree. IOA, on the other hand, cannot be used as a substitution for LCA, since the IOA only gives an average value of the pressure caused by a whole product group, whereas a LCA analyses a specific product. In general, LCAs are more relevant for analyses on a specific product level, whereas IOAs are more relevant on a country level.[53,54]

Ecological footprints and other embedded concepts versus IOA

The ecological footprint is an analytical tool for determining the land area needed to produce the products consumed and absorb the waste and emissions produced by a whole country.[55] The ecological footprint takes into account imports and

---

[48] E.g. Lenzen, 1998, and Statistics Sweden, 2000.

[49] See e.g. Peters and Hertwich, 2006.

[50] See references in previous section about MRIO analysis.

[51] E.g. Östblom, 1998, Carlsson-Kanyama et al., 2007, and Swedish EPA and Statistics Sweden, 2008.

[52] See Chapter 3.2.1 regarding $\boldsymbol{e}_{dir}$.

[53] See Hendrickson et al., 2006, for a good introduction. Peters, 2010, and Finnveden and Moberg, 2005, discuss country-level to product-level issues, and hybrid models. Also discussed in Spreng, 1988.

[54] See also Chapter 2.1.2 for a comparison between LCA and IOA.

[55] Introduced in Rees, 1992, and Wackernagel and Rees, 1996. See also WWF, 2010.

exports, but not the indirect effects through the whole supply chain like the IOA does. However, recent research has proposed a developed ecological footprint analysis combined with IOA.[56]

In this context the concept of virtual water and similar embedded concepts like emergy need mentioning. The analysis of these concepts in relation to IOA will be suggested for further research.[57]

3.3.3 Time series and EKCs based on input–output analysis

Overview and studies performed

Most environmental IOA studies have been studying single years only,[58] but there are some exceptions. In a study by Weber and Matthews, the emissions embodied in US trade for the years 1997, 2002 and 2004 are analysed using an unidirectional trade MRIO.[59] Roca and Serrano study Spanish pollution for the years 1995 and 2000, using a SRIO model.[60] In a Nordic council study from 2010, Peters and Solli study the Nordic countries using multidirectional MRIO analysis for 1997, 2001 and 2004.[61] Wiedmann et al., construct a time series from 1992–2004 for the UK, using a unidirectional MRIO.[62] Recently, Peters and colleagues performed a MRIO time series analysis covering the period 1990–2008 for embodied CO_2 emissions in trade between developing and developed countries.[63] The general results from all these studies show increasing emissions, and in general higher levels compared to official production-based data.

For the sake of performing IOA-based EKC studies, time series are needed when performing longitudinal analysis for a certain country. However, IOA-based cross-sectional analysis is also an option when performing EKC studies. This is done by Hertwich and Peters who perform a cross-country study utilizing multidirectional MRIO analysis, covering the whole world.[64] In a study by Davis and Caldeira a cross-country analysis is also performed, though no EKC analysis is performed – although, it can be shown from their data, that there exists no EKC-like pattern, and CO_2 emissions are rising with increasing GDP.[65] In the Roca and Serrano study above a cross-sectional EKC analysis is also performed over increasing income groups – results suggest absolute decoupling does not occur.[66]

See Chapter 3.3.4 for Swedish studies.

---

[56] See Wiedmann et al., 2006, which also gives an overview of the ecological footprint literature.

[57] See Lenzen, 2009, for an IOA study concerning virtual water.

[58] Peters and Solli, 2010.

[59] Weber and Matthews, 2007.

[60] Roca and Serrano, 2007.

[61] Peters and Solli, 2010.

[62] Wiedmann et al., 2010.

[63] Peters et al., 2011.

[64] Hertwich and Peters, 2009.

[65] Davis and Caldeira, 2010.

[66] Roca and Serrano, 2007.

Decomposition analysis

When constructing time series of environmental pressure, it is of interest to decompose the various factors contributing to the change of the environmental pressure. For instance, looking at the IPAT equation, the impact I is multiplicative decomposed into the factors P, A and T. It is also possible to decompose I additively into contributing terms that individually correspond to P, A and T – this will be shown below in the case of two variables.

The most common form of decomposition analysis is index decomposition analysis (IDA), dealing with environmental factors which are not based on IOA and the Leontief inverse. Structural decomposition analysis (SDA), on the other hand, is a method for decomposing factors in IOA-based studies.[67]

Multiplicative decomposition measures the relative change in a variable, and is, as the case for the IPAT above showed when the analysis was not done with a sectoral resolution, straightforward. Additive decomposition, measuring the absolute change in a variable, requires some examination though. Suppose we have a simplified form of IPAT relation, say emissions (e) of CO_2, depending on volume (v) in GDP, and on intensity (i) expressed as CO_2/GDP. Then we have

$$e = vi \, . \tag{3.16}$$

The idea behind additive decomposition is to find out how much e would change due to the change of v given that i remains unchanged, and how much e would change, due to the change of i given that v remains unchanged.[68] In other words, we would like to express $\Delta e = \Delta(vi)$ as $\Delta e = f(\Delta v) + g(\Delta i)$. This can be derived by expressing the total derivative of e when e is a function $e(v(t), i(t)) = v(t)i(t)$. Differentiation gives[69]

$$\frac{de}{dt} = \frac{\partial e}{\partial v}\frac{dv}{dt} + \frac{\partial e}{\partial i}\frac{di}{dt} \quad \Leftrightarrow \quad de = \frac{\partial e}{\partial v}dv + \frac{\partial e}{\partial i}di \, , \tag{3.17}$$

and considering that $e = vi$, the partial derivatives become $\frac{\partial e}{\partial v} = i$ and $\frac{\partial e}{\partial i} = v$, so equation (3.17) transforms to

$$de = idv + vdi \, . \tag{3.18}$$

So for a small change in e we have actually decomposed e into two terms, the first term depending only on changes in v, the other term depending only on changes in i.

If considering the two-dimensional surface that the function $e(v, i) = vi$ describes in the diagram in Figure 3.3, the terms of de describe the change happening in e,

---

[67] See Wood and Lenzen, 2009, Hoekstra and van der Bergh, 2003, and Ang and Zhang, 2000 for overviews and literature surveys. Minx et al., 2009, is a recent SDA study for UK CO_2 emissions.

[68] Kander, 2002, calls this counterfactual analysis, i.e. what would the change in impact have been, if one of the independent variables had been constant.

[69] Hoekstra and van den Bergh, 2002, and Adams, 1995.

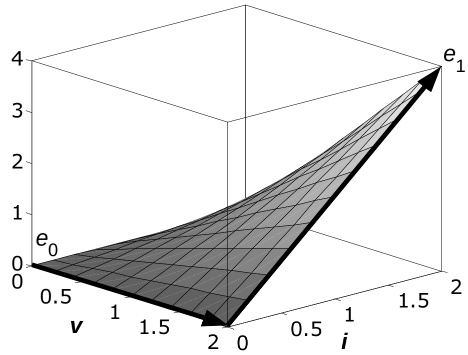


Figure 3.3. Plot of the surface $e(v,i) = vi$.

i.e. the change in height above the v,i-plane (the floor of the box in the diagram), when going on the surface $e(v,i) = vi$ the infinitesimal distance from the start point e_0 to an end point infinitely close to e_0. This distance is accomplished by going along the surface for instance the distance dv in the v-direction, and the distance di in the i-direction. Thus, going the distance dv in the v direction, leads to the increase idv in height above the v,i-plane, and going the distance di in the i-direction, leads to the increase vdi in height above the v,i-plane, all in all leading to an increase in height that amounts to $de = idv + vdi$ as described by equation (3.18).

The distance on the surface from e_0 to a point infinitely close to e_0 could also be accomplished by first going the distance di in the i-direction, and then the distance dv in the v-direction. However, these two ways of getting from e_0 to the point infinitely close to e_0 are unambiguous, since the function e can be considered to be a plane for infinitesimal changes.

However, when discretization of equation (3.18) is done, we get for instance

$$\Delta e = i_0 \Delta v + v_1 \Delta i \quad \Leftrightarrow \quad (e_1 - e_0) = i_0(v_1 - v_0) + v_1(i_1 - i_0). \tag{3.19}$$

Consider the surface $e(v,i)$ again in Figure 3.3. The arrows indicate one of the possibilities of how to get from the starting point, e_0, to the endpoint, e_1, in the discrete case, by first going in the v-direction, and then in the i-direction – this alternative is also what equation (3.19) describes. However, there is also another possibility, not shown in the diagram, and that is to, starting at the same point e_0, instead first go in the i-direction, and then in the v-direction, to end up at e_1. Accordingly, since $e(v,i)$ is a non-linear function, there are two ways of going from e_0 to e_1, and thereby two ways to discretize equation (3.18). A common solution is to use the average of these two ways:[70]

$$\Delta e = i_0 \Delta v + v_1 \Delta i = i_1 \Delta v + v_0 \Delta i \tag{3.20}$$

$$= \frac{1}{2}(i_0 \Delta v + i_1 \Delta v) + \frac{1}{2}(v_1 \Delta i + v_0 \Delta i)\,. \tag{3.21}$$

---

[70] See Dietzenbacher and Los, 1998, and Miller and Blair, 2009. A number of other more sophisticated methods are available, see e.g. Hoekstra and van der Bergh, 2003.

We can now conclude, by saying that the change in $\Delta e = f(\Delta v) + g(\Delta i)$, where the functions f and g are given by the two terms of equation (3.21). When decomposing into more variables, the same approach as above is used. To arrive at the percentage contributions of the components, division by e_0 is done as in

$$100 \cdot \frac{\Delta e}{e_0} = 100 \cdot \frac{f(\Delta v)}{e_0} + 100 \cdot \frac{g(\Delta i)}{e_0} \,. \tag{3.22}$$

Applying this for IOA studies, i.e. performing structural decomposition analysis (SDA), yields that e.g. equation (3.15), i.e. $\boldsymbol{e}_c = \boldsymbol{E}_i \boldsymbol{L} \boldsymbol{y}$, can be decomposed for instance as

$$\Delta \boldsymbol{e}_c = \boldsymbol{E}_i^0 \boldsymbol{L}^0 \Delta \boldsymbol{y} + \boldsymbol{E}_i^0 \Delta \boldsymbol{L} \boldsymbol{y}^1 + \Delta \boldsymbol{E}_i \boldsymbol{L}^1 \boldsymbol{y}^1 \,. \tag{3.23}$$

It may at first seem strange in e.g. the second term above, to take the difference of $\boldsymbol{L}$, which is a matrix, when the difference $\Delta \boldsymbol{e}_c$ is a vector. That is however not any problem, since the second term is in fact $(\boldsymbol{E}_i^0 \boldsymbol{L}^1 \boldsymbol{y}^1 - \boldsymbol{E}_i^0 \boldsymbol{L}^0 \boldsymbol{y}^1)$ which is indeed a vector.

SDA is however only meaningful if the IOTs and subsequently $\boldsymbol{L}^1$ and $\boldsymbol{L}^0$ are available in constant prices. In this study we have not been able to obtain IOTs in constant prices, and consequently a SDA will not be performed. An IDA will however be performed, based on the results in equation (3.21) and (3.22) – see Chapter 4.4.3.

3.3.4 Swedish studies

Most of the studies utilizing IOA for estimating the environmental pressure caused by the Swedish economy, analyse a single year only. In 1998, Östblom made a study of CO_2, SO_2 and NO_x comparing them with Sweden's environmental goals.[71] In 2000, Statistics Sweden, analysed CO_2, SO_2 and NO_x.[72] In 2007, Carlsson-Kanyama et al., made a study of CO_2 using among others data from multidirectional MRIO databases.[73] The Swedish Environmental Protection Agency performed a similar study in 2008.[74]

Swedish IOA-based time series analyses are few. Decomposition analyses was performed in studies by Bergman[75] and Östblom[76] who analysed the change in Swedish energy use during the sixties and the seventies. Kander and Lindmark has performed long-term longitudinal studies for CO_2 covering up to two hundred years, though the IOA performed only include the twentieth century. They also

---

[71] Östblom, 1998.

[72] See Statistics Sweden, 2000 and an updated English version in Statistics Sweden, 2002b.

[73] Carlsson-Kanyama et al., 2007.

[74] Swedish EPA, 2008. Also referred to in Swedish EPA, 2010a, and Swedish EPA, 2010b. See Swedish EPA and Statistics Sweden, 2008, for detailed methods.

[75] Bergman, 1977.

[76] Östblom, 1980.

perform an EKC study based on their data.[77] Statistics Sweden made a SDA study in 2003 of CO_2.[78] Finally, in 2010 a study based on multidirectional MRIO for the years 1997, 2001 and 2004 was published.[79]

Most of these studies, show higher levels of pollutants compared to official production-based data, and in the latest MRIO study from 2010, emissions increased with time.[80] An exception is the long term studies by Kander and Lindmark mentioned above, though this is probably due to the employment of a SRIO model with Swedish emission intensities for the production occurring abroad.

The study presented in this report, will add to the earlier Swedish IOA-based time series analyses, by analysing, among others, the consumption-based emissions of CO_2 equivalents for a complete time series (1993–2005). This study will also test the EKC hypothesis against the development of the consumption-based CO_2 equivalents, which hasn't been done before on Swedish data. See Chapter 4 for details.

3.3.5 Uncertainties

Not so many studies have been performed analysing uncertainties in environmental input–output models.[81] The uncertainties range from aggregation errors[82] to incomplete data or data of low quality. The latter applies for instance in all the cases where input–output tables are not available for all years, or for all countries which a particular study analyses – in other words, a prevailing problem in all environmental IOAs.

The linearity, which is the basis of the input–output analysis, can be understood as an assumption introducing uncertainties in the results when final demand differs a lot from the original final demand from which the technological matrix originated. However, this ought to be a problem only in change-oriented studies or projections, where an analysis of the effects of some certain change on the margin is performed. In contrary, this present study could be considered as an accounting study, whose purpose only is to allocate the energy use or emissions which already have occurred.[83]

The problem of uncertainties in studies making use of exchange rates between countries – which is almost always the case in MRIO modelling and in some

---

[77] See Lindmark, 2001, and Kander and Lindmark, 2006.

[78] Statistics Sweden, 2003. Statistics Sweden also has a time series of CO_2 emissions available on their web page, see Statistics Sweden, 2011h.

[79] Peters and Solli, 2010.

[80] Ibid.

[81] See Wiedmann, 2009, for a literature survey. Hendrickson et al., 2006, gives an introduction to the subject, showing how Monte Carlo simulation can be employed.

[82] See Kymn, 1990, and Miller and Blair, 2009, for an overview of the aggregation problem in input–output analysis in general. Lenzen et al., 2004, analyses the problem of aggregation in connection to environmental IOAs.

[83] Finnveden and Moberg, 2005, make this distinction. In Brander et al., 2009, a similar distinction is made between consequential and attributional approaches to LCA studies.

cases in SRIO modelling as well – have been discussed by e.g. Weber in a study of the embodied emissions in US international trade. In Weber's study, using purchasing power parity (PPP) exchange rates for valuing products instead of market exchange rates (MER), yields almost 50 percent lower emissions.[84]

In this study uncertainties will be studied to the extent that the results are presented based on the PPP approach, with the Swedish intensities abroad approach and the MER approach as lower and upper bounds respectively.[85]

3.3.6 Other topics

A consideration in input–output models not discussed so far is the extent to which *investments* are used as inputs in the industry. The usual input–output table (e.g. the Swedish 2005 IOT, see Appendix E) doesn't consider investments as being inputs in the intermediate matrix, but instead consider them to be a part of the final demand. This means that the environmental repercussions coming from investments in e.g. factories or power plants, are not included in the environmental impacts occurring along the supply chain due to the consumption of some product. For instance, when a final user is consuming electricity from the energy sector, the CO_2 emissions occurring directly and indirectly due to the building of the nuclear power plant which produces the electricity, are excluded. These questions are addressed in open versus closed input–output models, and in the field of dynamic input–output modelling, and will be suggested as an area for further research.[86,87]

Another issue with interest for resource use research, is so called *supply-constrained input–output models*.[88] In normal models, the supply or the output is considered to be a function of the final demand, $\boldsymbol{x} = \boldsymbol{f}(\boldsymbol{y})$. In supply-constrained models, some parts of the output will be constrained, making the other parts of the output being a function of the constrained parts. Hence, the output of the non-constrained products is not only dependent on the final demand, but also on how much output the constrained products can deliver (in standard IO-models, there is no limit on how much output the various products can deliver). This subject has been studied for instance with respect to peak oil.[89]

---

[84] See Weber and Matthews, 2007. MER versus PPP is also discussed in e.g. ITPS, 2008, and Nordhaus, 2007, arguing for the PPP approach, and in Peters and Hertwich, 2009, arguing for the MER approach.

[85] Also, a short examination of the uncertainties in connection with the aggregation problem was done in an early stage of the study, but this will not be presented here.

[86] See Miller and Blair, 2009, although environmental considerations in connection with this issue is not discussed there.

[87] Including investments in this way would also solve the problem of not properly allocate the investments in the exports industry. These are now wrongly included in the domestic final demand.

[88] See Miller and Blair, 2009.

[89] Kerschner and Hubacek, 2009.

Chapter 4

Study-specific data and methods

In the previous chapter, we went through the theoretical foundations for the methods used in input–output analysis, and its environmental extension. In this chapter, we will describe the methods used in this specific study. This chapter assumes that the theory explained in Chapter 3 is already known, accordingly we will here only describe the specifics for this study and not go into particulars about the theory lying behind.

For detailed calculations and data, see the accompanying Excel database presented in Appendix F.

4.1 Organization

Data and methods used can be organized into the following parts:

ECONOMICAL DATA AND METHODS:

- Collection and pretreatment of economical data from SUTs and IOTs.
- Generation of IOT time series using updating methods for years missing official IOTs.
- Calculation of the Leontief inverse and the required production to meet final demand.

ENVIRONMENTAL DATA AND METHODS:

- Collection of domestic environmental data
- Calculation of domestic intensities
- Calculation of world average intensities

MASTER CALCULATIONS:

- The master expression
- Physical trade balances
- IPAT and EKCs
- Decomposition analysis
- Sector analysis
- Analysis of final demand categories

4.2 Economical data and methods

4.2.1 Collection and pretreatment of economical data from SUTs and IOTs

Supply tables, use tables and input–output tables are obtained from the Swedish national accounts at Statistics Sweden.[1] All these tables are available in two time series revisions, and both these revisions are parallelly used in the calculations:

- *Revision 1993–2003*: For each year a supply table in basic prices and a use table in market prices are obtained. IOTs are obtained for the year 1995 and 2000. The IOTs are subdivided into a domestic table, an imports table, and a total table (domestic plus imports).
- *Revision 2000–2005*: For each year a supply table in basic prices and a use table in market prices are obtained. IOTs are obtained for the year 2000 and 2005.[2] The IOTs are subdivided into a domestic table, an imports table, and a total table (domestic plus imports).

The original tables provided by the national accounts, are in sizes of 55 x 55 industries or products. Since the data from the environmental accounts are divided into 52 industries, all SUTs and IOTs are aggregated using an aggregation matrix, $\boldsymbol{G}$, which means that certain industries or products are put together, yielding 52 x 52 matrices, and vectors 52 elements long.[3] For vectors, e.g. total output and final demand, the aggregation is performed through e.g.[4]

$$\tilde{\boldsymbol{x}}_p = \boldsymbol{G}\boldsymbol{x}_p\,, \tag{4.1}$$

---

[1] Statistics Sweden, 2011c, 2006a, 2009, 2006b, and 2008.

[2] The IOT for 2000 from this latter time series revision, should not be confused with the IOT for 2000 from the former time series revision.

[3] The industries aggregated are shown in the accompanying Excel files, see Appendix F.

[4] See Appendix C for details about aggregation operations.

meaning that some of the rows in $\boldsymbol{x}_p$ are added and put together in $\tilde{\boldsymbol{x}}_p$. For the make and intermediate matrices the aggregation is done by e.g.

$$\tilde{\boldsymbol{S}} = \boldsymbol{G}\boldsymbol{S}\boldsymbol{G}' \,, \tag{4.2}$$

meaning that some of the rows and their corresponding columns are added and put together in $\boldsymbol{S}$ to form $\tilde{\boldsymbol{S}}$.

4.2.2 Generation of IOT time series using updating methods for years missing official IOTs

Since the official IOTs are published every five years only, IOTs for the missing years is calculated in the study. This is done beginning with a year where an official IOT in basic prices is available, e.g. year 2000, in order to use that year's division of domestic production, imports, and taxes less subsidies. The following steps are then undertaken:

1. The intermediate matrix in the IOT in market prices for year 2000 is generated from the SUTs from that year, through $\boldsymbol{F}_{gen} = \boldsymbol{U}\boldsymbol{S}_c'$. The final demand matrix $\boldsymbol{y}$ in the IOT in market prices for year 2000 is picked from the use table for that year.[5]
2. The shares of domestic production, imports, and taxes less subsidies are calculated for both the intermediate matrix of the IOT and the final demand table of the IOT. For the intermediate matrix, this is done by[6]

$$\boldsymbol{F}_d^r = \boldsymbol{F}_d \oslash \boldsymbol{F}_{gen} \,, \tag{4.3}$$

$$\boldsymbol{F}_m^r = \boldsymbol{F}_m \oslash \boldsymbol{F}_{gen} \,, \tag{4.4}$$

   and for the final demand matrix by

$$\boldsymbol{y}_d^r = \boldsymbol{y}_d \oslash \boldsymbol{y} \,, \tag{4.5}$$

$$\boldsymbol{y}_m^r = \boldsymbol{y}_m \oslash \boldsymbol{y} \,. \tag{4.6}$$

3. For any year (here called the calculation year) that is using the official IOT from year 2000 (see step 5 below), a domestic and an imports IOT is generated by firstly constructing an IOT in market prices (as in step 1 above), yielding $\tilde{\boldsymbol{F}}_{gen}$ and $\tilde{\boldsymbol{y}}$ (tilde above variables will here mean variables referring to the calculation year). Then $\tilde{\boldsymbol{F}}_d$, $\tilde{\boldsymbol{F}}_m$, $\tilde{\boldsymbol{y}}_d$ and $\tilde{\boldsymbol{y}}_m$ are calculated by using the ratios calculated in step 2 above, yielding

$$\tilde{\boldsymbol{F}}_d = \boldsymbol{F}_d^r \otimes \tilde{\boldsymbol{F}}_{gen} \,, \tag{4.7}$$

$$\tilde{\boldsymbol{F}}_m = \boldsymbol{F}_m^r \otimes \tilde{\boldsymbol{F}}_{gen} \,, \tag{4.8}$$

$$\tilde{\boldsymbol{y}}_d = \boldsymbol{y}_d^r \otimes \tilde{\boldsymbol{y}} \,, \tag{4.9}$$

$$\tilde{\boldsymbol{y}}_m = \boldsymbol{y}_m^r \otimes \tilde{\boldsymbol{y}} \,. \tag{4.10}$$

---

[5] Here $\boldsymbol{y}$ is considered a matrix, and not a vector as in all other calculations.

[6] See Appendix C for definition of the element-wise multiplication and division operators $\otimes$ and $\oslash$.

4. Finally, the calculated IOT for the calculation year, denoted by $\tilde{\boldsymbol{F}}_d$, $\tilde{\boldsymbol{F}}_m$, $\tilde{\boldsymbol{y}}_d$ and $\tilde{\boldsymbol{y}}_m$ are calibrated against the known sums of the real official $\tilde{\boldsymbol{x}}_p$ and $\tilde{\boldsymbol{m}}$ from the supply table from the calculation year. Since summing all the elements of $\tilde{\boldsymbol{F}}_d$ and $\tilde{\boldsymbol{y}}_d$ should yield the sum of $\tilde{\boldsymbol{x}}_p$ (see the tables in Appendix E), but may not actually do this since they are generated from the official IOT which applies for another year, the ratio between the sum of $\tilde{\boldsymbol{x}}_p$ to the sum of all elements in $\tilde{\boldsymbol{F}}_d$ and $\tilde{\boldsymbol{y}}_d$ is calculated, and then all elements in $\tilde{\boldsymbol{F}}_d$ and $\tilde{\boldsymbol{y}}_d$ is multiplied by this ratio. This guarantees that the new calibrated $\tilde{\boldsymbol{F}}_d$ and $\tilde{\boldsymbol{y}}_d$ sums up to the real official sum of $\tilde{\boldsymbol{x}}_p$. The same reasoning goes for the imports part of the IOT.[7]

5. The official IOTs used for the various years in these calculations, are the following:

   (a) Revision 1993–2003: For the years 1993–1997 the IOT from 1995 is used. For the years 1998–2003, the IOT from 2000 is used.

   (b) Revision 2000–2005: For the years 2000–2003 the IOT from 2000 is used. For the years 2004–2005, the IOT from 2005 is used.

4.2.3 Calculation of the Leontief inverse and the required production to meet final demand

The next step is to calculate the matrix of technical coefficients $\boldsymbol{A}$. Two versions are calculated, the domestic version $\boldsymbol{A}_d$ and the total version $\boldsymbol{A}_{tot} = \boldsymbol{A}_d + \boldsymbol{A}_m$:

$$\boldsymbol{A}_d = \boldsymbol{F}_d \hat{\boldsymbol{x}}_p^{-1}, \tag{4.11}$$

$$\boldsymbol{A}_{tot} = (\boldsymbol{F}_d + \boldsymbol{F}_m)\hat{\boldsymbol{x}}_p^{-1}, \tag{4.12}$$

where $\boldsymbol{F}_d$ and $\boldsymbol{F}_m$ are the calibrated intermediate domestic and imports matrices from the calculated IOT for the current calculation year, and $\boldsymbol{x}_p$ are the generated and calibrated $\boldsymbol{x}_p = \boldsymbol{F}_d\boldsymbol{i} + \boldsymbol{y}_d$. The real official $\boldsymbol{x}_p$ is not used, since it differs element-wise from the generated and calibrated one (even though their sums are equal), and this makes the calculations not completely consistent.

Based on that, the corresponding Leontief inverses are calculated as

$$\boldsymbol{L}_d = (\boldsymbol{I} - \boldsymbol{A}_d)^{-1}, \tag{4.13}$$

$$\boldsymbol{L}_{tot} = (\boldsymbol{I} - \boldsymbol{A}_{tot})^{-1}. \tag{4.14}$$

Next, the total production – generated domestically and abroad due to domestic final demand (i.e. exclusive exports) of domestically produced products ($\boldsymbol{y}_d^{nexp}$) and of products produced abroad ($\boldsymbol{y}_m^{nexp}$) – is calculated as $\boldsymbol{L}_{tot}\boldsymbol{y}_{tot}^{nexp}$, where $\boldsymbol{y}_{tot}^{nexp} = \boldsymbol{y}_d^{nexp} + \boldsymbol{y}_m^{nexp}$. That corresponds to the sum of the whole tree in Figure 3.2. The production generated domestically due to only domestic final demand (i.e.

---

[7] See Eurostat, 2008, for more advanced calibration procedures.

exclusive exports) of domestically produced products ($\boldsymbol{y}_d^{nexp}$) on the other hand, is calculated as $\boldsymbol{L}_d\boldsymbol{y}_d^{nexp}$. That corresponds to the sum of the nodes on the left edge of the tree in Figure 3.2. And finally, the products produced abroad only – due to domestic final demand (i.e. exclusive exports) of domestically produced products and of products produced abroad – then becomes $\boldsymbol{L}_{tot}\boldsymbol{y}_{tot}^{nexp} - \boldsymbol{L}_d\boldsymbol{y}_d^{nexp}$. Note though, that feedback effects are not taken into account here, i.e. the share of products produced abroad will probably be slightly too big since some of the imports have probably further back in the supply chain been produced in Sweden as exports. See also Chapter 3.3.1.

To summarize, required production produced in Sweden is

$$\boldsymbol{L}_d\boldsymbol{y}_d^{nexp}\,, \tag{4.15}$$

and required production abroad is

$$\boldsymbol{L}_{tot}\boldsymbol{y}_{tot}^{nexp} - \boldsymbol{L}_d\boldsymbol{y}_d^{nexp}\,. \tag{4.16}$$

The domestic production caused by our exports is also interesting, and it can be expressed as

$$\boldsymbol{L}_d\boldsymbol{y}_d^{exp}\,, \tag{4.17}$$

where $\boldsymbol{y}_d^{exp}$ is the exports part of the final demand of domestically produced products only (thus not including imports going to exports).

4.3 Environmental data and methods

4.3.1 Collection of domestic environmental data

Environmental pressure from industry, including bunkers

Environmental data are obtained from the environmental accounts from Statistics Sweden.[8] The data comes from a newly revised time series (March, 2011) covering the period 1993–2005. Here the time series is pertaining to one revision only, i.e. the same methods are used throughout the whole time series.

The data include bunkers, i.e. resource use and emissions data due to international aviation and sea transports. This differs from the official UNFCCC data.[9] Thus, even though these data from Statistics Sweden are purely production-based, they are still higher than the official production-based UNFCCC data. Bunkers are used by both Swedish users and users from the rest of the world (e.g. domestic and foreign shipping companies), which may suggest Swedish users get allocated

---

[8] See Statistics Sweden, 2011d. For methods used by the environmental accounts to obtain the data, see also Statistics Sweden, 2004, and Statistics Sweden, 2005.

[9] The reporting done by Sweden to UNFCCC, the United Nations Framework Convention on Climate Change. See Swedish EPA, 2011.

too much. However, since Swedish users also use bunkers in other parts of the world and that use is not included in the calculations, it may even itself out. In lack of data covering the allocation of bunker use between domestic and foreign users in Sweden, this is the best method available.[10]

The energy resource part of the data from Statistics Sweden, refer to total final consumption of these resources, i.e. transformation losses during processing of the primary energy source, is not included.[11]

For every year in the time series, these environmental data are organized in a resource use and emissions x industry matrix, $\boldsymbol{E}_{ind}$, where e_{ij}^{ind} refers to resource uses or emissions of type i generated by the production in industry$j$. The resource uses and emissions i are the following 15 variables:

- *Energy resource use types*: Aviation fuels, other petroleum products, fuel oil 1, fuel oil 2–5, engine petrol, diesel oil, solid fossils, and fossil gases (measured as TJ/year).
- *Emissions*: CO_2, CH_4, N_2O, SO_2, NO_x, CO, and NMVOC (measured as Mt/year).

Environmental pressure from direct use

In addition to these environmental data of resource use and emissions in the industry (which will be used in the IOA calculations) the direct use of resource uses or emissions by final consumers need be added to the total calculations. These data correspond to the environmental direct use box, in the right lower corner of Figure 3.1. This is the resource uses or emissions occurring downstream after consumption during the usage phase, e.g. heating of housing and transports.

These data are obtained from the same data sets from the environmental accounts as the data above, but will for the analysis be organized into a separate vector $\boldsymbol{e}_{dir}$, where e_i^{dir} refers to energy resource use or emission of type i. In reality $\boldsymbol{e}_{dir}$ is separated into columns denoting different consumer categories (non-profit organizations' use, public use, and private use), but here these columns are added together and treated as one column.

Official data

For comparison, official production-based data corresponding to the environmental variables listed above, are obtained from Statistics Sweden (include bunkers),[12] the Swedish energy authority (include bunkers),[13] and from the Swedish reporting to UNFCCC (exclude bunkers).[14]

---

[10] Statistics Sweden, 2011b. See Cadarso et al., 2010, for a recent attempt to develop a new methodology in this field.

[11] Statistics Sweden, 2011b.

[12] Statistics Sweden, 2011d.

[13] Swedish Energy Agency, 2010.

[14] Swedish EPA, 2011.

4.3.2 Calculation of domestic intensities

Firstly, the matrix $\boldsymbol{E}_{ind}$ need to be transformed to obtain the resource uses or emissions generated per product (see equation (3.3)). This is done by

$$\boldsymbol{E}_p = \boldsymbol{E}_{ind}\boldsymbol{S}'_c\,, \tag{4.18}$$

where e^p_{ij} refers to the resource use or emissions type i generated by product j. Thereafter the Swedish environmental intensity matrix $\boldsymbol{E}^{swe}_i$ is calculated by

$$\boldsymbol{E}^{swe}_i = \boldsymbol{E}_p\hat{\boldsymbol{x}}_p^{-1}\,, \tag{4.19}$$

where $\boldsymbol{x}_p$ is the calibrated total production values for the various products over a year ($\boldsymbol{x}_p = \boldsymbol{F}_d\boldsymbol{i} + \boldsymbol{y}_d$, $\boldsymbol{F}_d$ and $\boldsymbol{y}_d$ obtained in the calibration procedure explained in Chapter 4.2.2). Note that $\boldsymbol{x}_p$ accordingly refers to gross output from the homogeneous industries, and not the value added numbers. In $\boldsymbol{E}^{swe}_i$ the element $e^{i,swe}_{ij}$ refers to the intensity of energy resource use or emission type i, in the production of product j.

4.3.3 Calculation of world average intensities

World average intensities approach

In order to estimate the resource uses and emissions Swedish final demand causes abroad, world average intensities are used. The reason for this is that it is reasonable to believe that production occurring abroad is more resource use and emissions intensive than Swedish production, thus world average intensities yield more accurate estimates of resource use and emissions than Swedish intensities would provide.

It could be argued though, that the production abroad should be attributed intensities depending on where the production is imported from.[15] Two problems exist with such an approach though. Firstly, in the Swedish statistics of imports, only information of the dispatching countries are shown, thus information about the country of origin where the products were produced and where the resource use or emissions took place, is not known.[16] Investigations done in the 1990s suggested most of the dispatching countries where the same as the country of origin,[17] but it is hard to know how much this has changed since then. Secondly, the products produced abroad to satisfy our final demand, are not only produced in the countries we are importing from, but also in countries that our import countries in their turn import from, and so on through the whole supply chain. It may be that a large portion of the indirect inputs come from other more resource and emissions intensive countries.[18,19]

---

[15] This method is applied in Statistics Sweden, 2000, and in Swedish EPA and Statistics Sweden, 2008.

[16] Statistics Sweden, 2000, Swedish EPA, 2008, and Swedish EPA, 2010b.

[17] Statistics Sweden, 2000.

[18] Swedish EPA, 2008.

[19] E.g. exports from China to Europe constitutes a considerable part of Europe's CO_2 emissions, see Davis and Caldeira, 2010. See also Andersen et al., 2010, for transports from China.

Accordingly, intensities from our direct import countries may yield too low values of the emissions our final demand causes abroad. On the other hand world average intensities may yield too high values, since these intensities are higher than typical values from the European countries which we are importing from – somewhere around 20 % higher in 2005 for CO_2.[20] But again, an unknown part of what we import from European countries, may actually have been produced somewhere else, so the true values may be somewhere in between. A more detailed analysis of these matters will be suggested for further research.

When it comes to the calculations of the world average intensities, the approach used in this study is to calculate the ratio between world intensities of resource uses or emissions per dollar GDP to Swedish intensities of resource uses or emissions per dollar GDP, and then multiply this ratio with the Swedish environmental per-product intensities (see details below). The world intensities (e.g. emissions per GDP) can not be used directly, since the Swedish output resulting from the IOA part of the study, refers to gross output from the industries and not from the value added obtained in the industries.

Data

All GDP data is obtained from the World Bank.[21] Swedish GDP and World GDP are used, covering the whole period 1993–2005. Two different GDP time series with different calculation methods are used. One uses the purchasing power parity (PPP) method in constant 2005 international dollars – this is the time series we mainly will use. The other time series uses market exchange rates (MER) in constant 2000 US dollars – this time series will be used as a comparison only.

The reason for using the PPP approach, is that the allocation of Swedish-induced emissions abroad will be estimated too high with the MER-based GDP, due to the fact that MER-based GDP underestimates the output produced in the world (when GDP is underestimated, the numerator in the ratio used to calculate the world average intensity, will be too high).[22] Some argue that the MER approach should still be used, since products traded over borders are in fact valued MER.[23] However, in this present study the argument is that the exports from the ROW receives a too big share of the output from the ROW when the output of the ROW is valued at MER, since the output from the ROW, going both to exports and to domestic use, is really higher according to the PPP approach. Thus, the exports' (from the ROW) share in the responsibility for producing emissions there, is not as high.

World energy resource use data is obtained from IEA, with a time series covering the whole period used in this study (1993–2005).[24] The variables used from the

---

[20] Based on Statistics Sweden, 2011g, and World Bank, 2010.

[21] World Bank, 2010.

[22] ITPS, 2008, has the same reasoning.

[23] E.g. Weber and Matthews, 2007, and Peters and Hertwich, 2009. Nordhaus, 2007, gives a contrary view.

[24] IEA, 2010.

IEA database are oil, coal and gas. Note that these data refer to total final consumption of energy, and not to total primary energy demand. The reason for this is that the Swedish data refer to total final consumption of energy, i.e. transformation losses when converting energy resources to the kind of energy used, are excluded.

World emissions data is obtained from the EDGAR database, newly revised to cover time series up to the year 2005.[25] The variables used from the EDGAR database is CO_2, CH_4, N_2O, SO_2, NO_x, CO, and NMVOC.

World energy resource use and emissions data are assembled into the vector $\boldsymbol{e}_{world}$.

All Swedish energy resource uses and emissions data used in the world average intensities calculations are obtained from the Swedish environmental accounts as in the calculations of the domestic intensities above. The data used are the sums of the energy resource uses and emissions in both industry and as direct use, assembled into the vector $\boldsymbol{e}_{swe} = \boldsymbol{E}_p \boldsymbol{i} + \boldsymbol{e}_{dir}$. It could be argued that the environmental data for Sweden ought to be obtained from the same sources as the environmental data from the world above. However, the environmental data for Sweden from these sources were found to differ too much from the Swedish environmental accounts data, and it is reasonable to believe that Swedish environmental accounts data are more reliable.

Calculations

Two vectors, $\boldsymbol{k}_{PPP}$ and $\boldsymbol{k}_{MER}$ are compiled describing the ratio of world intensity to Swedish intensity. For the PPP case, each cell in these vectors are calculated as

$$k_i^{PPP} = \frac{e_i^{world}/GDP_{PPP}^{world}}{e_i^{swe}/GDP_{PPP}^{swe}} \tag{4.20}$$

where k_i^{PPP} refers to the world–Sweden intensity ratio for the resource use or emission type i, e_i^{world} (which comes from the vector $\boldsymbol{e}_{world}$ defined above) refers to the total amount of that resource use or emission type i generated during a year for the world, and e_i^{swe} (which comes from the vector $\boldsymbol{e}_{swe}$ defined above) refers to the total amount of that resource use or emission type i generated during a year for Sweden. Since $\boldsymbol{e}_{world}$ are obtained in a more aggregate version than $\boldsymbol{e}_{swe}$ (in $\boldsymbol{e}_{swe}$ there are for instance six categories of oil, and in $\boldsymbol{e}_{world}$ there are just one category of oil), some of the elements in $\boldsymbol{e}_{swe}$ are added together before the cells in $\boldsymbol{k}_{PPP}$ are calculated.[26]

Finally, to obtain the world average intensities, every column in the matrix $\boldsymbol{E}_i^{swe}$ are multiplied element-wise with column vector $\boldsymbol{k}_{PPP}$ to obtain the matrix $\boldsymbol{E}_i^{PPP}$, which is done by first diagonalizing $\boldsymbol{k}_{PPP}$ to $\hat{\boldsymbol{k}}_{PPP}$ and then do

$$\boldsymbol{E}_i^{PPP} = \hat{\boldsymbol{k}}_{PPP} \boldsymbol{E}_i^{swe} . \tag{4.21}$$

The corresponding calculations are carried out to obtain $\boldsymbol{E}_i^{MER}$.

---

[25] EDGAR, 2010. This database is used by WRI among others, see WRI, 2011.

[26] See the accompanying Excel database for details (Appendix F).

4.4 Master calculations

4.4.1 The master expression

At this stage, we put all previous calculations together, to produce the main results. The master expression then obtained can be expressed as

$$(4.22) \qquad \mathit{Environmental\,pressure} \;=\; \mathit{Domestic} \;+\; \mathit{Abroad} \;+\; \mathit{Direct\,use}\,.$$

Domestic means all resource uses or emissions generated in Sweden due to Swedish final demand of domestic products. *Abroad* means resource uses or emissions generated abroad due to Swedish final demand of domestic products and of products produced abroad. *Direct use* means resource uses or emissions generated by Swedish final consumers in the usage phase of products (e.g. heating, transports).

More formally, the master expression is expressed as

$$(4.23) \qquad \tilde{\boldsymbol{e}}_{tot} \;=\; \boldsymbol{G}\,(\,\boldsymbol{E}_i\boldsymbol{L}_d\boldsymbol{y}_d^{nexp} \;+\; \hat{\boldsymbol{k}}\boldsymbol{E}_i(\boldsymbol{L}_{tot}\boldsymbol{y}_{tot}^{nexp} - \boldsymbol{L}_d\boldsymbol{y}_d^{nexp}) \;+\; \boldsymbol{e}_{dir}\,)\,,$$

and this calculation is performed for every year in the two time series revisions 1993–2003, and 2000–2005.

The aggregation matrix $\boldsymbol{G}$ is used to aggregate the various environmental parameters listed in Chapter 4.3.1, yielding the aggregated vector $\tilde{\boldsymbol{e}}_{tot}$ which now contains the following environmental parameters:[27]

- *Energy resource uses types*: Oil, coal, gas and total fossil fuel use (measured as TWh/year).
- *Emissions*: CO_2, CH_4, N_2O, CO_2eq, SO_2, NO_x, CO, and NMVOC (measured as Mt/year).

In the vector $\tilde{\boldsymbol{e}}_{tot}$, $\tilde{e}_i^{tot}$ refers accordingly to the resource use or emission of type i generated totally upstream through the whole supply chain, and downstream including the usage phase and the disposal phase.[28] The world–Sweden intensity ratio $\boldsymbol{k}$ is diagonalized to $\hat{\boldsymbol{k}}$ in order to be able to multiply it with the resource use or emissions-based Swedish intensities.

Some variations of equation (4.23) are calculated. With $\hat{\boldsymbol{k}}$ as $\hat{\boldsymbol{k}}_{PPP}$ or $\hat{\boldsymbol{k}}_{MER}$ the environmental load based on PPP-based GDP or MER-based GDP are determined. With $\hat{\boldsymbol{k}} = \boldsymbol{I}$ the environmental load based on Swedish intensities for production abroad, are determined.

---

[27] See the accompanying Excel database (Appendix F), too see the exact structure of $\boldsymbol{G}$. For CO_2eq, the following weights are used: 1 for CO_2, 21 for CH_4 and 310 for N_2O. See Fuglestvedt et al., 2003. A similar aggregation approach for constructing CO_2eq is used in Lenzen, 1998.

[28] The disposal phase is included to that extent that waste services are a part of the industry.

4.4.2 Physical trade balances

The resource use and emissions caused by exports are calculated as

$$\tilde{\boldsymbol{e}}_{exp} = \boldsymbol{G}\boldsymbol{E}_i\boldsymbol{L}_d\boldsymbol{y}_d^{exp}\,, \tag{4.24}$$

where $\boldsymbol{y}_d^{exp}$ is the exports part of the final demand of domestically produced products (imports going to exports not included). Based on this result and the middle term in equation (4.23), a physical trade balance for resource uses or emissions is calculated as

$$\boldsymbol{G}\,(\boldsymbol{E}_i\boldsymbol{L}_d\boldsymbol{y}_d^{exp} - \hat{\boldsymbol{k}}_{PPP}\boldsymbol{E}_i(\boldsymbol{L}_{tot}\boldsymbol{y}_{tot}^{nexp} - \boldsymbol{L}_d\boldsymbol{y}_d^{nexp}))\,. \tag{4.25}$$

4.4.3 Decomposition analysis

Equation (4.23) is in itself decomposed into three terms. However, it is also possible to decompose the middle term into the contribution from $\boldsymbol{k}$ and the contribution from the rest of that term, in order to analyse how much of the change in environmental pressure abroad is caused by the change in the intensities abroad, or by the change in impact abroad if Swedish intensities applied.

Analysing a certain environmental variable e_i,[29] we have equation (4.23) as

$$e_i = \boldsymbol{e}_i^i\boldsymbol{L}_d\boldsymbol{y}_d^{nexp} + k_i\boldsymbol{e}_i^i(\boldsymbol{L}_{tot}\boldsymbol{y}_{tot}^{nexp} - \boldsymbol{L}_d\boldsymbol{y}_d^{nexp}) + e_i^{dir}\,, \tag{4.26}$$

where $\boldsymbol{e}_i^i$ is a row vector with intensities for the environmental variable i, and e_i^{dir} is the sum of direct use of resource uses or emissions for the environmental variable i.

Now, if we denote the right side of the middle term in equation (4.26) as $m_i{=}\boldsymbol{e}_i^i(\boldsymbol{L}_{tot}\boldsymbol{y}_{tot}^{nexp} - \boldsymbol{L}_d\boldsymbol{y}_d^{nexp})$ – thus the middle term becomes equal to k_im_i – we can decompose the middle term into $f(\Delta k_i) + g(\Delta m_i)$, to see the effects of changing k_i and the effects of changing m_i. We also denote the leftmost term as $e_i^d = \boldsymbol{e}_i^i\boldsymbol{L}_d\boldsymbol{y}_d^{nexp}$, in order to make the following equation easier to read. Relying on the results in equation (3.21) and (3.22), the decomposition of equation (4.26) then becomes

$$100\cdot\frac{\Delta e_i}{e_i^0} = 100\cdot\frac{\Delta e_i^d}{e_i^0} + 100\cdot\frac{f(\Delta k_i)}{e_i^0} + 100\cdot\frac{g(\Delta m_i)}{e_i^0} + 100\cdot\frac{\Delta e_i^{dir}}{e_i^0}\,, \tag{4.27}$$

and the components $f(\Delta k_i)$ and $g(\Delta m_i)$ are

$$f(\Delta k_i) = \frac{1}{2}(m_i^0\Delta k_i + m_i^1\Delta k_i)\,, \tag{4.28}$$

$$g(\Delta m_i) = \frac{1}{2}(k_i^0\Delta m_i + k_i^1\Delta m_i)\,. \tag{4.29}$$

To obtain a decomposition diagram of equation (4.27), the "deltas" are changed consecutively from the base year up to the end year of the time series.

---

[29] Index tot and tilde stripped from $\tilde{e}_i^{tot}$ for making it easier to read.

4.4.4 IPAT and consumption–environmental impact relationships

IPAT diagrams and consumption–environmental impact diagrams are also generated in order to see if any decoupling or EKC patterns can be detected. For a certain resource use or emission type i in $\tilde{\boldsymbol{e}}_{tot}$ from equation (4.23), the IPAT is formed as[30]

$$100 \cdot \frac{e_i^t}{e_i^0} = 100 \cdot \frac{P^t}{P^0} \times 100 \cdot \frac{(C/P)^t}{(C/P)^0} \times 100 \cdot \frac{(e_i/C)^t}{(e_i/C)^0}\ , \tag{4.30}$$

where t runs over all years studied, and 0 indicates base year, P is population, C is final demand less exports in constant prices.[31] Note that C is used, not $\boldsymbol{y}_{tot}^{nexp}$, since the latter is not in constant prices.

Consumption–environmental impact diagrams are generated by plotting e_i against final demand less exports per capita in constant prices. The Swedish values in constant prices are converted to dollars using a fixed exchange rate from 2005.[32]

4.4.5 Product groups analysis

The effect of the final demand of specific product groups for certain sectors is done by applying equation (4.23) and in $\boldsymbol{y}_d^{nexp}$ and $\boldsymbol{y}_{tot}^{nexp}$ cancel all elements out except for the ones which product groups are to be analysed. The use of $\boldsymbol{e}_{dir}$ is not relevant here, since $\boldsymbol{e}_{dir}$ doesn't belong to any product group.

4.4.6 Analysis of final demand categories

The environmental pressure caused by various categories of final demand (i.e. households, public sector, investments and exports), is obtained by applying equation (4.23), but using $\boldsymbol{y}_d$ and $\boldsymbol{y}_{tot}$ rather than $\boldsymbol{y}_d^{nexp}$ and $\boldsymbol{y}_{tot}^{nexp}$. Furthermore, in $\boldsymbol{y}_d$ and $\boldsymbol{y}_{tot}$ all columns are removed except for the column which final demand category is to be analysed (thus $\boldsymbol{y}_d$ and $\boldsymbol{y}_{tot}$ are considered matrices with several columns which represent the various categories of final demand – in all other calculations, the final demand vector is considered to be the sum of all final demand category columns). The use of $\boldsymbol{e}_{dir}$ is excluded in these calculations.

---

[30] Index tot and tilde stripped from $\tilde{e}_i^{tot}$ for making it easier to read.

[31] Population data and consumption data in constant prices from Statistics Sweden, 2011e, and Statistics Sweden, 2011f.

[32] World Bank, 2010.

Chapter 5

Results

In the previous chapter we went through the detailed methods used in this study. In this chapter we will present the results generated by those methods. The results are organized into the following sections:

- Time series of environmental impact in domestic, abroad, and direct use components. Diagrams for all energy use and emission variables studied.
- Decomposition analysis for oil use, and for CO_2, CH_4 and SO_2 emissions.
- IPAT-diagrams for fossil fuel use, and for CO_2, CH_4 and SO_2 emissions.
- Diagrams for analysing consumption–environmental impact relationships (decoupling and EKC patterns), for fossil fuel use, and for CO_2, CH_4 and SO_2 emissions.
- Product groups analysis for fossil fuels, and for CO_2 equivalents. This means analysing how the consumption of various product groups affect the environment.
- Emissions of CO_2 equivalents distributed over the categories of final demand.

In some instances above where analysis is not done on all environmental variables, a more comprehensive results table is available in Appendix G. For all results, see the accompanying Excel database (introduced in Appendix F).

Sources for production-based data in the diagrams, and indications whether these include bunkers or not, are given in the figure captions. For sources and methods concerning consumption-based data in the diagrams, see Chapter 4. All consumption-based data are based on environmental accounts data which include the use of bunkers. All consumption-based results including resource use and emissions abroad are based on the PPP assumption, if not otherwise indicated – see Chapter 4.3.3 for details.

5.1 Environmental impact from production in Sweden and abroad, and from direct use

In Figure 5.1–5.3, the consumption-based environmental impact is presented for all the environmental variables analysed in the study. The diagrams in these figures correspond to equation (4.22) and (4.23) in Chapter 4.4.1. That is, *total consumption-based* environmental impact is divided into *domestic* impact (due to domestic final demand of domestic products), impact *abroad* (due to domestic final demand of domestic and imported products), and impact in *direct use* (impact due to e.g. heating of housing and transports by final consumers). *Production-based* data are included in the diagrams as a comparison.

Data for total consumption-based impact, domestic impact, and impact abroad, come in two time series revisions – 1993–2003 and 2000–2005 – and for that reason these curves are shown doubled for the years 2000–2003.

For energy uses (Figure 5.1), direct use seems to be declining a little bit, while use caused abroad is increasing slightly, resulting in a neither decreasing or increasing trend in total consumption-based energy use.

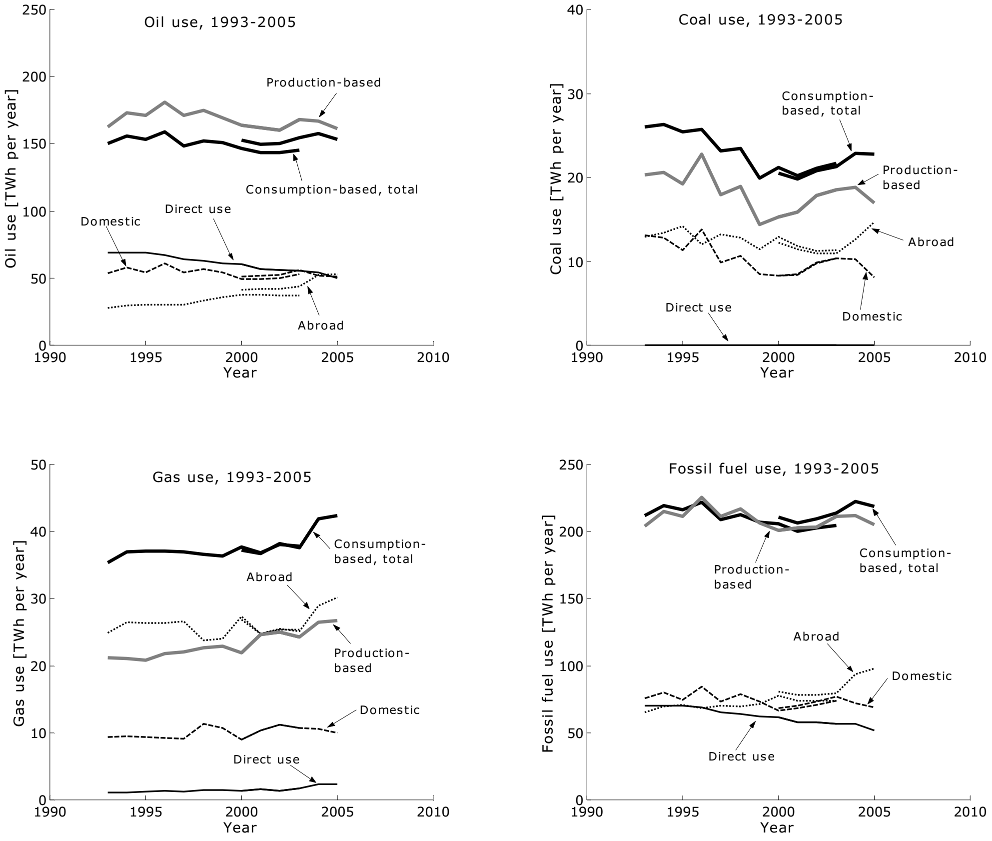


Figure 5.1. Consumption-based time series of oil use, coal use, gas use, and fossil fuel use. *Source*: Production-based data from Statistics Sweden, 2011d (including bunkers).

For the greenhouse gases (Figure 5.2), an increasing trend for the consumption-based data is detectable, going contrary to the emissions from the production-based UNFCCC data. This is most evident in the case of CH_4, which probably is explained by a strong increase in net imports of food and agricultural products.[1] In the aggregate, emissions of CO_2eq increased approximately 20 % in the period.

For SO_2 and NO_x (Figure 5.3), the emissions are declining in the first time series, but in the second time series they come at a higher level, and are possibly on the rise. The reason for this large discrepancy between the time series seems to be due to a large reclassification in the new time series revision of exports of shipping services (i.e. sea transports), with a decrease of about 20 %. Since exports and all their indirect effects are deducted from the calculations, emissions caused by domestic final demand will then increase, especially since the shipping industry is very emissions intensive.[2]

For CO and NMVOC (Figure 5.3), emissions decline. At the same time, however, the component of emissions abroad increase.

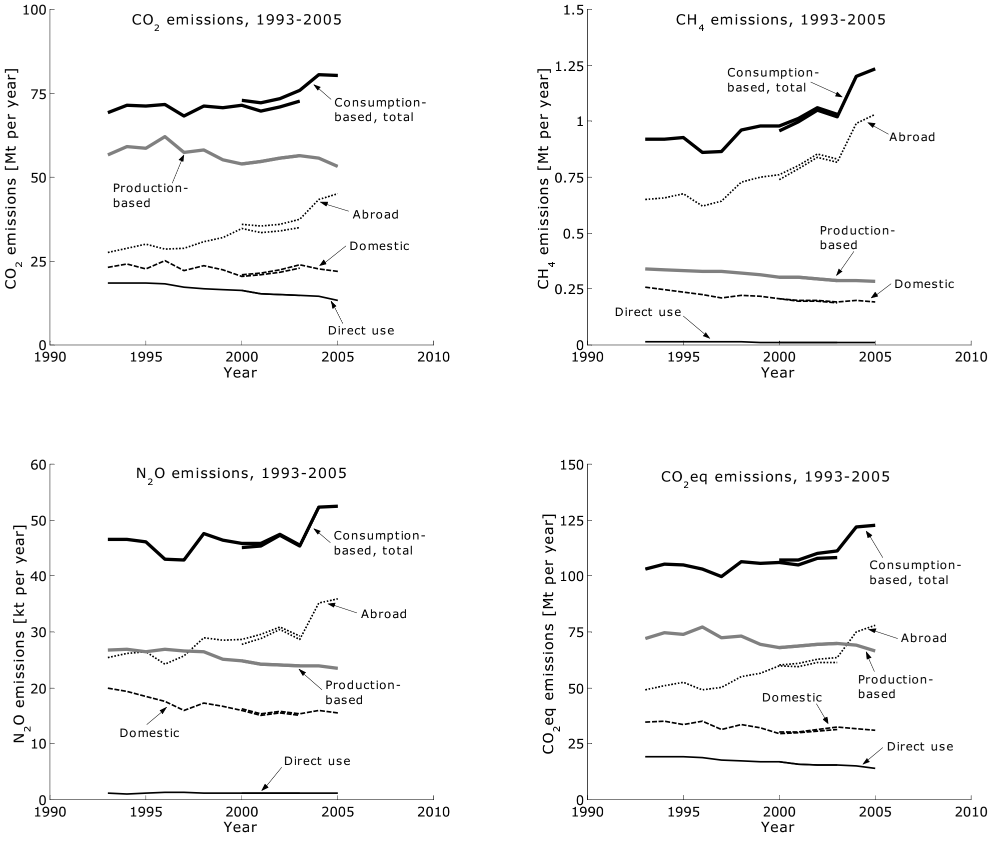


Figure 5.2. Consumption-based time series of greenhouse gas emissions. *Source*: Production-based data from Swedish EPA, 2011 (UNFCCC; excluding bunkers).

---

[1] Increased by more than 30 % in the period 2000–2005 – see Statistics Sweden and Swedish Board of Agriculture, 2006.

[2] Confirmed by Statistics Sweden, 2011b. Also, the data in the new time series revision are considered to have higher quality according to Statistics Sweden, 2011a.

Table 5.1 shows data for fossil fuel use and CO_2 equivalents, with consumption-based data based on three different assumptions: the PPP assumption, the MER assumption, and the assumption of Swedish intensities for production abroad (see Chapter 4.3.3 for details about these assumptions). Using the assumption of Swedish intensities yields similar values as the official production-based data. Using the MER assumption yields even higher values than the PPP assumption. The intensity ratio refers to the ratio between world intensities and Swedish intensities.

The physical trade balances refer to the net exports of fuel use or emissions. A positive value means that the energy use or emissions occurring on the Swedish territory due to the consumption abroad of Swedish products, are higher than the energy use or emissions occurring abroad due to Swedish final demand. Negative values mean that the energy use or emissions occurring abroad due to our final demand are higher than the energy use or emissions occurring in Sweden due to our exports. The physical trade balances for fossil fuel use and CO_2 equivalents show negative values, and in particular for CO_2 equivalents these negative values are growing (i.e. growing even more negative).

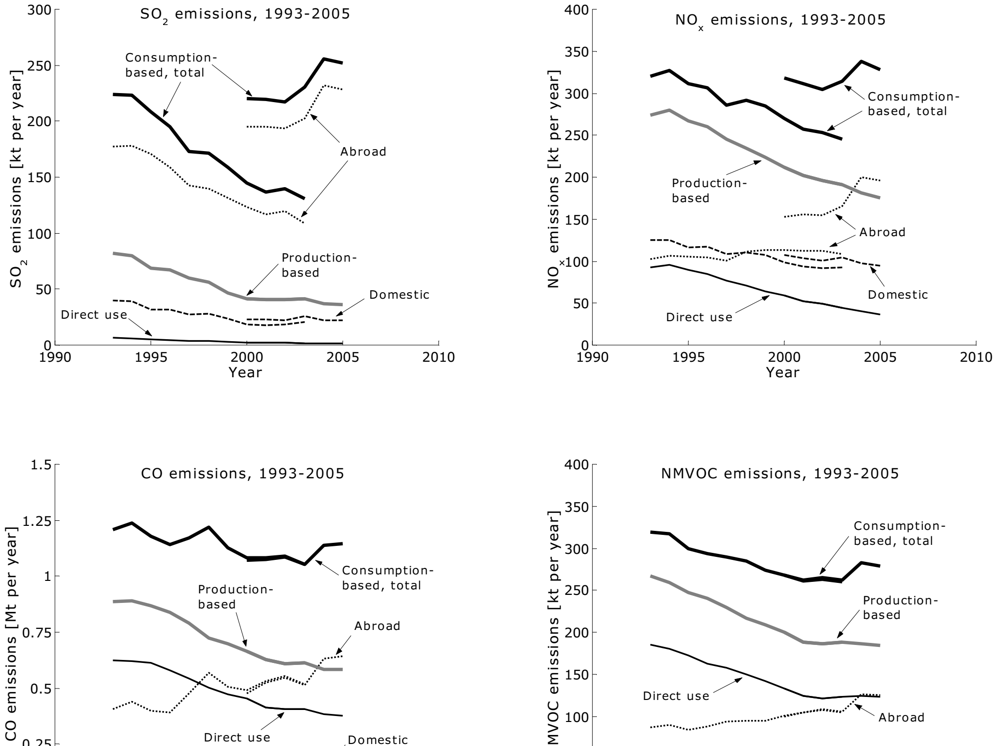


Figure 5.3. Consumption-based time series of SO_2, NO_x, CO and NMVOC emissions. *Source*: Production-based data from Swedish EPA, 2011 (UNFCCC; excluding bunkers).

Table 5.1. Consumption-based and production-based data, and physical trade balance, for fossil fuel use and CO_2 equivalents. Cons. (PPP) refers to the PPP assumption; analogous for the other similar row captions. *Source*: Production-based data from Statistics Sweden, 2011d (fossil fuel use, including bunkers) and from Swedish EPA, 2011 (UNFCCC; CO_2eq emissions, excluding bunkers).

Variable \ Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004	2005
Economy																	
Population (1000s)	8719	8781	8827	8841	8846	8851	8858	8872	8896	8925	8958	8872	8896	8925	8958	8994	9030
Dom. FD/cap ($/year)	28807	29675	30293	30603	31205	32683	33921	35281	35261	35705	36287	35281	35261	35705	36287	36916	37845
Fossil fuels (TWh/year)																	
Cons. (PPP)	212	219	216	221	209	212	207	206	200	203	205	210	206	209	213	222	219
Cons. (MER)	237	246	244	249	237	240	236	238	231	235	237	244	239	243	249	265	264
Cons. (swe. int.)	188	195	189	198	182	189	180	174	172	174	177	178	177	180	185	188	180
Int. ratio (PPP)	1.58	1.53	1.61	1.51	1.60	1.52	1.61	1.70	1.63	1.63	1.61	1.66	1.59	1.60	1.56	1.59	1.66
Phys. trade balance	-7.78	-4.58	-4.54	4.15	2.65	4.39	-0.77	-4.76	2.37	0.47	6.44	-9.38	-3.93	-6.38	-2.52	-10.47	-13.82
Production-based	204	215	211	226	211	217	206	201	203	203	211	201	203	203	211	212	205
CO_2eq (Mt/year)																	
Cons. (PPP)	103	105	105	103	100	106	106	106	105	108	108	107	107	110	111	122	123
Cons. (MER)	122	125	126	123	120	128	129	131	130	134	135	132	133	137	139	156	159
Cons. (swe. int.)	75	76	74	75	70	74	71	69	68	69	70	70	70	71	72	75	72
Int. ratio (PPP)	2.36	2.31	2.41	2.30	2.40	2.42	2.55	2.61	2.62	2.69	2.66	2.59	2.60	2.67	2.63	2.70	2.83
Phys. trade balance	-27	-26	-26	-21	-21	-26	-29	-32	-30	-33	-31	-33	-32	-35	-34	-43	-47
Production-based	72	75	74	77	73	73	70	68	69	69	70	68	69	69	70	69	66

5.2 Decomposition analysis

In order to determine the various components contributing to the change in environmental pressure, an additive index decomposition analysis has been undertaken. In Figure 5.4, the results for the period 2000–2005, for oil use, and for CO_2, CH_4 and SO_2 emissions, are shown. The results for the other variables, and for the period 1993–2003 are available in the accompanying Excel database – see Appendix F.

The decomposition analysis involves the examination of how much the various components analysed contribute to the total percentage change in energy use or emissions in the period. Here, the components in the diagrams are *domestic* energy use or emissions caused by Swedish final demand for domestic products, energy use or emissions *abroad* if Swedish intensities applied, *intensity ratio* between world intensity and Swedish intensity, and energy use or emissions in *direct use.*

The decomposition of environmental pressure abroad into an intensity ratio component (i.e. ratio between world and Swedish intensity) and a "neutral" abroad component, entails the possibility to analyse how much the change in pressure abroad is caused by changing world intensities in relation to Swedish intensities,

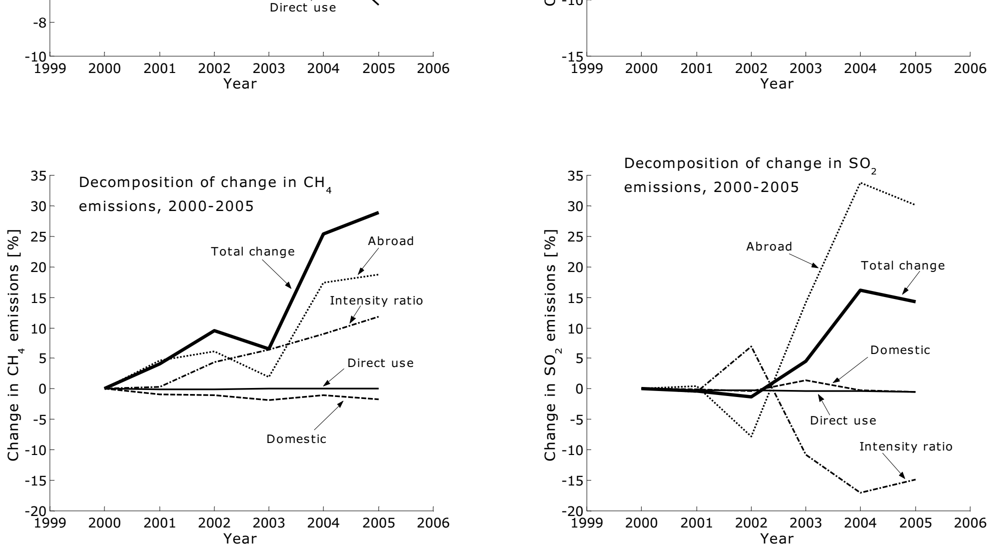


Figure 5.4. Decomposition analysis of change in oil use, and in CO_2, CH_4 and SO_2 emissions, in the period 2000–2005.

or by changing impact abroad due to Swedish final demand when Swedish intensities apply. See Chapter 4.4.3 for details regarding the calculations used in this decomposition analysis.

As have been noted earlier, the decline in direct use for oil use is counteracted by the energy use or emissions caused by our demand for foreign produced products and their inputs through the supply chain abroad. For CO_2 most of the change comes from higher levels of emissions from products produced abroad, and to some extent, worsened emission intensities of the world relative the intensities of Sweden. The same applies to CH_4 in an even higher degree. For SO_2 total emissions rise, even though the component of intensity ratio between the world intensity and the intensity of Sweden declines.

5.3 IPAT diagrams

In Figure 5.5, IPAT diagrams for fossil fuel use, and CO_2, CH_4 and SO_2 emissions are presented for the period 2000–2005. For reasons easy to understand in the

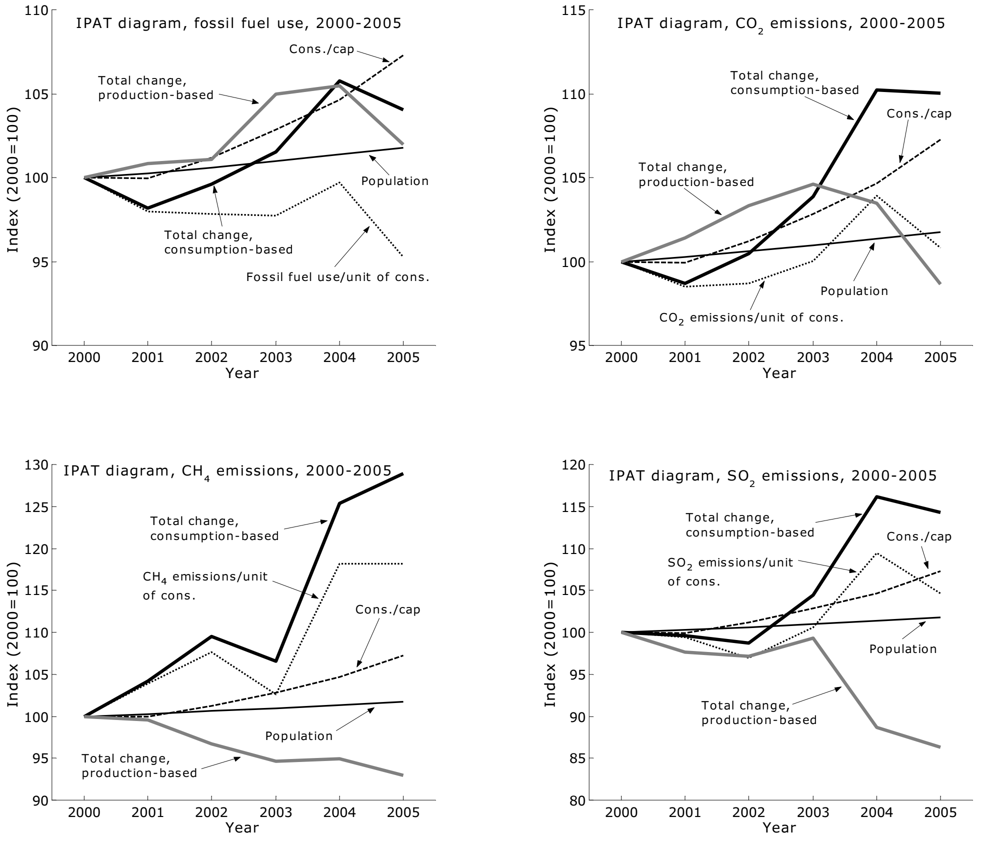


Figure 5.5. Consumption-based IPAT diagrams for fossil fuel use, and for CO_2, CH_4 and SO_2 emissions in the period 2000–2005. *Source*: Production-based data from Statistics Sweden, 2011d (fossil fuel use, including bunkers) and from Swedish EPA, 2011 (UNFCCC; CO_2, CH_4 and SO_2 emissions, excluding bunkers).

case of Sweden, the population factor does not contribute in a crucial way. The affluence factor – consumption per capita, or more correctly, Swedish final demand per capita – contributes in a more evident way. The technology factor – i.e. the intensity – contributes more or less for the emissions shown in the figure, but for fossil fule use, this factor counteracts the other in some extent.

Results for the other environmental variables and for the period 1993–2003, are available in the accompanying Excel database – see Appendix F.

5.4 Consumption–environmental impact diagrams concerning decoupling and EKC patterns

In Figure 5.6, consumption-based environmental impact against Swedish final demand regarding fossil fuel use, and CO_2, CH_4 and SO_2 emissions are shown. During the period from 1993–2005, Swedish final demand grew from approximately 28 000 constant US dollars, to 38 000 constant US dollars. At the same time,

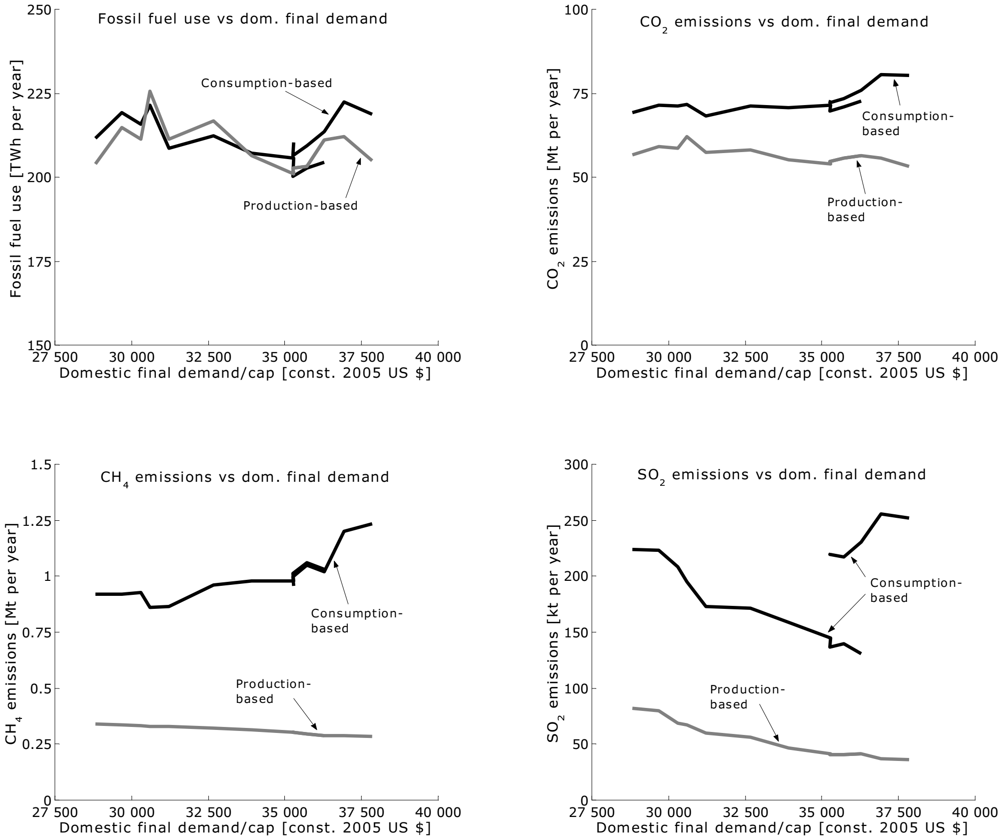


Figure 5.6. Consumption-based environmental impact versus domestic final demand for fossil fuel use, and for CO_2, CH_4 and SO_2 emissions. *Source*: Production-based data from Statistics Sweden, 2011d (fossil fuel use, including bunkers) and from Swedish EPA, 2011 (UNFCCC; CO_2, CH_4 and SO_2 emissions, excluding bunkers).

fossil fuel use remained at approximately the same level. However, CO_2 emissions and especially CH_4 emissions rose with rising domestic final demand. That suggests that when looking from a consumption perspective, there is no EKC pattern for these emissions and decoupling has not occurred – contrary to what the production-based data indicate. Moreover, these emissions are much higher than their production-based analogs.

Regarding SO_2 emissions, they decline in the first time series and accordingly have decoupled there, but the opposite applies to the second time series (see Chapter 5.1 for an explanation of this). Both time series though, show a higher level than the official production-based data.

The doubling of the consumption-based curves, is due to the fact that the two time series revisions of the Swedish national accounts were used, resulting in duplicate values for the period 2000–2003.

The other environmental variables are available in the accompanying Excel database – see Appendix F.

5.5 Environmental impact per product group

In Figure 5.7, the fossil fuel use and the emissions of CO_2 equivalents due to the consumption of goods or the consumption of services less transports,[3] are shown for the period 2000–2005 and compared to the production-based data for these product groups. In Table 5.2, a more comprehensive list of product groups are shown, and their consumption-based and production-based emissions of CO_2 equivalents respectively. In the accompanying Excel database, results for the other environmental variables are available – see Appendix F.

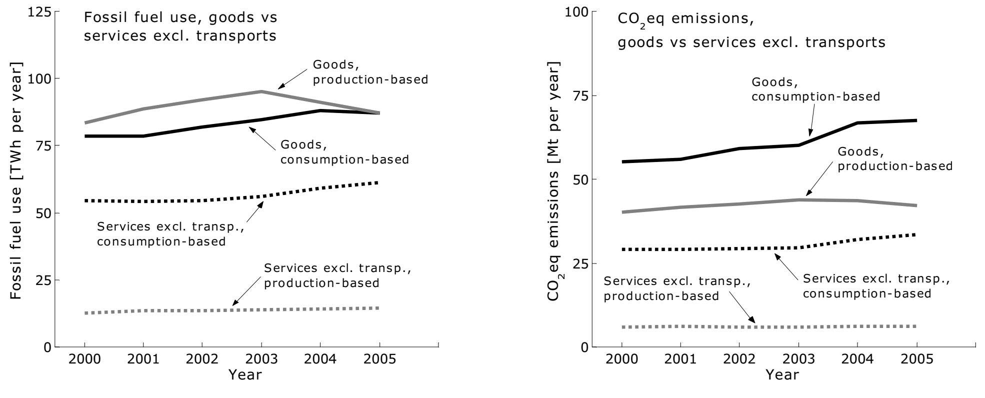


Figure 5.7. Fossil fuel use and emissions of CO_2 equivalents in 2000–2005, for goods and for services less transports in the production-based case and in the consumption-based case. *Source*: Production-based data Statistics Sweden, 2011d (incl. bunkers).

---

[3] Transports have been deducted from services in order to include only low environmental impact activities, which is what is normally associated with services.

Table 5.2. Consumption-based and production-based emissions of CO_2 equivalents, per various product groups. *Source*: Production-based data from Statistics Sweden, 2011d (including bunkers).

Product group \ Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004	2005
CO_2eq (Mt/year), consumption-based																	
Goods	52.85	54.13	54.34	52.64	49.90	56.09	55.53	56.17	56.17	59.02	59.99	55.17	55.82	59.06	60.16	66.78	67.57
Services	30.96	31.94	31.44	31.61	31.87	32.61	33.04	33.15	33.09	33.16	32.92	35.14	35.49	35.31	35.79	40.00	41.07
Services, excl. transp.	27.03	27.69	27.23	27.35	27.38	28.07	28.14	28.25	27.86	28.13	28.08	29.04	29.15	29.21	29.50	32.10	33.47
Food	18.03	18.59	17.46	17.05	16.75	18.07	17.65	17.07	16.29	16.43	16.36	15.42	14.81	15.28	15.38	18.69	19.32
Steal and metal	-0.20	0.05	0.17	-0.21	0.17	-0.15	-0.12	0.29	-0.06	0.11	-0.17	0.27	-0.30	0.10	-0.18	-1.14	-0.22
Energy	5.68	6.00	5.55	7.19	5.62	5.99	5.20	4.12	4.99	5.58	6.36	3.99	4.86	5.48	6.25	5.96	4.83
Transports	3.93	4.25	4.20	4.26	4.49	4.54	4.90	4.91	5.24	5.03	4.85	6.10	6.33	6.11	6.29	7.89	7.60
Education, healthcare	5.99	6.06	5.87	5.67	5.49	5.78	5.59	5.44	5.72	6.10	6.10	5.52	6.17	6.24	6.24	6.73	6.74
Culture, sports	1.06	1.12	1.12	1.16	1.11	1.15	1.15	1.11	1.06	1.07	1.06	1.27	1.24	1.27	1.32	1.47	1.55
CO_2eq (Mt/year), production-based																	
Goods	42.04	44.29	43.69	47.68	43.42	44.32	41.13	40.10	41.68	42.67	43.74	40.10	41.68	42.67	43.74	43.58	42.08
Services	14.91	15.94	15.69	15.85	16.89	17.99	18.14	17.71	17.62	16.74	18.34	17.71	17.62	16.74	18.34	19.79	20.03
Services, excl. transp.	6.25	6.25	6.04	6.11	6.10	6.09	6.08	5.97	6.14	5.96	6.02	5.97	6.14	5.96	6.02	6.10	6.05
Food	1.05	1.08	1.09	1.11	1.13	1.13	1.11	0.98	0.87	0.92	1.02	0.98	0.87	0.92	1.02	0.83	0.75
Steal and metal	5.11	5.51	5.87	5.71	5.72	5.69	5.91	6.14	6.18	6.34	6.16	6.14	6.18	6.34	6.16	6.42	6.12
Energy	10.02	10.67	9.76	13.18	10.02	10.67	8.75	6.83	7.98	9.04	10.54	6.83	7.98	9.04	10.54	10.28	8.97
Transports	8.67	9.69	9.65	9.75	10.79	11.90	12.06	11.74	11.49	10.78	12.32	11.74	11.49	10.78	12.32	13.70	13.98
Education, healthcare	0.13	0.14	0.13	0.13	0.13	0.14	0.14	0.15	0.16	0.15	0.15	0.15	0.16	0.15	0.15	0.15	0.14
Culture, sports	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.09	0.09	0.07	0.08	0.09	0.09	0.09	0.10

It can be noted that the consumption-based emissions for various services are at a much higher level than their corresponding production-based counterparts, which shows that services, indirectly through the supply chain, depend on more resource and emissions intensive sectors.

5.6 Environmental impact per final demand category

Figure 5.8 shows consumption-based emissions of CO_2 equivalents per final demand category in 1993–2005. For e.g. households, all emissions occurring in Sweden and abroad due to the Swedish households' consumption are included. Note though that emissions due to direct use are not included – these data only refer to the emissions caused upstream through the supply chain by the purchases these final demand categories make. The doubling of the curves in 2000–2003 is due to the use of the two time series revisions from the Swedish national accounts.

The public sector and the investments sector show almost no variation in the period. The households sector however, show a quite strong increase from approximately 55 Mt CO_2eq per year in the beginning of the period to almost 75 Mt CO_2eq per year in the end of the period.

Exports, which are deducted from the other calculations in this study, are here included as one of the final demand categories to show its rising environmental impact – the emissions almost double in the period, from approximately 50 Mt CO_2eq per year to almost 95 Mt CO_2eq per year. Note though that these emissions include also emissions abroad due to the inputs from abroad required by the Swedish exports industry.

Results for the other environmental variables are available in the accompanying Excel database – see Appendix F.

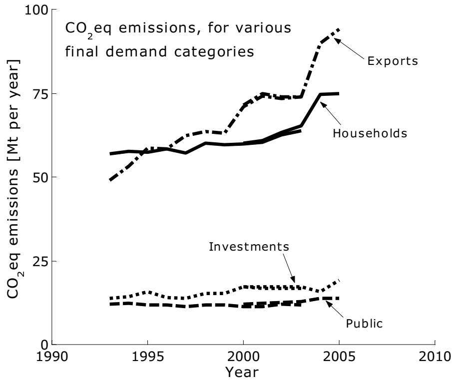


Figure 5.8. Consumption-based emissions of CO_2 equivalents in 1993–2005, distributed over the various categories of final demand.

Chapter 6

Discussion and conclusions

The purpose of this study has been to contribute to the understanding of whether economic growth is the main cause to the world's environmental problems. In a world where we have already passed many of the ecological limits, and where resource depletion and climate change are some of the biggest challenges facing humankind,[1] many are of the opinion that it is not possible to grow our economies for ever. Others say that growing the economy is a prerequisite for being able to develop new technologies which will solve the environmental problems. Referring to the IPAT equation, this means to increase the A factor in order to decrease the T factor even more, so that the A factor – and obviously the P factor as well – doesn't eat up the gains done by the T factor. In plain language, efficiency gains need to be bigger than increases in scale.

When analysing whether it is possible to grow a particular country's economy and at the same time decrease its environmental impact – which is also what the environmental Kuznets curve (EKC) hypothesis suggests – we have to get an accurate description of what environmental impact the economy really causes. That is, we have to consider not only the domestic environmental impact but also the worldwide environmental impact caused by the consumption in the economy. Considering only the domestic environmental impact – as is normally done in EKC studies – is simply not telling the whole picture. That is the reason why EKC studies and studies measuring individual countries' environmental performance need analyse the impact from a consumption perspective which includes the impact caused abroad.[2]

In order to get an indication whether or not economic growth and increased consumption is compatible with decreasing environmental impact, we have in this study analysed the worldwide, consumption-based environmental impact caused by the Swedish domestic final demand. This has been done by estimating the consumption-based development of twelve environmental variables for the period 1993–2005, using environmental input–output analysis.

---

[1] See Rockström et al., 2009, for a recent overview of the environmental state of the world.

[2] E.g. Carson, 2010, Rothman, 1998, and Arrow et al., 1995.

6.1 Summary of main results and outcomes

Below follows an overview of the main results obtained from the analysis. Included in this overview are also methodological attainments and other outcomes that this study has produced. After that, in the next sections, follows a discussion regarding the reliability of these results, and the results in comparison to other studies. Conclusions and suggestions for further research end the chapter.

- METHODOLOGICAL RESULTS:
    - The wider conclusion that environmental impact be analysed from a consumption perspective to supplement the production-based data primarily published today. This has important policy implications, e.g. in climate change negotiations.
    - The development of a new method for updating input–output tables which utilizes the shares of domestic production and imports from the official tables, and calibrates against known yearly domestic production and imports totals (see Chapter 4.2.2).
    - The deployment of a single-regional input–output model augmented with world average intensities (see Chapter 4.3.3).
    - An index decomposition analysis which separates the change in impact into components describing changes in domestic production, changes in production abroad as if produced with Swedish intensities, changes in the ratio of world intensity to Swedish intensity, and changes in direct use (see Chapter 4.4.3).
    - Analysis of the rationale behind using market exchange rates (MER) or purchasing power parity (PPP) exchange rates, suggesting the latter due to that measure taking into account the exported products' share of the exporting country's total output in a more relevant way (see Chapter 4.3.3).
- RESULTS AND FEATURES REGARDING DATA:
    - The utilizing of recently (2010–2011) published environmental data from the Swedish environmental accounts, IEA and the international EDGAR database of global emissions.
    - The construction of an Excel database with Swedish consumption-based data for the period 1993–2005, showing results for all analysed environmental variables on all aspects that was presented in Chapter 5 (for some aspects presented there, only a selection of the environmental variables was shown). See Appendix F.

- EMPIRICAL RESULTS:
    - Consumption-based emissions of CO_2 equivalents increase approximately 20 % between 1993 and 2005, mainly driven by an increase in CH_4 emissions. This should be compared to a decrease in the official production-based UNFCCC data. That means CO_2 equivalents and all greenhouse gases exhibits no EKC patterns and has not yet decoupled from growth in domestic final demand.
    - In general, the increase in emissions is caused by increased demand for imported products which yields increasing emissions abroad.
    - The levels of all emissions are considerably higher in the consumption-based case compared to the production-based case.
    - Total fossil fuel use show no considerable difference to production-based data, whether in level or in trends (though consumption-based coal use and gas use lie at higher levels). CO and NMVOC emissions are decreasing as in the production-based data, but from higher levels.
    - Impact from the consumption of services are in some instances ten times higher than the corresponding production-based impact.
    - Impact from final demand categories (excluding direct use) are for both energy resource uses and emissions in general increasing. This holds especially for the exports category, whose worldwide impact in the case of CO_2 equivalents has doubled in the whole period studied. The exports dependence on fossil fuel use has also increased dramatically, approximately 80 % in the period studied (see details in the accompanying Excel database introduced in Appendix F).
- FURTHER RESEARCH:
    - Identification of a number of aspects and extensions to this study that need further research (see Chapter 6.5).

6.2 Uncertainties

The main uncertainties arise in the calculations of the resource uses and emissions generated abroad. To begin with, this impact is based on the use of Swedish input–output tables as a proxy for the industry structure of the rest of the world, where MRIO tables would be preferred. Building time series using SRIO tables was still preferred as a first step in this research, and also since time series using MRIO modelling has other limitations (see next section about comparisons to other studies). Also, in one study where different methods were compared, it was concluded that it is more important to obtain correct emission intensities than correct input–output coefficients for the Swedish import countries.[3] However, future research should follow building time series using MRIO modelling.

Next in the uncertainties of impact abroad are the world average intensities. On one hand they may be too high since, e.g. in the case of CO_2, the Swedish import countries have a somewhat lower intensity than the world average intensity (though imports to importing countries are then excluded) – approximately 20 % lower.[4] On the other hand, the PPP approach used implies a conservative estimate compared to the MER approach which is normally used in trade oriented environmental IOA studies (the MER approach yields approximately 20 % higher values).[5] Note though, since Swedish emissions occurring on the domestic territory are added to the total figure, this uncertainty will become only about 10 %.

Other uncertainties include the allocation of bunkers between Swedish users and ROW users (see Chapter 4.3.1), and the general problem of aggregation errors which occur in all IO models. Moreover, the required production to meet our final demand may be somewhat overestimated due to including investments in the exports industry[6] and due to feedback effects.[7] Uncertainties arise also in the IOT updating procedure for years missing official IOTs, but, accordingly, the years 1995, 2000 and 2005 have in this sense no uncertainties.

When it comes to the linearity assumption in IO models – i.e. the assumption that economies of scale are not considered and increased final demand use the same input structure – it is regarded as not being a relevant issue of concern in this study. This study can be considered an accounting study only, i.e. we are not projecting the emissions occurring if final demand would change, but we allocate linearly the historical emissions that actually occurred over various final demand categories and over final demand for various product groups. For instance, this is evident in the case of exports whose direct and indirect effects are deducted linearly. To deduct the exports from a hypothetical industry structure which only would serve the exports is irrelevant, since such an industry structure is not the structure that we in fact had.

---

[3] Carlsson-Kanyama et al., 2007.

[4] Based on Statistics Sweden, 2011g, and World Bank, 2010.

[5] See Chapter 4.3.3 for details about the methods and assumptions in the calculations of the world average intensities, and why the PPP approach was preferred.

[6] See Chapter 3.3.6 for a discussion of investments in IO models.

[7] See Chapter 3.3.1 and 4.2.3.

6.3 Comparison to other IOA and EKC studies

This study is the first study building a complete time series (1993–2005) of consecutive IOAs regarding Swedish consumption-based emissions of CO_2 equivalents.[8] The most similar study to this regarding Swedish emissions of CO_2 equivalents, is a study by Peters and Solli from 2010 which compares emissions in 2001 with emissions in 2004 using MRIO modelling.[9] Their results lie in the same region as in this present study (approximately between 100–120 Mt CO_2eq/year). The strengths in their study is that it uses MRIO modelling with more detailed resolution of emission intensities for the import countries. A weakness is that only two years are analysed, which makes trend estimations uncertain. In that sense, this present study is more robust as it has built a longer time series. It is also robust in the sense that it uses fairly consistent IOTs and environmental data from one single source (Statistics Sweden), whereas MRIO modelling is based on IOTs with varying degree of aggregation and coming from different years for the various countries included in the MRIO table.[10]

In the EKC studies by Kander and Lindmark,[11] a SRIO model is used in constructing an IOA-based 80-year-long time series of CO_2 emissions, which exhibits a typical EKC pattern. However, in their studies, Swedish emission intensities are applied for the production occurring abroad, yielding too low values since Swedish import countries have considerably higher emission intensities than Sweden itself has.[12] If superposing the values from the time series of consumption-based emissions of CO_2 from this present study upon their EKC-shaped data, the CO_2 emissions will lie approximately at the peak of their EKC, and possibly be on the rise as well. This doesn't imply in itself that the consumption-based emissions of CO_2 are higher now than ever though. But it seems likely, since their EKC is probably more correct in earlier years when the difference between the Swedish energy system and the energy system abroad probably wasn't so big with regards to emission intensities (before the Swedish nuclear power plants were built).

The same conclusions regarding non-existent EKC patterns in IOA-based time series of SO_2 emissions seem not be possible to draw with the results from this study. Even though SO_2 emissions in the second time series seem to be rising at a level of approximately 250 000 tonnes per year, the peak in production-based data occurred in the end of the 1960s at a level of 960 000 tonnes per year.[13] Thus, it is unreasonable to believe that consumption-based data in that time was lower than 250 000 tonnes per year.

---

[8] And some other variables. However, IOA-based time series of only CO_2 have been analysed before in Lindmark, 2001, and Kander and Lindmark, 2006, and in Statistics Sweden, 2003, Statistics Sweden, 2011h, and Peters et al., 2011.

[9] Peters and Solli, 2010.

[10] See e.g. GTAP, 2011.

[11] Lindmark, 2001, and Kander and Lindmark, 2006.

[12] Statistics Sweden, 2011g, and World Bank, 2010.

[13] Johansson and Kriström, 2007.

6.4 Conclusions

Reliability of results

Even though more detailed analyses are needed to get more robust results (see further research in Chapter 6.5), the results seem to correlate quite well with results from similar studies – at least in the case of CO_2 equivalents. The results could be a little bit high due to the world average intensities, but this is on the other hand compensated by conservative estimates due to the PPP approach. An advantage is also that the time series is built on consistent IOTs and environmental data from one single source (Statistics Sweden). All in all, this means the results from this study can be considered fairly reliable.

No decoupling and no EKC pattern in Swedish consumption-based greenhouse gas emissions

As regards the EKC hypothesis, many earlier studies have shown that even though local environmental indicators often exhibit EKC shapes, this is not the case for global indicators like CO_2 emissions.[14] Official Swedish data have suggested Sweden is an exception in this matter, and many others have pointed out Sweden as a country that has been able to decouple economic growth from increasing emissions of CO_2 and other greenhouse gases.[15] However, this present study suggests that even in the case of Sweden, greenhouse gases increase and a decoupling has not occurred when considering the emissions caused worldwide by our consumption.

What has triggered the increase in greenhouse gases?

Has the growth in GDP or in domestic final demand even been the *main cause* for the increasing emissions of greenhouse gases? The study suggests that it is indeed the increase in our final demand that has triggered these emissions to increase. This is pointed out by the decomposition analysis, which suggests that our increased demand for imported products has driven the increase in emissions.[16] This can be explained by, although we have a positive and increasing trade balance, the imported products have higher emission intensities than the products we produce for exports. Accordingly, the increase in our consumption has been possible at the expense of increased emissions abroad.[17] This has important implications for climate change negotiations where emission reductions need to be

---

[14] See e.g. Galeotti, 2003, and Carson, 2010.

[15] E.g. OECD, 2011, NIER, 2011.

[16] Even though bunkers make the levels higher than in official UNFCCC data, they seem not to have contributed to the increase in a significant way.

[17] This is also the conclusion in Peters et al., 2011, but there with regard to increased consumption in the developed world at the expense of higher emissions in the developing world – referred to as "weak carbon leakage".

the obligation of those countries who through their consumption and way of living are responsible for the emissions to occur.

On the other hand, if the world would have the same development of greenhouse gases as the official Swedish production-based data, then we would have decreasing emissions at the same time as final demand was increasing. But the world is still not there, which may imply that increasing Swedish final demand as a necessity means increased emissions worldwide (if we were not to cut down heavily on imports). It could well be that the development of world emissions of CO_2 equivalents do have an EKC-shape, but that we are still too far left on this EKC that it would be disastrous for us to wait until we have passed its peak.

Thus, Sweden has done a fairly good job in taking its responsibility to reduce its territorial production-based emissions of greenhouse gases. But – as this study suggests – we are still responsible for increasingly contributing to higher concentrations of greenhouse gases in the atmosphere through our consumption and way of living.

Is growth the ultimate environmental problem?

What can this study tell us about growth in general as being either the ultimate environmental problem causing all the other environmental problems to occur, or as being a necessity in order to find solutions to decrease environmental impact? We have found that for some resource uses and emissions decoupling has indeed occurred and for some others decoupling has not occurred. More environmental variables like material use and waste flows need be considered to get a more comprehensive picture, and to be able to find out with more certainty whether growth is desirable or not.[18] In the case of greenhouse gases, this study has showed that the arguments in favor of growth in consumption have not been convincing so far.

From problem formulations to solutions

To conclude, this study belongs to the problem formulation side of the environmental problems–solutions dichotomy. Its aim has been to contribute to an accurate description of our environmental problems and their causes, in order to better know where to look for solutions to these problems. Accordingly, although more research is needed to get more certain results here, what is even more important to follow hereafter is research focusing on the solution side. An overview of both these kinds of further research is presented in the following section. See also Chapter 2.3.2 for an overview of proposed solutions.

---

[18] However, production-based data of waste flows in Sweden show a steady increase – see e.g. Sjöström and Östblom, 2010. See Krausmann et al., 2009 for a global outlook on material use.

6.5 Further research

Further research to improve and extend the model used in this study is needed. Also the objects of study could be extended in several ways, and even solutions need be pursued. Some of the most important points include:

- METHODOLOGICAL IMPROVEMENTS AND EXTENSIONS:
    - Construct time series based on trade data and intensities of Swedish trading partners, as a comparison to the world average intensities approach.
    - More in-depth analysis of the various factors affecting the energy uses and emissions caused, such as the causes behind the increased CH_4 and SO_2 emissions. More detailed analysis of the contribution from bunkers.
    - Include land use, land-use change and forestry (LULUCF) data.
    - Perform a structural decomposition analysis based on IO-tables in constant prices.
    - Improve the IOT updating method with RAS techniques.
    - Construct time series based on MRIO modelling.
    - Include the use of investments in the intermediate matrix in dynamic IO-modelling.
    - Cross-sectional analysis of environmental impact over increasing income groups.
- EXTENSIONS OF SYSTEM BOUNDARIES AND OBJECTS OF STUDY:
    - Extensions of objects of study: Total energy use (including electricity), exergy and emergy use, virtual water, ecological footprint, pressure on biological stocks and ecosystem services (e.g. our contribution to overfishing), material use and waste flows, water pollution, emissions of persistent organic pollutants.
    - Temporal extensions: The extension of the time series backwards and forwards in time.
    - Geographical extensions: The study of other countries as well, and ultimately the whole world.
- SOLUTIONS:
    - Explore and analyse solutions to the environmental problems identified in the research presented in this report and in the above suggested further research. See Chapter 2.3.2 for an overview of proposed solutions.

Recommended readings

Some of the references that have been of particular importance for this study are presented below for those who want to read more. Full references of these recommendations are given in the reference list in the following chapter.

A systems theory approach for analysing environmental problems at various system levels is presented in the must-read paper *Leverage Points: Places to Intervene in a System* by Donella H. Meadows, 1999. A good textbook introducing the field of industrial ecology is *Industrial Ecology and Sustainability Engineering* by Thomas E. Graedel and Braden R. Allenby, 2010. The field of ecological economics is inspiredly introduced in *Ecological Economics. Principles and Applications* by Herman E. Daly and Joshua Farley, 2004.

A recent contribution to the growth debate is *Prosperity without Growth. Economics for a Finite Planet* by Tim Jackson, 2009, which also presents several important concepts in the field, including decoupling and the IPAT equation. The rebound effect is discussed in *Energy Efficiency and Sustainable Consumption. The Rebound Effect* edited by Horace Herring and Steve Sorrell, 2009. An important Swedish study analysing economic growth is the dissertation *Economic growth, energy consumption and CO_2 emissions in Sweden 1800–2000* by Astrid Kander, 2002. Another important Swedish dissertation in this field is *Growth versus the Environment – Is There a Trade-off?* by Per Kågeson, 1997.

Input–output analysis is very well covered in Ronald E. Miller and Peter D. Blair's classical textbook *Input–Output Analysis. Foundations and Extensions* from 1985, now in an extended second edition from 2009. For environmental input–output analysis, a good introduction is *Environmental Life Cycle Assessment of Goods and Services. An Input–Output Approach* by Chris T. Hendrickson et al., 2006. Various interesting environmental applications are also given in *Handbook of Input–Output Economics in Industrial Ecology* edited by Sangwon Suh, 2009.

Solutions within the frame of conventional economic theory are given in the optimistic *Factor Five. Transforming the Global Economy through 80% Improvements in Resource Productivity* by Ernst von Weizsäcker et al., 2009. Non-mainstream solutions are given in *The Performance Economy* by Walter R. Stahel, 2010, who proposes an economy based on the sales of functions instead of the sales of products. In *Managing Without Growth. Slower by Design, Not Disaster* by Peter A. Victor, 2008, a non-growth-based model of an economy is presented.

References

Adams, R.A., 1995. *Calculus: a complete course.* 3rd ed. Addison-Wesley Publishers Limited, Don Mills, Ontario.

Aleklett, K. and Campbell, C.J., 2003. The peak and decline of world oil and gas production. *Minerals & Energy – Raw Materials Report*, 18 (1), 5–20.
http://dx.doi.org/10.1080/14041040310008374

Alfredsson, E., 2002. *Green consumption, energy use and carbon dioxide emission.* Doctoral thesis. Department of Social and Economic Geography, Umeå University. GERUM 2002:1.
http://umu.diva-portal.org/smash/get/diva2:144590/FULLTEXT01

Alfredsson, E., 2004. "Green" consumption – no solution for climate change. *Energy*, 29 (4), 513–524.
http://dx.doi.org/10.1016/j.energy.2003.10.013

Andersen, O., Gössling, S., Simonsen, M., Walnum, H.J., Peeters, P. and Neiberger, C., 2010. CO2 emissions from the transport of China's exported goods. *Energy Policy*, 38 (10), 5790–5798.
http://dx.doi.org/10.1016/j.enpol.2010.05.030

Andersson, G., Jorner, U., Ågren, A., 2007. *Regressions- och tidsserieanalys.* 3rd ed. Studentlitteratur.

Ang, B.W. and Zhang, F.Q., 2000. A survey of index decomposition analysis in energy and environmental studies. *Energy*, 25 (12), 1149–1176.
http://dx.doi.org/10.1016/S0360-5442(00)00039-6

Ariansen, P., 1993. *Miljöfilosofi. En introduktion.* Bokförlaget Nya Doxa, Nora.

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C.S., Jansson, B.-O., Levin, S., Mäler, K.-G., Perrings, C., Pimentel, D., 1995. Economic growth, carrying capacity, and the environment. *Science*, 268 (5210), 520–521.

Axelsson, U. and Marcus, H.-O., 2008. Företagets miljöarbete i praktiken. In: *Miljö i ett företagsperspektiv.* 2nd ed. Prevent, Arbetslivsinstitutet and IVL Svenska miljöinstitutet. Stockholm.

Azar, C., Holmberg, J. and Karlsson, S., 2002. *Decoupling – past trends and prospects for the future.* Environmental Advisory Council, Ministry of the Environment.
`http://www.sou.gov.se/mvb/pdf/decoupling.pdf`

Beckerman, W., 1992. Economic growth and the environment: whose growth? Whose environment? *World Development*, 20 (4), 481–496.

Bergman, L., 1977. *Energy and economic growth in Sweden. An analysis of historical trends and present choices.* The economic research institute at the Stockholm school of economics.

Blair, P.D., 2011. Personal communication. Executive director, Division on Engineering and Physical Sciences, The National Academy of Sciences, Washington, D.C. Coauthor of Miller, R.E. and Blair, P.D. Input–output analysis. Foundations and extensions.

Brander, M., Tipper, R., Hutchison, C. and Davis, G., 2009. Consequential and attributional approaches to LCA: a guide to policy makers with specific reference to greenhouse gas LCA of biofuels. Technical Paper TP-090403-A. *Ecometrica press*, April 2009.
`http://www.ecometrica.co.uk/wp-content/plugins/download-monitor/download.php?id=2`

Cadarso, M.-Á., López, L.-A., Gómez, N. and Tobarra, M.-Á., 2010. CO2 emissions of international freight transport and offshoring: measurement and allocation. *Ecological Economics*, 69 (8), 1682–1694.
`http://dx.doi.org/10.1016/j.ecolecon.2010.03.019`

Campbell, N.A., 1996. *Biology.* 4th ed. The Benjamin/Cummings Publishing Company, Inc., Menlo Park, California.

Carlsson-Kanyama, A., Assefa, G., Peters, G. and Wadeskog, A., 2007. *Koldioxidutsläpp till följd av Sveriges import och konsumtion: beräkningar med olika metoder.* Avdelningen för industriell ekologi, KTH. TRITA-IM: 2007:11.
`http://www.ima.kth.se/eng/respublic/CO2_utslaepp_import_konsumtion.pdf`

Carson, R.T., 2010. The environmental Kuznets curve: seeking empirical regularity and theoretical structure. *Review of Environmental Economics and Policy*, 4 (1), 3–23.
`http://dx.doi.org/10.1093/reep/rep021`

Cleveland, C.J., Kaufmann, R.K. and Stern, D.I., 2000. Aggregation and the role of energy in the economy. *Ecological Economics*, 32 (2), 301–317.
`http://dx.doi.org/10.1016/S0921-8009(99)00113-5`

Commoner, B., 1972. The environmental cost of economic growth. In: Ridker, R.G. (ed). *Population, resources, and the environment.* The commission on population growth and the American future, Research reports, Volume III, Washington, D.C.

Daly, H.E., 1968. On economics as a life science. *The Journal of Political Economy*, 76 (3), 392–406.

Daly, H.E. and Farley, J., 2004. *Ecological economics. Principles and applications.* Island Press, Washington.

Davis, S. J. and Caldeira, K., 2010. Consumption-based accounting of CO2 emissions. *Proceedings of the National Academy of Sciences of the United States of America*, 107 (12), 5687–5692.
`http://dx.doi.org/10.1073/pnas.0906974107`

de Haan, M., 2002. *Disclosing international trade dependencies in environmental pressure indicators: the domestic consumption perspective.* 2nd version. Paper for the International Input–Output Association conference, 10–15 October 2002, Montreal, Canada.

Dietz, T. and Rosa, E.A., 1994. Rethinking the environmental impacts of population, affluence and technology. *Human Ecology Review*, Summer/Autumn, 1, 277–300.

Dietzenbacher, E. and Los, B., 1998. Structural decomposition techniques: sense and sensitivity. *Economic Systems Research*, 10 (4), 307–323.

Ehrlich, P.R. and Holdren, J.P., 1970. The people problem. *Saturday Review*, 53 (27), 42–43.

Ehrlich, P.R. and Holdren, J.P., 1971. Impact of population growth. *Science*, 171 (3977), 1212–1217.

Eklund, K., 2004. *Vår ekonomi. En introduktion till samhällsekonomin.* 10th ed. Bokförlaget Prisma, Stockholm.

Emission Database for Global Atmospheric Research (EDGAR), 2010. Release version 4.1. European Commission JRC Joint Research Centre and Netherlands Environmental Assessment Agency (PBL). Retrieved 2011-04-12.
`http://edgar.jrc.ec.europa.eu`

European Community (EC), 1996. *Council Regulation (EC) No 2223/96 of 25 June 1996 on the European system of national and regional accounts in the Community.* Official Journal L 310, 30/11/1996, 1–469.
`http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996R2223:EN:NOT`

Eurostat, 2008. *Eurostat manual of supply, use and input–output tables.* Methodologies and working papers. Office for Official Publications of the European Communities, Luxembourg.
`http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-07-013/EN/KS-RA-07-013-EN.PDF`

Finnveden, G. and Moberg, Å., 2005. Environmental systems analysis tools – an overview. *Journal of Cleaner Production*, 13 (12), 1165–1173.
http://dx.doi.org/10.1016/j.jclepro.2004.06.004

Finnveden, G., Wadeskog, A., Ekvall, T., Engström, R., Hjelm, O. and Palm, V., 2007. *Miljödata för produktgrupper – användning av input–output-analyser i miljösystemanalytiska verktyg.* Miljöstrategisk analys – fms, KTH. TRITA-INFRA-FMS 2007:4.
http://www.infra.kth.se/fms/pdf/Miljodata.pdf

Fuglestvedt, J.S., Berntsen, T.K., Godal, O., Sausen, R., Shine, K.P. and Skodvin, T., 2003. Metrics of climate change: assessing radiative forcing and emission indices. *Climatic Change*, 58 (3), 267–331.
http://dx.doi.org/10.1023/A:1023905326842

Fullerton, D. (ed), 2006. *The economics of pollution havens.* New horizons in environmental economics. Edward Elgar, Cheltenham, UK.
http://www.bepress.com/bejeap/advances/vol4/iss2/

Galeotti, M., 2003. *Economic development and environmental protection.* Fondazione Eni Enrico Mattei Working Paper Series, 2003.089.
http://www.feem.it/userfiles/attach/Publication/NDL2003/NDL2003-089.pdf

Global Trade Analysis Project (GTAP), 2011. Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University. Retrieved 2011-05-10.
https://www.gtap.agecon.purdue.edu

Goklany, I.M., 2007. *The improving state of the world. Why we're living longer, healthier, more comfortable lives on a cleaner planet.* Cato Institute, Washington, D.C.

Graedel, T.E. and Allenby, B.R., 2010. *Industrial ecology and sustainable engineering.* Pearson, Boston.

Granger, C.W.J., 1969. Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, 37 (3), 424–438.

Grossman, G.M. and Krueger, A.B., 1991. *Environmental impacts of a North American free trade agreement.* National Bureau of Economic Research. NBER Working Paper No. 3914.
http://www.nber.org/papers/w3914.pdf

Hawken, P., Lovins, A. and Lovins, L.H., 1999. *Natural capitalism. Creating the next industrial revolution.* Little, Brown and Company, Boston.

Hendrickson, C.T., Lave, L.B. and Matthews, H.C., 2006. *Environmental life cycle assessment of goods and services. An input–output approach.* Resources for the future, Washington, D.C.

Herring, H. and Sorrell, S. (eds), 2009. *Energy efficiency and sustainable consumption. The rebound effect.* Energy, climate and the environment series. Palgrave Macmillan, Basingstoke, UK.

Hertwich, E.G. and Peters, G.P., 2009. Carbon footprint of nations: a global, trade-linked analysis. *Environmental Science and Technology*, 43 (16), 6414–6420.
http://dx.doi.org/10.1021/es803496a

Hoekstra, R. and van den Bergh, J.C.J.M., 2002. Structural decomposition analysis of physical flows in the economy. *Environmental and Resource Economics*, 23 (3), 357-378.
http://dx.doi.org/10.1023/A:1021234216845

Hoekstra, R. and van den Bergh, J.C.J.M., 2003. Comparing structural and index decomposition analysis. *Energy Economics*, 25 (1), 39-64.
http://dx.doi.org/10.1016/S0140-9883(02)00059-2

Hornborg, A., 1992. Machine fetishism, value, and the image of unlimited good: towards a thermodynamics of imperialism. *Man (N.S.)*, 27 (1), 1–18.
http://dx.doi.org/10.2307/2803592

Hornborg, A., 2010. *Myten om maskinen. Essäer om makt, modernitet och miljö.* Daidalos, Göteborg.

Hume, D., 1739. *A treatise of human nature: being an attempt to introduce the experimental method of reasoning into moral subjects. Vol. I. Of the understanding.* London.

International Energy Agency (IEA), 2010. World energy balances. *IEA World Energy Statistics and Balances (database).* Retrieved 2011-04-14.
http://dx.doi.org/10.1787/data-00512-en

International Input–Output Association (IIOA), 2011. Retrieved 2011-05-09.
http://www.iioa.org

ITPS (Swedish Institute For Growth Policy Studies), 2008. *Konsten att nå både klimatmål och god tillväxt. Underlag till en klimatstrategi för EU.* A2008:008.
http://www.tillvaxtanalys.se/tua/export/sv/filer/publikationer-arkiv/itps/rapporter/2008/konsten-att-na-bade-klimatmal-och-god-tillvaxt-08.pdf

Jackson, T., 2009. *Prosperity without growth. Economics for a finite planet.* Earthscan, London.

Jevons, W.S., 1866. *The coal question; an inquiry concerning the progress of the nation, and the probable exhaustion of our coal-mines.* 2nd ed. Macmillan and Co., London.
http://files.libertyfund.org/files/317/0546_Bk_Sm.pdf

Johansson, P.-O. and Kriström, B., 2007. On a clear day you might see an environmental Kuznets curve. *Environmental and Resource Economics*, 37 (1), 77–90.
http://dx.doi.org/10.1007/s10640-007-9112-9

Kander, A., 2002. *Economic growth, energy consumption and CO2 emissions in Sweden 1800–2000.* Doctoral dissertation. Lund studies in economic history 19. Almqvist & Wiksell International, Stockholm.
http://lup.lub.lu.se/luur/download?func=downloadFile&fileOId=1789938

Kander, A. and Lindmark, M., 2006. Foreign trade and declining pollution in Sweden: a decomposition analysis of long-term structural and technological effects. *Energy Policy*, 34 (13), 1590–1599.
http://dx.doi.org/10.1016/j.enpol.2004.12.007

Kerschner, C. and Hubacek, K., 2009. Assessing the suitability of input–output analysis for enhancing our understanding of potential economic effects of peak oil. *Energy*, 34 (3), 284–290.
http://dx.doi.org/10.1016/j.energy.2008.07.009

Krausmann, F., Gingrich, S., Eisenmenger, N., Erb, K.-H., Haberl, H. and Fischer-Kowalski, M., 2009. Growth in global materials use, GDP and population during the 20th century. *Ecological Economics*, 68 (10), 2696–2705.
http://dx.doi.org/10.1016/j.ecolecon.2009.05.007

Kuznets, 1955. Economic growth and income inequality. *The American Economic Review*, 45 (1), 1–28.

Kymn, K.O., 1990. Aggregation in input–output models: a comprehensive review, 1946–71. *Economic Systems Research*, 2 (1), 65–93.

Kågeson, P., 1997. *Growth versus the environment – is there a trade-off?* Doctoral dissertation. Department of Environmental and Energy Systems Studies, Lund University.

Lenzen, M., 1998. Primary energy and greenhouse gases embodied in Australian final consumption: an input–output analysis. *Energy Policy*, 26 (6), 495–506.
http://dx.doi.org/10.1016/S0301-4215(98)00012-3

Lenzen, M., 2009. Understanding virtual water flows: a multiregion input–output case study of Victoria. *Water Resources Research*, 45 (9), W09416.
http://dx.doi.org/10.1029/2008WR007649

Lenzen, M., Pade, L.-L. and Munksgaard, J., 2004. CO2 multipliers in multi-region input–output models. *Economic Systems Research*, 16 (4), 391–412.
http://dx.doi.org/10.1080/0953531042000304272

Leontief, W.W., 1941. *The structure of American economy, 1919–1929. An empirical application of equilibrium analysis.* Harvard University Press, Cambridge, Massachusetts.

Leontief, W.W., 1970. Environmental repercussions and the economic structure: an input–output approach. *The Review of Economics and Statistics*, 52 (3), 262–271.

Lindmark, M., 2001. *Koldioxideffektivitet i ekonomisk-historiskt perspektiv.* Occasional papers in Economic History – Umeå University no. 5. Institutionen för ekonomisk historia, Umeå universitet.

Machado, G., Schaeffer, R. and Worrell, E., 2001. Energy and carbon embodied in the international trade of Brazil: an input–output approach. *Ecological Economics*, 39 (3), 409–424.
http://dx.doi.org/10.1016/S0921-8009(01)00230-0

Malmaeus, M., 2011. *Ekonomi utan tillväxt. Ett svenskt perspektiv.* Cogito. Cogito rapport nr 10.
http://www.cogito.nu/sites/default/files/Ekonomi%20utan%20tillvaxt.pdf

Mayr, E., 1961. Cause and effect in biology. *Science*, 134 (3489), 1501–1506.

Meadows, D.H., 1999. *Leverage points: places to intervene in a system.* The Sustainability Institute, Hartland, Vermont.
http://www.sustainabilityinstitute.org/pubs/Leverage_Points.pdf

Meadows, D.H., Meadows, D.L., Randers, J. and Behrens III, W.W., 1972. *The limits to growth.* Universe Books, New York.

Miller, R.E. and Blair, P.D., 1985. *Input–output analysis. Foundations and extensions.* Prentice-Hall, Englewood Cliffs, New Jersey.

Miller, R.E. and Blair, P.D., 2009. *Input–output analysis. Foundations and extensions.* 2nd ed. Cambridge University Press, New York.

Minx, J.C., Baiocchi, G., Wiedmann, T. and Barrett, J., 2009. *Understanding changes in UK CO2 emissions 1992–2004: a structural decomposition approach.* Report to the UK Department for Environment, Food and Rural Affairs by Stockholm Environment Institute at the University of York and the University of Durham. DEFRA, London, UK.
http://www.sei-international.org/publications?pid=1624

NIER (National Institute of Economic Research), 2011. *Klimatpolitikens utmaningar under mandatperioden.* Specialstudier Nr 25.
http://www.konj.se/201.html

Nordhaus, W., 2007. Alternative measures of output in global economic-environmental models: purchasing power parity or market exchange rates? *Energy Economics*, 29 (3), 349–372.
http://dx.doi.org/10.1016/j.eneco.2006.02.003

OECD, 2001. *OECD Environmental Outlook*. OECD Publishing, Paris.
http://dx.doi.org/10.1787/9789264188563-en

OECD, 2002. *Indicators to measure decoupling of environmental pressure from economic growth*. General Secretariat. SG/SD(2002)1/FINAL.
http://www.oecd.org/officialdocuments/displaydocumentpdf?cote=sg/sd(2002)1/final

OECD, 2011. *OECD Economic Surveys: Sweden 2011*. OECD Publishing, Paris.
http://dx.doi.org/10.1787/eco_surveys-swe-2011-en

Ozturk, I., 2010. A literature survey on energy–growth nexus. *Energy Policy*, 38 (1), 340–349.
http://dx.doi.org/10.1016/j.enpol.2009.09.024

Peters, G.P., 2008. From production-based to consumption-based national emission inventories. *Ecological Economics*, 65 (1), 13–23.
http://dx.doi.org/10.1016/j.ecolecon.2007.10.014

Peters, G.P., 2010. Carbon footprints and embodied carbon at multiple scales. *Current Opinion in Environmental Sustainability*, 2 (4), 245–250.
http://dx.doi.org/10.1016/j.cosust.2010.05.004

Peters, G.P. and Hertwich, E.G., 2006. Pollution embodied in trade: the Norwegian case. *Global Environmental Change*, 16 (4), 379–387.
http://dx.doi.org/10.1016/j.gloenvcha.2006.03.001

Peters, G.P. and Hertwich, E.G., 2008. Post-Kyoto greenhouse gas inventories: production versus consumption. *Climatic Change*, 86 (1–2), 51–66.
http://dx.doi.org/10.1007/s10584-007-9280-1

Peters, G.P. and Hertwich, E.G., 2009. The application of multi-regional input–output analysis to industrial ecology. Evaluating trans-boundary environmental impacts. In: Suh, S. (ed.). *Handbook of input–output economics in industrial ecology*. Eco-efficiency in industry and science, volume 23. Springer, Dordrecht.

Peters, G. and Solli, C., 2010. *Global carbon footprints. Methods and import/export corrected results from the Nordic countries in global carbon footprint studies*. Nordic Council of Ministers. TemaNord 2010:592.
http://www.norden.org/en/publications/publications/2010-592

Peters, G.P., Minx, J.C., Weber, C.L. and Edenhofer, O., 2011. Growth in emission transfers via international trade from 1990 to 2008. *Proceedings of the National Academy of Sciences of the United States of America*, 108 (21), 8903–8908.
http://dx.doi.org/10.1073/pnas.1006388108

Physics Forums, 2010. *Matrix inverse equals power-series*. Retrieved 2010-09-12.
http://www.physicsforums.com/showthread.php?t=423897

Radetzki, M., 2010. *Människorna, naturresurserna och biosfären.* SNS Förlag, Stockholm.

Rees, W.E., 1992. Ecological footprints and appropriated carrying capacity: what urban economics leaves out. *Environment and Urbanization*, 4 (2), 121–130.
http://dx.doi.org/10.1177/095624789200400212

Robèrt, K.-H., 2000. Tools and concepts for sustainable development, how do they relate to a general framework for sustainable development, and to each other? *Journal of Cleaner Production*, 8 (3), 243–254.

Robèrt, K.-H., Schmidt-Bleek, B., Aloisi de Larderel, J., Basile, G., Jansen, J.L., Kuehr, R., Price Thomas, P., Suzuki, M., Hawken, P. and Wackernagel, M., 2002. Strategic sustainable development – selection, design and synergies of applied tools. *Journal of Cleaner Production*, 10 (3), 197–214.
http://dx.doi.org/10.1016/S0959-6526(01)00061-0

Roca, J. and Serrano, M., 2007. Income growth and atmospheric pollution in Spain: an input–output approach. *Ecological Economics*, 63 (1), 230–242.
http://dx.doi.org/10.1016/j.ecolecon.2006.11.012

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin III, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. and Foley, J.A., 2009. A safe operating space for humanity. *Nature*, 461 (7263), 472–475.
http://dx.doi.org/10.1038/461472a

Rockström, J. and Wijkman, A., 2011. *Den stora förnekelsen.* Thomas Magnusson Medströms Bokförlag, Stockholm.

Rothman, D.S., 1998. Environmental Kuznets curves – real progress or passing the buck? A case for consumption-based approaches. *Ecological Economics*, 25 (2), 177–194.
http://dx.doi.org/10.1016/S0921-8009(97)00179-1

Sandelin, B., 2005. *Vad är BNP?* Pocketbiblioteket nr 12. SNS Förlag, Stockholm.

Sanne, C., 2007. *Keynes barnbarn. En bättre framtid med arbete och välfärd.* Formas, Stockholm.

SEI (Stockholm Environment Institute), 2010. *Introducing the Resources and Energy Analysis Programme (REAP).* Working Paper.
http://www.sei-international.org/mediamanager/documents/Publications/Rethinking-development/introducing%20reap%20100216%20web.pdf

SEI (Stockholm Environment Institute), Netherlands Environmental Assessment Agency, Sustainable Europe Research Institute and Statistics Sweden, 2009. *Development of a methodology for the assessment of global environmental impacts of traded goods and services*. SKEP ERA-NET Project EIPOT.
http://www.sei.se/eipot/EIPOT_Final_Report_07Aug09.pdf

Shafik, N. and Bandyopadhyay, S., 1992. *Economic growth and environmental quality. Time-series and cross-country evidence*. The World Bank, Policy Research Working Papers, World Development Report, WPS 904.
http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/1992/06/01/000009265_3961003013329/Rendered/PDF/multi_page.pdf

Simon, S. and Proops, J. (eds), 2000. *Greening the accounts*. Current issues in ecological economics. Edward Elgar, Cheltenham, UK.

Sjöström, M. and Östblom, G., 2010. Decoupling waste generation from economic growth – a CGE analysis of the Swedish case. *Ecological Economics*, 69 (7), 1545–1552.
http://dx.doi.org/10.1016/j.ecolecon.2010.02.014

SOU, 1991:37. *Räkna med miljön! Förslag till natur- och miljöräkenskaper*. Betänkande av miljöräkenskapsutredningen. Allmänna Förlaget, Stockholm.

SOU, 2002:118. *Utveckling och förbättring av den ekonomiska statistiken. Bilaga 3. Beräkningsrutiner för nationalräkenskaperna*. Slutbetänkande av Utredningen om översyn av den ekonomiska statistiken. Fritzes, Stockholm.
http://www.scb.se/Statistik/NR/NR0103/_dokument/SOU2002.pdf

Spangenberg, J.H. and Lorek, S., 2002. Environmentally sustainable household consumption: from aggregate environmental pressures to priority fields of action. *Ecological Economics*, 43 (2–3), 127–140.
http://dx.doi.org/10.1016/S0921-8009(02)00212-4

Spreng, D.T., 1988. *Net-energy analysis and the energy requirements of energy systems*. Praeger, New York.

Stahel, W.R., 2007. Resource-miser business models. *International Journal of Environmental Technology and Management*, 7 (5–6), 483–495.
http://dx.doi.org/10.1504/IJETM.2007.015626

Stahel, W.R., 2010. *The performance economy*. 2nd ed. Palgrave Macmillan, Basingstoke, UK.

Stahmer, C., 2000. The magic triangle of input–output tables. In: Simon, S. and Proops, J. (eds). *Greening the accounts*. Current issues in ecological economics. Edward Elgar, Cheltenham, UK.

Statistics Sweden, 2000. *Miljöpåverkan av svensk handel – resultat från en pilotstudie.* Rapport 2000:5.
http://www.scb.se/statistik/MI/MI1202/2000I02/MI71%C3%96P0005.pdf

Statistics Sweden, 2002a. *Miljöräkenskaper. Innehåll, användning och användare.* Rapport 2002:3.
http://www.scb.se/statistik/MI/MI1202/2000I02/MI71OP0203.pdf

Statistics Sweden, 2002b. *Environmental impact of Swedish trade.* Rapport 2002:2.
http://www.scb.se/statistik/MI/MI1202/2000I02/MI71OP0202.pdf

Statistcs Sweden, 2003. *Structural decomposition of environmental accounts data – the Swedish case.*
http://www.scb.se/statistik/MI/MI1202/1993I99/
MI1202_1993I99_BR_MIFT0407.pdf

Statistics Sweden, 2004. *Fördelning av utsläpp från mobila källor branschvis.* Metodrapport, Avdelningen för miljö- och regionalstatistik.
http://www.scb.se/statistik/_publikationer/MI1202_2004A01_BR_MIFT0409.pdf

Statistics Sweden, 2005. *Dokumentation av Miljöräkenskapernas bränsleberäkningar.*
http://www.scb.se/statistik/_publikationer/MI1301_2005A01_BR_MIFT0502.pdf

Statistics Sweden, 2006a. *Supply and use tables 1995–2003 published May 2006.* Retrieved 2010-10-13.
http://www.scb.se/statistik/NR/NR0101/2007a03a/
S%20&%20U%20tab%201995-2003%20(NR0101%2029-11-07).xls

Statistics Sweden, 2006b. *Symmetric input–output tables 1995 and 2000 published May 2006.* Retrieved 2010-10-13.
http://www.scb.se/statistik/NR/NR0101/2007a03a/
I-O%20tab%201995%20&%202000%20(NR0101%2029-11-07).xls

Statistics Sweden, 2008. *Symmetric input–output tables 2000 and 2005 published June 2008.* Retrieved 2010-08-31.
http://www.scb.se/statistik/NR/NR0102/2008A06A/
Input-output%202000%20and%202005_2008.xls

Statistics Sweden, 2009. *Supply and use tables 2006 published February 2009.* Retrieved 2010-08-31.
http://www.scb.se/Statistik/NR/NR0102/2006A01a/SUT00-06_CUP.xls

Statistics Sweden, 2010. *Nationalräkenskaper 1993–2007.* Statistiska meddelanden, Nr 10, SM 1001.
http://www.scb.se/statistik/NR/NR0102/2007A01/
NR0102_2007A01_SM_NR10SM1001.pdf

Statistics Sweden, 2011a. Personal communication with Ann-Marie Bråthén, National accounts.

Statistics Sweden, 2011b. Personal communication with Anders Wadeskog, Environmental accounts.

Statistics Sweden, 2011c. Supply and use tables for 1993–1994. Retrieved from Ida Björk, National accounts, 2011-04-08.

Statistics Sweden, 2011d. *Miljöräkenskapsdata – analys och simulering*. Updated 2011-03-16. Retrieved 2011-04-12 under the heading “Branschdata”.
http://www.mirdata.scb.se

Statistics Sweden, 2011e. *Bruttonationalprodukten (BNP) årsdata 1993--*. Updated 2011-03-01. Retrieved 2011-04-15.
http://www.scb.se/Statistik/NR/NR0103/2010K04/NR0103_2010K04_DI_01_SV_BNP1994.xls

Statistics Sweden, 2011f. *Nationalräkenskaper detaljerade årsberäkningar 1950–2008 (Publ. 2011-03-01)*. Retrieved 2011-04-19.
http://www.scb.se/Statistik/NR/NR0103/2010K04/NR_detaljerade_%c3%a5rsber%c3%a4kningar_1950_2008.xls

Statistics Sweden, 2011g. Handel med varor och tjänster. Varuimport och varuexport efter handelspartner, ej bortfallsjusterat. År 1995–2010. *Statistikdatabasen*. Retrieved 2011-04-20.
http://www.ssd.scb.se/databaser/makro/start.asp

Statistics Sweden, 2011h. *Totala CO2-utsläpp från slutlig användning av varor och tjänster i Sverige (ton)*. Retrieved 2011-05-21.
http://www.mirdata.scb.se/worldwide/WorldWide.aspx

Statistics Sweden and Swedish Board of Agriculture, 2006. Import och export av jordbruksvaror och livsmedel. In: *Jordbruksstatistisk årsbok 2006 med data om livsmedel*. Statistics Sweden, Örebro.
http://www.scb.se/statistik/_publikationer/JO1901_2005A01_BR_20_JO01SA0601.pdf

Stern, D.I., Common, M.S. and Barbier, E.B., 1996. Economic growth and environmental degradation: the environmental Kuznets curve and sustainable development. *World Development*, 24 (7), 1151–1160.
http://dx.doi.org/10.1016/0305-750X(96)00032-0

Swedish Energy Agency, 2010. *Energy in Sweden – facts and figures 2010*. ET2010:46.
http://www.energimyndigheten.se/Statistik/Energilaget/

Swedish Environmental Protection Agency (EPA), 2006. *Rekyleffekten och effektivitetsfällan – att jaga sin egen svans i miljöpolitiken.* Rapport 5623.
http://www.naturvardsverket.se/Documents/publikationer/620-5623-9.pdf

Swedish Environmental Protection Agency (EPA), 2008. *Konsumtionens klimatpåverkan.* Rapport 5903.
http://www.naturvardsverket.se/Documents/publikationer/978-91-620-5903-3.pdf

Swedish Environmental Protection Agency (EPA), 2010a. *Miljömålen – svensk konsumtion och global miljöpåverkan.* de Facto 2010.
http://www.naturvardsverket.se/Documents/publikationer/978-91-620-1280-9.pdf

Swedish Environmental Protection Agency (EPA), 2010b. *Den svenska konsumtionens globala miljöpåverkan.*
http://www.naturvardsverket.se/Documents/publikationer/978-91-620-1284-7.pdf

Swedish Environmental Protection Agency (EPA), 2011. *Sveriges rapportering till FN:s klimatkonvention och EU.* Updated 2011-03-15. Retrieved 2011-04-12.
http://www.naturvardsverket.se/sv/Start/Statistik/Vaxthusgaser/Sveriges-rapportering-till-FNs-klimatkonvention-och-EU

Swedish Environmental Protection Agency (EPA) and Statistics Sweden, 2008. *PM om beräkningarna i rapporten Konsumtionens klimatpåverkan.* Swedish EPA, Dnr 190-7912-08Km.
http://www.naturvardsverket.se/upload/05_klimat_i_forandring/pdf/klimat_konsumtion_berakningsunderlag.pdf

The Natural Edge Project, 2008. *Decoupling briefing for the International Panel for Sustainable Resource Management.* Submission to International Panel for Sustainable Resource Management, United Nations Environment Programme. Retrieved 2010-07-31.
http://www.naturaledgeproject.net/Documents/UNEPDecouplingBriefingOctober2008.doc

Tsao, J.Y., Saunders, H.D., Creighton, J.R., Coltrin, M.E. and Simmons, J.A., 2010. Solid-state lighting: an energy-economics perspective. *Journal of Physics D: Applied Physics*, 43 (35).
http://dx.doi.org/10.1088/0022-3727/43/35/354001

United Nations (UN), 1993. *Handbook of national accounting. Integrated environmental and economic accounting.* Studies in methods, Series F, No. 61. United Nations, New York.
http://unstats.un.org/unsd/publication/SeriesF/SeriesF_61E.pdf

United Nations (UN), 1999. *Handbook of national accounting. Handbook of input–output table compilation and analysis.* Studies in methods, Series F, No. 74. United Nations, New York.
http://unstats.un.org/unsd/publication/SeriesF/SeriesF_74E.pdf

United Nations (UN), 2011. *World population prospects. The 2010 revision.* United Nations, Department of Economic and Social Affairs, Population Division. Retrieved 2011-06-26.
http://esa.un.org/unpd/wpp/index.htm

United Nations (UN), Commission of the European Communities – Eurostat, International Monetary Fund, Organisation for Economic Co-operation and Development, and World Bank, 1993. *System of national accounts 1993.* Studies in methods, Series F, No. 2, Rev. 4. United Nations, New York.
http://unstats.un.org/unsd/nationalaccount/docs/1993sna.pdf

United Nations (UN), European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, and World Bank, 2003. *Handbook of national accounting. Integrated Environmental and Economic Accounting 2003.* Studies in methods, Series F, No. 61, Rev. 1., Final draft.
http://unstats.un.org/unsd/envaccounting/seea2003.pdf

United Nations (UN), European Commission, International Monetary Fund, Organisation for Economic Co-operation and Development, and World Bank, 2008. *System of national accounts 2008.* Studies in methods, Series F, No. 2, Rev. 5. United Nations, New York.
http://unstats.un.org/unsd/nationalaccount/docs/SNA2008.pdf

United Nations Environment Programme (UNEP), 2011. *Towards a green economy. Pathways to sustainable development and poverty eradication.*
http://www.unep.org/GreenEconomy/Portals/93/documents/Full_GER_screen.pdf

Victor, P.A., 2008. *Managing without growth. Slower by design, not disaster.* Advances in ecological economics. Edward Elgar, Cheltenham, UK.

Victor, P.A., 2010. Ecological economics and economic growth. *Annals of the New York Academy of Sciences*, 1185, 237–245.
http://dx.doi.org/10.1111/j.1749-6632.2009.05284.x

von Weizsäcker, E., Hargroves, K., Smith, M.H., Desha, C. and Stasinopoulos, P., 2009. *Factor five. Transforming the global economy through 80% improvements in resource productivity.* Earthscan, London.

Wackernagel, M. and Rees, W.E., 1996. *Our ecological footprint. Reducing human impact on the earth.* The new catalyst bioregional series. New Society Publishers, Gabriola Island, Canada.

Waugh, F.V., 1950. Inversion of the Leontief matrix by power series. *Econometrica*, 18 (2), 142–154.
http://dx.doi.org/10.2307/1907265

Weber, C.L. and Matthews, H.S., 2007. Embodied environmental emissions in U.S. international trade, 1997–2004. *Environmental Science and Technology*, 41 (14), 4875–4881.
http://dx.doi.org/10.1021/es0629110

Weber, C.L. and Peters, G.P., 2009. Climate change policy and international trade: policy considerations in the US. *Energy Policy*, 37 (2), 432–440.
http://dx.doi.org/10.1016/j.enpol.2008.09.073

Weisz, H. and Duchin, F., 2006. Physical and monetary input–output analysis: what makes the difference? *Ecological Economics*, 57 (3), 534–541.
http://dx.doi.org/10.1016/j.ecolecon.2005.05.011

Wiedmann, T., 2009. A review of recent multi-region input–output models used for consumption-based emission and resource accounting. *Ecological Economics*, 69 (2), 211–222.
http://dx.doi.org/10.1016/j.ecolecon.2009.08.026

Wiedmann, T., Minx, J., Barrett, J. and Wackernagel, M., 2006. Allocating ecological footprints to final consumption categories with input–output analysis. *Ecological Economics*, 56 (1), 28–48.
http://dx.doi.org/10.1016/j.ecolecon.2005.05.012

Wiedmann, T., Wood, R., Minx, J.C., Lenzen, M., Guan, D. and Harris, R., 2010. A carbon footprint time series of the UK – results from a multi-region input–output model. *Economic Systems Research*, 22 (1), 19–42.
http://dx.doi.org/10.1080/09535311003612591

Wood, R. and Lenzen, M., 2009. Principal methodological approaches to studying sustainable consumption: scenario analysis, ecological footprints and structural decomposition analysis. In: Suh, S. (ed.). *Handbook of input–output economics in industrial ecology*. Eco-efficiency in industry and science, volume 23. Springer, Dordrecht.

World Bank, 2010. *World Development Indicators*. Retrieved 2010-12-07.
http://data.worldbank.org/data-catalog/world-development-indicators

World Resources Institute (WRI), 2011. *EarthTrends*. Retrieved 2011-04-20.
http://earthtrends.wri.org/searchable_db/index.php?theme=3

WWF, 2010. *Living planet report 2010. Biodiversity, biocapacity and development.*
http://www.wwf.se/source.php?id=1308995

Östblom, G., 1980. *Energianvändningen i Sverige 1965–1978.* Forskningsgruppen för energisystemstudier, Nationalekonomiska institutionen, Stockholms universitet. Skrift Nr 1980:1.

Östblom, G., 1998. The environmental outcome of emissions-intensive economic growth: a critical look at official growth projections for Sweden up to the year 2000. *Economic Systems Research*, 10 (1), 19–29.

Appendices

Appendix A
Glossary and abbreviations

Aggregate E.g. when two different emissions are put together, considered as one homogeneous group of emissions. Implies loss of information.

Basic prices Prices not including taxes less subsidies. It is the money the producer gets after the state has taken their part which was included in the *market prices.*

Bunkers Fuels or the emissions from these fuels used in international transportation (maritime or aviation).

Carbon leakage Emissions of greenhouse gases outside the domestic territory due to regulations or increased consumption inside the domestic territory.

CH_4 Methane, a greenhouse gas 21 times more powerful than CO_2. Emitted from e.g. the livestock industry.

CO Carbon monoxide, a toxic gas resulting from combustion of carbon in oxygen-deficient environments, e.g. in vehicles.

CO_2 Carbon dioxide, the most common greenhouse gas, emitted from the burning of fossil fuels in energy production and transportation, and in the cement industry. Sweden emit approximately 60 million tonnes per year, globally approximately 30 billion tonnes per year.

CO_2eq CO_2 equivalents, the amount of greenhouse gas emissions taking into account that other greenhouse gases besides CO_2 has a higher global warming potential than CO_2 itself. E.g. one tonne of methane becomes 21 tonnes of CO_2eq, and one tonne of N_2O becomes 310 tonnes of CO_2eq.

Consumption-based, consumption perspective Calculations of energy use or emissions occurring through the whole supply chain, as a consequence of the final consumption of a product. Compare *production-based, production perspective.*

Constant prices Prices stripped from changes caused by inflation, only reflecting real volume changes. Used when comparing economic values between years, e.g. the development of GDP.

Current prices Prices including inflation.

Direct use, environmental direct use The energy use or the emissions occurring in the usage phase of a product, e.g. petrol for the usage of a car or heating of housing.

Depreciation The wearing out of capital, value reduction of capital .

Domestic final demand That part of the final demand that represents what the domestic users purchase, i.e. the final demand less exports. Compare *Final demand of domestic products.*

Downstream In this study, the usage phase and the disposal phase of a product. Or anything happening later on from a certain point in the supply chain.

Ecological footprint A measure of the area needed to take care of all the environmental impact a product or an individual causes.

EKC Environmental Kuznets curve.

Environmental input–output analysis The usage of input–output analysis combined with intensities of environmental flows per monetary value, to estimate the environmental impact throughout the whole supply chain.

Environmental Kuznets curve A hypothesis saying that environmental degradation as a function of economic level, will take an inverted U-shaped form.

FD Final demand.

Feedback effect Imports to a country that have been exported from the same country in an earlier stage of the supply chain.

Final consumption The same as final demand.

Final demand Purchases done by private and public consumers, purchases done for investments, and exports (purchases done by the rest of the world). Also denoted as final consumption, or final use. It is final in the sense that it is not used for further production. Compare *Intermediate use.*

Final demand of domestic products Purchases done by the consumer, investment and exports categories, of products produced domestically, thus not including imports. Compare *Domestic final demand.*

Final demand of imports Purchases done by the consumer, investment and the exports category, of products produced abroad.

Final use The same as final demand.

GDP Gross domestic product.

Gross domestic product The sum of all industries' value added in a country. Also the sum of consumption, investments and net exports (exports less imports). It is gross in the meaning that also the depreciation part of the investments is included.

Gross output The output or production value from an industry, including all inputs of other products. It is gross in the meaning that both the value of the production that the industry has performed (the *value added*), and the production other industries has performed for the first industry's input, are counted. Not the same as gross in *Gross domestic product.*

Input Some kind of resource, often a product, needed in the production of products. Mostly measured in monetary values (exception: physical IO-tables).

Input–output analysis An economic method used to analyse the production needed throughout the whole supply chain in order to satisfy a certain kind of final demand.

Input–output table A table showing the input of products needed per user categories, i.e. intermediate users (products' use of products) and final users. The input–output table is a converted use table. It differs from the use table in that the intermediate users are products (imaginary homogeneous industries producing only one product) instead of industries.

Intensities The amount of resources needed or emissions generated per dollar's worth of products. Intensities link economic flows with physical flows, so that physical flows can be estimated with the use of economical data in combination with intensities, i.e. by multiplying the latter two.

Intermediate matrix The product x product table in the input–output table or the product x industry table in the use table (there normally called the use matrix). The intermediate matrix describes the intermediate use of products in contrast to the final use of products.

Intermediate use Purchases done by industries and used as inputs in production. Also denoted as intermediate demand or intermediate consumption. Compare *Final demand*.

IO Input–output. E.g. IO-model, IO-table.

IOA Input–output analysis.

IOT Input–output table.

kt Kiloton, thousand tonnes.

LCA Life cycle assessment.

Leontief inverse A matrix describing the total amount of various products (along a column) needed throughout the whole supply chain to satisfy the final consumption of some set of products (each column representing some kind of final consumed product each). In this report denoted with $\boldsymbol{L} = (\boldsymbol{I} - \boldsymbol{A})^{-1}$.

Make matrix The product x industry matrix in the supply table.

Market prices Basic prices plus taxes less subsidies.

Matrix of technical coefficients The matrix describing the value of inputs needed in the production of products, per dollar's worth of total inputs. In this report denoted with $\boldsymbol{A}$.

MER Market exchange rates. The exchange rates normally used when different currencies are exchanged for each other.

MRIO Multi-regional input–output. MRIO models include IOTs from various regions or countries.

Mt Megaton, million tonnes.

N_2O Nitrous oxide. A greenhouse gas 310 times more powerful than CO_2. Emitted e.g. in agriculture and in industrial processes.

NDP Net domestic product.

Net domestic product The sum of consumption, net investments and net exports (exports less imports). Net investments are investments less depreciation, i.e. the part of investments which increase the capital stock (see Figure 2.6).

NMVOC Non-methane volatile organic compound, a group of organic compounds emitted from e.g. car traffic and industrial processes.

NO_x Nitrogen oxides, i.e. NO and NO_2. Among the most important gases responsible for the acidification of ecosystems. Emitted in combustion processes e.g. from car traffic.

Output In this study mostly the same as gross output, i.e. the value of a product, including all the inputs needed for its production, including wages going to labor force inputs needed in the production (value added). Sometimes it means only the value added part of e.g. an industry's output, but it should then really be denoted as net output.

PPP Purchasing power parity. Exchange rates which take into account the fact that a certain amount of money expressed in a common currency has the power to buy various amounts of the same goods depending on country.

Production-based, production perspective Energy use or emissions occurring inside a country's territory, without the inclusion of indirect use or emissions occurring abroad due to imports.

Products In this study either goods or services. Can be divided into SNI groups which correspond to the various industries producing the products.

ROW Rest of the world.

SNA System of national accounts. The accounting system standard developed by UN and used by national accounts offices all around the world.

SNI Swedish Standard Industrial Classification (Svensk näringsgrensindelning). The standard in which Swedish industries are divided into various groups denoted by SNI codes. The classification of products is based on this standard.

Every row and column in the intermediate matrix of the use table and the input–output table and in the make matrix of the supply table correspond to a SNI code. SNI is based on the EU standard NACE. See Appendix G.

SO_2 Sulfur dioxide, one of the most important gases responsible for the acidification of ecosystems. Emitted in the combustion of fossil fuels.

SRIO Single-regional input–output. SRIO models use a single input–output table from a single country.

Supply The flow of products going into the society, later on used (i.e. purchased) by the industry or the final consumers. Includes both products produced domestically, and imports, i.e. products produced abroad.

Supply chain The chain of suppliers (industries) transforming inputs (ultimately raw materials) step by step to a finished product for final use.

Supply table A table showing the various products produced by the various industries as well as imports of these products.

SUT Supply and use table.

TWh Terawatthours. The total Swedish energy supply has been around 600 TWh per year the last 20 years.

UNFCCC United Nations Framework Convention on Climate Change. A treaty signed at the Rio summit in 1992. The Kyoto protocol is an amendment to this treaty. As a part of the treaty, Sweden submit emission reports to the UNFCCC secretariat annually.

Upstream The production occurring in an earlier stage in the supply chain.

Use The various ways in which the supply flow coming into the society is used and distributed over various user categories (i.e. various consumer categories). These categories could be intermediate users (consumption carried out by industries) or various final users (private and public consumers, investors and consumers abroad (exports)).

Use matrix The intermediate product x industry matrix in the use table.

Use table A table showing the input of products needed per user category, i.e. per various intermediate users (industries) and per various final users (private and public consumers, investors and exports).

Value added Revenues of production less costs for product inputs.

World average intensities In this study, the resource use or emission intensities of the various products groups produced in the average world industries. Correspond to $\boldsymbol{E}_i^{PPP}$ and $\boldsymbol{E}_i^{MER}$ in equation (4.21).

Appendix B
List of variables

$\boldsymbol{A}_d$	The domestic part of the matrix of technical coefficients: $\boldsymbol{A}_d = \boldsymbol{F}_d \hat{\boldsymbol{x}}_p^{-1}$ or $(a_{ij}^d) = (f_{ij}^d / x_j^p)$. The element a_{ij}^d represents the use of domestic input of product i per dollar's worth of production of product j.
$\boldsymbol{A}_m$	The imports part of the matrix of technical coefficients: $\boldsymbol{A}_m = \boldsymbol{F}_m \hat{\boldsymbol{x}}_p^{-1}$ or $(a_{ij}^m) = (f_{ij}^m / x_j^p)$. The element a_{ij}^m represents the use of imported input of product i per dollar's worth of production of product j.
$\boldsymbol{A}_{tot}$	The matrix of technical coefficients, domestic plus imports: $\boldsymbol{A}_{tot} = \boldsymbol{A}_d + \boldsymbol{A}_m$ or $(a_{ij}^{tot}) = ((f_{ij}^d + f_{ij}^m)/x_j^p)$. The element a_{ij}^{tot} represents the use of domestic plus imported inputs of product i per dollar's worth of production of product j.
$\boldsymbol{E}_{ind}$	Environmental matrix of resource uses and emissions per industry. The element e_{ij}^{ind} represents resource use or emission of type i generated directly by industry j.
$\boldsymbol{E}_p$	Environmental matrix of resource uses and emissions per product: $\boldsymbol{E}_p = \boldsymbol{E}_{ind}\boldsymbol{S}_c'$. The element e_{ij}^p represents resource use or emission of type i generated directly by product j.
$\boldsymbol{e}_{dir}$	The environmental direct use vector. The element e_i^{dir} represents direct resource use or emission of type i generated directly by final consumers downstream the event of consumption. This vector is originally divided into several columns, but here it is treated as a single vector.
$\boldsymbol{E}_i^{swe}$	The Swedish environmental intensity matrix: $\boldsymbol{E}_i^{swe} = \boldsymbol{E}_p \hat{\boldsymbol{x}}_p^{-1}$. The element $e_{ij}^{i,swe}$ represents resource use or emission of type i generated directly in Sweden per dollar's worth of product j.
$\boldsymbol{E}_i^{MER}$	World average intensity matrix based on the MER approach: $\boldsymbol{E}_i^{MER} = \hat{\boldsymbol{k}}_{MER}\boldsymbol{E}_i^{swe}$. The element $e_{ij}^{i,MER}$ represents resource use or emission of type i generated directly abroad per dollar's worth of product j.
$\boldsymbol{E}_i^{PPP}$	World average intensity matrix based on the PPP approach: $\boldsymbol{E}_i^{PPP} = \hat{\boldsymbol{k}}_{PPP}\boldsymbol{E}_i^{swe}$. The element $e_{ij}^{i,PPP}$ represents resource use or emission of type i generated directly abroad per dollar's worth of product j.
$\boldsymbol{e}_{swe}$	The vector of Swedish total resource uses and emissions from both industry and direct use, including bunkers: $\boldsymbol{e}_{swe} = \boldsymbol{E}_p\boldsymbol{i} + \boldsymbol{e}_{dir}$. The element e_i^{swe} represents resource use or emission of type i generated directly by industry and final consumers.
$\boldsymbol{e}_{world}$	The vector of global total resource uses and emissions. The element e_i^{world} represents resource use or emission of type i generated totally in the whole world.

$\boldsymbol{e}_c$	The vector of consumption-based resource uses and emissions generated directly and indirectly throughout the whole supply chain due to final demand. The element e_i^c represents resource use or emission of type i generated.
$\boldsymbol{e}_{tot}$	The vector of consumption-based resource uses and emissions generated directly and indirectly throughout the whole supply chain due to total final demand (excluding exports) of domestic and imported products, including downstream effects in direct use ($\boldsymbol{e}_{dir}$). The element e_i^{tot} represents resource use or emission of type i generated. See equation (4.23).
$\boldsymbol{F}_d$	The intermediate product x product matrix of the domestic part of the input–output table. The element f_{ij}^d represents the input of the domestical products i in the production of all products j produced over a year.
$\boldsymbol{F}_m$	The intermediate product x product matrix of the imports part of the input–output table. The element f_{ij}^m represents the input of the imported products i in the production of all products j produced over a year.
$\boldsymbol{F}_{tot}$	The intermediate product x product matrix of the domestic plus imports input–output table. The element f_{ij}^{tot} represents the input of the domestical and imported products i in the production of all products j produced over a year.
$\boldsymbol{G}$	Aggregation matrix.
$\boldsymbol{i}$	The unit vector (a column vector with only ones).
$\boldsymbol{k}$	Ratio of world intensity to Swedish intensity vector. Could be $\boldsymbol{k}_{MER}$ or $\boldsymbol{k}_{PPP}$ depending on whether the MER or the PPP approach is used. The element k_i refers to the world–Sweden intensity ratio for the resource use or emission type i. See equation (4.20).
$\boldsymbol{I}$	The identity matrix.
$\boldsymbol{L}_d$	The Leontief inverse, domestic: $\boldsymbol{L}_d = (\boldsymbol{I} - \boldsymbol{A}_d)^{-1}$. The element l_{ij}^d represents the total domestic production, direct and indirect, of product i needed throughout the whole supply chain per dollar's worth of consumption of product j.
$\boldsymbol{L}_{tot}$	The Leontief inverse, total: $\boldsymbol{L}_{tot} = (\boldsymbol{I} - \boldsymbol{A}_{tot})^{-1}$. The element l_{ij}^{tot} represents the total domestic and imported production, direct and indirect, of product i needed throughout the whole supply chain per dollar's worth of consumption of product j.
$\boldsymbol{m}$	The vector of total imports per product.

$\boldsymbol{S}$	The make matrix of the supply table.
$\boldsymbol{S}_c$	The coefficient matrix of the make matrix: $\boldsymbol{S}_c = \boldsymbol{S}\hat{\boldsymbol{x}}_{ind}^{-1}$.
$\boldsymbol{U}$	The intermediate use matrix of the use table.
$\boldsymbol{x}_{ind}$	The vector of total output per industry, equals to total domestic production per industry.
$\hat{\boldsymbol{x}}_{ind}$	Diagonalization of the vector $\boldsymbol{x}_{ind}$.
$\boldsymbol{x}_p$	The vector of total output per product, equals to total domestic production per product, equals to total input per product.
$\hat{\boldsymbol{x}}_p$	Diagonalization of the vector $\boldsymbol{x}_p$.
$\boldsymbol{y}_d$	The vector of final demand (including exports) of domestic products. The final demand vectors are each originally divided into several columns, but are here treated as single vectors.
$\boldsymbol{y}_m$	The vector of final demand (including exports) of products produced abroad.
$\boldsymbol{y}_{tot}$	The vector of final demand (including exports) of domestic products and products produced abroad.
$\boldsymbol{y}_d^{nexp}$	The vector of domestic final demand (excluding exports) of domestic products.
$\boldsymbol{y}_m^{nexp}$	The vector of domestic final demand (excluding exports) of products produced abroad.
$\boldsymbol{y}_{tot}^{nexp}$	The vector of domestic final demand (excluding exports) of domestic products and products produced abroad.

Appendix C
Matrix algebraic conventions

General conventions

- Matrices are in uppercase bold letters: $\boldsymbol{A}$
- Vectors are in lowercase bold letters: $\boldsymbol{x}$
- Elements in vectors or matrices are in lowercase, normal letters: x_1
- For an element a_{ij} in the matrix $\boldsymbol{A}$, i refers to the row number of that element, and j refers to the column number.
- A matrix or a vector could be denoted as $\boldsymbol{A}$ or (a_{ij}); these ways of writing are equivalent, i.e. $\boldsymbol{A} = (a_{ij})$.
- The matrix $\boldsymbol{I}$ is the unity matrix, with only ones on the diagonal.
- The vector $\boldsymbol{i}$ is a unit vector with only ones in a column, e.g. $\boldsymbol{i}' = \begin{pmatrix} 1 & 1 & 1 \end{pmatrix}$.
- Denoting matrices or vectors with some attribute, is done in index position, e.g. $\boldsymbol{A}_d$. For elements this is however denoted in exponent position, as index position is reserved for purpose of position of the element in the matrix, e.g. a_{ij}^d. This will probably not be any problem, since elements are seldom powered. Some times exponent position is used as well for matrices, e.g. in decomposition analysis where $\boldsymbol{E}_i^0$ refers to intensities in year 0. When powering is done, this will be evident from the context.
- Vectors are by default column vectors. Row vectors are consequently denoted by e.g. $\boldsymbol{x}'$.

Diagonalizing

Diagonalizing of vector $\boldsymbol{x}$ is denoted $\hat{\boldsymbol{x}}$, which means that if $\boldsymbol{x}' = \begin{pmatrix} x_1 & x_2 & x_3 \end{pmatrix}$, then

$$\hat{\boldsymbol{x}} = \begin{pmatrix} x_1 & 0 & 0 \\ 0 & x_2 & 0 \\ 0 & 0 & x_3 \end{pmatrix} .$$

In $\hat{\boldsymbol{x}}^{-1}$ all elements on the diagonal are inverted, that is

$$\hat{\boldsymbol{x}}^{-1} = \begin{pmatrix} 1/x_1 & 0 & 0 \\ 0 & 1/x_2 & 0 \\ 0 & 0 & 1/x_3 \end{pmatrix} .$$

So doing $\boldsymbol{F}\hat{\boldsymbol{x}}^{-1}$, means to divide every element in the first column of $\boldsymbol{F}$ with x_1, the second column with x_2, and so on.

Multiplication

Multiplication like $\boldsymbol{Ay}$ can be interpreted as

$$\boldsymbol{Ay} = \boldsymbol{b} \Rightarrow$$

$$\begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \\ y_3 \end{pmatrix} = \left[y_1 \begin{pmatrix} a_{11} \\ a_{21} \\ a_{31} \end{pmatrix} + y_2 \begin{pmatrix} a_{12} \\ a_{22} \\ a_{32} \end{pmatrix} + y_3 \begin{pmatrix} a_{13} \\ a_{23} \\ a_{33} \end{pmatrix} \right] =$$

$$= \begin{pmatrix} y_1 a_{11} + y_2 a_{12} + y_3 a_{13} \\ y_1 a_{21} + y_2 a_{22} + y_3 a_{23} \\ y_1 a_{31} + y_2 a_{32} + y_3 a_{33} \end{pmatrix} = \begin{pmatrix} b_1 \\ b_2 \\ b_3 \end{pmatrix},$$

which means that the first column in $\boldsymbol{A}$ is multiplied by y_1, the second column in $\boldsymbol{A}$ is multiplied by y_2, and the third column in $\boldsymbol{A}$ is multiplied by y_3, which after adding the resulting columns leads to a new column vector $\boldsymbol{b}$. If $\boldsymbol{A}$ is instead multiplied by a matrix $\boldsymbol{Y}$, the same procedure is done fore each column in $\boldsymbol{Y}$ yielding subsequently as many columns in the resulting matrix $\boldsymbol{B}$.

Aggregation

Aggregation of vector $\boldsymbol{x}$, meaning that certain rows of $\boldsymbol{x}$ are put together, is accomplished by e.g.

$$\begin{aligned} \tilde{\boldsymbol{x}} &= \boldsymbol{Gx} \Rightarrow \\ \begin{pmatrix} 2 \\ 5 \\ 7 \end{pmatrix} &= \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 2 \\ 4 \\ 1 \\ 7 \end{pmatrix}, \end{aligned}$$

showing that row number 2 and 3 are put together. Aggregation of matrix $\boldsymbol{S}$ so that certain rows and corresponding columns are put together, is done by e.g.

$$\begin{aligned} \tilde{\boldsymbol{S}} &= \boldsymbol{GSG}' \Rightarrow \\ \begin{pmatrix} 2 & 7 & 5 \\ 5 & 16 & 11 \\ 7 & 17 & 0 \end{pmatrix} &= \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 2 & 3 & 4 & 5 \\ 4 & 5 & 6 & 7 \\ 1 & 2 & 3 & 4 \\ 7 & 8 & 9 & 0 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}, \end{aligned}$$

showing that rows 2 and 3 and columns 2 and 3 are put together.

Element-wise multiplication

Since a matrix $\boldsymbol{A} = (a_{ij})$, and $\boldsymbol{A} + \boldsymbol{B} = (a_{ij} + b_{ij})$, element-wise multiplication between $\boldsymbol{A}$ and $\boldsymbol{B}$ can be expressed as $(a_{ij} \cdot b_{ij})$. This is sometimes denoted as $\boldsymbol{A} \otimes \boldsymbol{B}$, called the Habermard product. Accordingly,

$$\boldsymbol{A} \otimes \boldsymbol{B} = (a_{ij} \cdot b_{ij}) = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \otimes \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} = \begin{pmatrix} a_{11}b_{11} & a_{12}b_{12} \\ a_{21}b_{21} & a_{22}b_{22} \end{pmatrix} .$$

A similar Habermard division can then be defined as $\boldsymbol{A} \oslash \boldsymbol{B}$ which is the same as (a_{ij}/b_{ij}). Sometimes a column vector is multiplied element-wise with all the columns of a matrix. If we have $\boldsymbol{A}$ and $\boldsymbol{x}$, this is described as $(a_{ij} \cdot x_i)$.[1]

Environmental matrices built upon the Leontief inverse

Using element-wise multiplication it is possible to construct a sort of "environmental Leontief inverse" matrix for a certain environmental impact. If the impact's intensity vector is $\boldsymbol{e}_i$ (e.g. describing the CO_2 intensities of various products), this matrix becomes

$$\boldsymbol{E}_l = (e_i^i \cdot l_{ij}) ,$$

where the element e_{ij}^l denotes the emissions from the production of product i needed directly and indirectly per dollar's worth of consumption of product j.

A similar matrix is possible to construct using ordinary matrix multiplication in

$$\boldsymbol{E}_L = \boldsymbol{E}_i \boldsymbol{L} ,$$

where $\boldsymbol{E}_i$ is the environmental intensity matrix (with e_{ij}^i denoting resource use or emission of type i generated directly per dollar's worth of production of product j), and the element e_{ij}^L in $\boldsymbol{E}_L$ denotes the total environmental impact of type i caused directly and indirectly per dollar's worth of consumption of product j.[2]

Upon this result, a consumption-based environmental impact matrix describing environmental impact per environmental variable and per consumed product due to any final demand $\boldsymbol{y}$ (not just per dollar) can be constructed through

$$\boldsymbol{E}_c = (e_{ij}^L \cdot y_j) .$$

Thus, the element e_{ij}^c denotes the total environmental impact of type i caused by the consumption of product j. An example of this matrix is shown in Appendix G.

---

[1] The dot in between the factors of e.g. $(a_{ij} \cdot b_{ij})$ is not needed, only there for clarity.

[2] Miller and Blair, 2009, discuss this matrix.

Appendix D
Proof that $\boldsymbol{A}^{n+1}$ converges to zero[1]

This adds to the derivation of the power series approximation of the Leontief inverse, presented in equations (3.8) and (3.9), which assumed that $\boldsymbol{A}^{n+1} \to \mathbf{0}$ if $n \to \infty$.

We can assume that the column sums of $\boldsymbol{A}$ are all less than 1 since all products have not only other products as inputs, but also labor force inputs, so the share of product inputs must be less than 1. Saying this, we have at the same time said that all the elements a_{ij} of $\boldsymbol{A}$ are also each of them less than 1, and we also assume that they are equal to or greater than 0. Further on, we define the norm $||\boldsymbol{A}||$ as the maximum element of $\boldsymbol{A}$, i.e. $||\boldsymbol{A}|| = max(a_{ij})$, and we also define s as the maximum column sum of $\boldsymbol{A}$, i.e. $s = max(\sum_k a_{kj})$.

Now, we will start off by examining if the maximum element of $\boldsymbol{A}^2$ is less than the maximum element of $\boldsymbol{A}$:

$$||\boldsymbol{A}^2|| = ||\boldsymbol{A}\boldsymbol{A}|| = max(\sum_k a_{ik}a_{kj}) \leq max(||\boldsymbol{A}|| \sum_k a_{kj}) = ||\boldsymbol{A}||s < ||\boldsymbol{A}||\,,$$

since $s < 1$. The sum $\sum_k a_{ik}a_{kj}$ in the equation above is the definition of matrix multiplication. In the step just after that, we have exchanged $||\boldsymbol{A}||$ for a_{ik} since $a_{ik} \leq ||\boldsymbol{A}||$, so if the proof holds when inserting $||\boldsymbol{A}||$, it will be even more true for a_{ik}. Thus, apparently is $||\boldsymbol{A}^2|| \leq ||\boldsymbol{A}||s < ||\boldsymbol{A}||$, i.e. the maximum element of $\boldsymbol{A}^2$ is less than the maximum element of $\boldsymbol{A}$.

The similar reasoning can now be done for the higher powers as well, yielding that

$$||\boldsymbol{A}^{n+1}|| = ||\boldsymbol{A}^n\boldsymbol{A}|| \leq ||\boldsymbol{A}^n||s \leq ||\boldsymbol{A}^{n-1}||s^2 \leq \ldots \leq ||\boldsymbol{A}||s^n \to 0,\ n \to \infty,$$

since, again, $s < 1$. So the maximum element of $\boldsymbol{A}^{n+1}$ goes to 0, which implies that the whole matrix $\boldsymbol{A}^{n+1} \to \mathbf{0}$ as $n \to \infty$.

---

[1] Based on Physics Forums, 2010. A slightly different approach is found in Waugh, 1950, and in Miller and Blair, 2009.

Appendix E
SUT and IOT for Sweden 2005

Supply table, Sweden 2005 (basic prices, current prices)

	Industries								
Products	Agricult. industry	Forest industry	…	House-hold serv.	Total production per product	Imports	Total supply at basic prices	Taxes less subs.	Total supply at market prices
Agricultural products (SNI 01)	36		2		38	14	52	19	71
Forestry products (SNI 02)		20	2		22	4	26		26
… (SNI 03-94)	3	1							
Household services (SNI 95)				1	1				1
Total production per industry	39	21		1	5100	1100	6200	400	6600

(Unit: Billion SEK/year)

Use table, Sweden 2005 (market prices, current prices)

	Industries					Final demand				
Products	Agricult. industry	Forest industry	…	House-hold serv.	Total intermed. use per product	Con-sumption	Gross investments	Exports	Total final demand per product	Total supply per product
Agricultural products (SNI 01)	6		31		37	31		3	34	71
Forestry products (SNI 02)		1	24		25	1	-1	1	1	26
… (SNI 03-94)	21	6								
Household services (SNI 95)						1			1	1
Total use per industry or FD	27	7		0	2700	2100	500	1300	3900	6600
Value added per industry	12	14		1	2400					
Total input per industry	39	21		1	5100					

(Unit: Billion SEK/year)

Input-output table, Sweden 2005 (basic prices, current prices)

	Products					Final demand				
Products	Agricult. products	Forest products	…	House-hold serv.	Total intermed. use per product	Con-sumption	Gross investments	Exports	Total final demand per product	Total supply per product (output+imports)
Agricultural products (SNI 01)	4+1		27+3		31+4	5+9		2+1	7+10	38+14
Forestry products (SNI 02)		1.2+0.1	20+4		21+4	1+0	-1.5+0	1+0	0.5+0	22+4
… (SNI 03-94)	15+4	4+2								
Household services (SNI 95)						1+0			1+0	1+0
Total use per product or FD	19+5	5+2			1900+700	1700+200	300+100	200+100	3200+400	5100+1100
Taxes less subsidies	2	1			100	200	100	0	300	400
Total use incl. taxes	26	8		0	2700	2100	500	1300	3900	6600
Value added per product	12	14		1	2400					
Total input per product	38	22		1	5100					
Imports	14	4		0	1100					
Total supply per product	52	26		1	6200					

(Unit: Billion SEK/year) Note: Cells include domestic+imports figures.

Source : Statistics Sweden, 2008 and 2009.

Appendix F
Organization of the Excel database

The Excel database is available at:
http://www.fysast.uu.se/ges/en/marten-berglund

The database is divided into ten different files, organized in three levels – see Figure F.1 below. Arrows in the figure describe the relationships between the files, i.e. from which files the various files fetch data used in the sheet calculations.[1,2]

ORIGINAL DATA, FILES ON THE BASE LEVEL:

S.xls	The official supply-tables, from 1993 to 2005, in both revisions.
U.xls	The official use-tables, from 1993 to 2005, in both revisions.
IO.xls	The official IOTs, from 1995 and 2000 in the first revision, and 2000 and 2005 in the second revision.
GDP.xls	GDP time series and other economic data, for Sweden and for the whole world.
E_swe.xls	Official Swedish environmental data from the Energy authority (energy use, including bunkers) and from the Swedish reporting to UNFCCC (emissions, excluding bunkers).
E_mir.xls	Environmental matrices (flows per industry) from the environmental accounts (including bunkers), from 1993–2005.
E_world.xls	Official global environmental data from IEA and from the EDGAR database. Including bunkers.

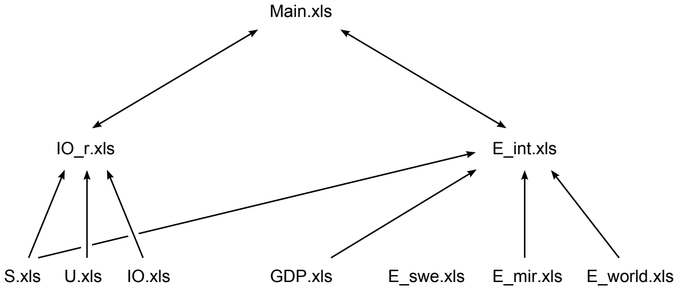


Figure F.1. Relations between the files in the Excel database.

---

[1] Only the most important relations are shown in the figure. Main.xls also fetches data directly from all the files on the base level except from IO.xls and E_world.xls.

[2] Though not included in the calculations, two additional files are part of the database: Figs.xls (data from figures in report) and Results.xls (results sheets from Main.xls, see below).

AUXILIARY CALCULATION FILES, FILES ON THE MIDDLE LEVEL:

IO_r.xls	In this file, the domestic and imports shares in the IOTs are extracted.
E_int.xls	In this file, the environmental matrix from E_mir.xls is converted from an energy uses or emissions x industry matrix, to an energy uses or emissions x product matrix. The corresponding intensity matrix is calculated. The intensity ratio between the world and Sweden, is calculated.

MAIN CALCULATION FILES, FILES ON THE TOP LEVEL:

Main.xls	All the main calculations are done here. Data are fetched from the files on the lower levels. The $\boldsymbol{A}$ matrix is generated and its corresponding Leontief inverse. The vectors and matrices describing required production per consumed products, as well as required energy use and generated emissions per consumed products, are calculated. All results are gathered in the 8th sheet section of this file, in five separate sheets (see the table of contents of the file in the first sheet).

The database can be considered a vector valued function $\boldsymbol{f}(t)$, which as input, t, takes years, and as output pours out various consumption-based environmental data. The input, t, is given in cell [Main.xls]Tot!B3 and the output is generated in the sheets in the 8th sheet section of the file Main.xls. The input t is actually not just a year, but also indicates which revision is to be used, denoted by a or b. Valid values for t are 1993a–2003a, and 2000b–2005b. A time series is generated by entering such a year and revision in the cell mentioned, and then saving all the outputs coming from that year and revision in a separate column. The same is repeated for all years in that revision.

The output is divided onto five sheets, with the following contents:

Tot	Consumption-based totals for various assumptions (PPP etc.), physical trade balances, economical data, official production based data, for all environmental variables.
IPAT	IPAT data and indices for all environmental variables.
IDA	Decomposition analysis data for all environmental variables.
Prod	Product groups analysis, the environmental impact per various product groups, for all environmental variables.
FD_cat	Environmental impact per the various final demand categories, for all environmental variables.

Calculations are done in accordance with what has been described in Chapter 4. The detailed description of these calculations are found in the table of contents-sheets, and directly as cell formulas in the various sheets.

Appendix G
Excel tables

A selection of interesting tables from the Excel database is shown on the following pages.

PAGE	DESCRIPTION
108	SNI codes for the various product groups.
109	The Swedish matrix of technical coefficients $\boldsymbol{A}_{tot}$ for 2005.
110	The Swedish Leontief inverse $\boldsymbol{L}_{tot}$ for 2005.
111	A consumption-based Swedish environmental impact matrix describing worldwide environmental impact per environmental variable and per consumed product due to Swedish final demand in 2005 of domestic and imported products. Corresponds to the $\boldsymbol{E}_c$ matrix described in Appendix C about environmental matrices (though $\boldsymbol{E}_c$ here is constructed from several different environmental intensity matrices due to distinct intensities in Sweden and abroad). Data are based on the PPP approach. Direct use is not part of these values, since this matrix only describes the impact caused upstream per consumed product, not the direct use impact by the final user (which can not be allocated per product).
112–116	The Tot sheet from Main.xls (slightly adjusted), showing the main consumption-based results for all environmental variables.

SNI codes

01	Agriculture
02	Forestry
05	Fishing
10-12	Extraction of energy resources
13-14	Mining of metal ores, other mining and quarrying
15-16	Food products, beverages and tobacco
17	Textiles industry
18	Textile products
19	Tanning and dressing of leather
20	Manufacture of wood and wood products
21	Pulp, paper and paper products
22	Publishing and printing
23	Coke, refined petroleum products and nuclear fuel
24	Chemicals and chemical products
25	Rubber and plastic products
26	Non-metallic mineral products
27	Basic metals
28	Fabricated metal products
29	Machinery and equipment
30	Office machinery and computers
31	Electrical machinery and apparatus
32	Radio, television and communication equipment
33	Medical and optical instruments, watches and clocks
34	Motor vehicles, trailers and semi-trailers
35	Manufacturing of other transport equipment
36	Furniture and other manufacturing
37	Recycling/Samhall
40	Electricity, gas, steam and hot water
41	Water
45	Construction
50-52	Auto sales, wholesale trade, retail trade
55	Hotels and restaurants
60	Land transport, pipelines
61	Water transport
62	Air transport
63	Supporting transport activities
64	Post and telecommunications
65	Banking
66	Insurance and pension funding
67	Other financial activities
70	Real estate activities
71	Renting of machinery and equipment
72	Computer and related activities
73	Research and development
74-75	Other business activities and public administration
80	Education
85	Health and social work
90	Sewage and refuse disposal
91	Membership organizations
92	Recreational, cultural and sporting activities
93	Other service activities
95	Private households with employed persons

The Swedish matrix of technical coefficients A_{tot} for 2005

SNI code	01	02	05	10-12	13-14	15-16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	40	41	45	50-52	55	60	61	62	63	64	65	66	67	70	71	72	73	74-75	80	85	90	91	92	93	95
01	0.14	0.00	0.00	0.01	0.00	0.19	0.00	0.02	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00
02	0.00	0.06	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.18	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
05	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-12	0.01	0.00	0.00	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-14	0.00	0.00	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15-16	0.11	0.00	0.00	0.01	0.00	0.20	0.00	0.00	0.09	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.17	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00
17	0.00	0.00	0.07	0.00	0.00	0.00	0.11	0.15	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.01	0.05	0.15	0.01	0.00	0.00	0.00	0.00	0.18	0.03	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.00	0.02	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
21	0.00	0.00	0.01	0.00	0.00	0.02	0.01	0.01	0.01	0.00	0.14	0.09	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.03	0.01	0.00	0.00	0.00	0.01	0.03	0.02	0.00	0.02	0.00	0.00	0.02	0.03	0.00	0.00
23	0.04	0.03	0.13	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.03	0.03	0.00	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.03	0.01	0.01	0.00	0.00	0.04	0.10	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
24	0.05	0.00	0.01	0.01	0.01	0.01	0.12	0.00	0.05	0.01	0.05	0.02	0.01	0.19	0.23	0.03	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.03	0.01	0.01	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.02	0.00
25	0.00	0.00	0.00	0.03	0.00	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.07	0.02	0.00	0.01	0.02	0.03	0.01	0.00	0.02	0.03	0.02	0.02	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00
26	0.01	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.09	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.03	0.31	0.14	0.06	0.07	0.04	0.00	0.03	0.04	0.03	0.08	0.03	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.01	0.02	0.01	0.02	0.01	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.13	0.09	0.04	0.01	0.00	0.03	0.04	0.05	0.04	0.03	0.00	0.06	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00
29	0.03	0.05	0.00	0.02	0.10	0.00	0.01	0.00	0.01	0.01	0.02	0.01	0.00	0.01	0.02	0.01	0.01	0.02	0.15	0.01	0.01	0.00	0.03	0.03	0.02	0.02	0.01	0.02	0.01	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00
30	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.05	0.07	0.24	0.00	0.10	0.01	0.03	0.00	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.03	0.00	0.00	0.00	0.01	0.00
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.35	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	0.03	0.01	0.00	0.02	0.03	0.01	0.01	0.00	0.01	0.02	0.06	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.05	0.04	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.03	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.03	0.04	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.02	0.01	0.03	0.00	0.11	0.00	0.00	0.00	0.04	0.00	0.00	0.01	0.02	0.01	0.00	0.00
50-52	0.07	0.03	0.08	0.02	0.05	0.04	0.03	0.02	0.03	0.03	0.04	0.01	0.00	0.02	0.04	0.05	0.08	0.04	0.05	0.05	0.03	0.00	0.04	0.04	0.04	0.03	0.02	0.01	0.02	0.04	0.02	0.06	0.07	0.01	0.04	0.01	0.01	0.00	0.00	0.00	0.01	0.04	0.01	0.02	0.01	0.01	0.01	0.07	0.02	0.04	0.03	0.00
55	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.02	0.01	0.01	0.00	0.02	0.01	0.01	0.01	0.00
60	0.01	0.00	0.02	0.04	0.03	0.02	0.02	0.04	0.01	0.04	0.05	0.01	0.00	0.01	0.01	0.04	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.00	0.01	0.03	0.02	0.01	0.14	0.00	0.00	0.30	0.01	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.01	0.02	0.00	0.03	0.04	0.01	0.00	0.00
61	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00
63	0.01	0.00	0.03	0.10	0.04	0.05	0.06	0.06	0.01	0.08	0.10	0.03	0.00	0.02	0.02	0.09	0.02	0.02	0.02	0.01	0.01	0.00	0.01	0.02	0.01	0.04	0.08	0.01	0.01	0.00	0.05	0.01	0.03	0.19	0.26	0.06	0.01	0.00	0.00	0.00	0.00	0.03	0.01	0.01	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
64	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.06	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.17	0.02	0.01	0.04	0.01	0.01	0.02	0.02	0.03	0.01	0.01	0.01	0.03	0.04	0.01	0.00
65	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.06	0.01	0.05	0.01	0.01	0.01	0.01	0.00	0.00	0.02	0.01	0.01	0.01	0.00
66	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.06	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.03	0.00	0.01	0.01	0.01	0.00	0.02	0.01	0.02	0.02	0.00	0.02	0.01	0.02	0.01	0.02	0.01	0.00	0.00	0.06	0.12	0.01	0.00	0.01	0.02	0.04	0.05	0.02	0.13	0.05	0.03	0.04	0.04	0.07	0.10	0.06	0.01	0.01	0.07	0.07	0.00
71	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.01	0.00	0.00	0.02	0.02	0.12	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.02	0.01	0.01	0.01	0.00
72	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.01	0.00	0.00	0.01	0.00	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.00	0.02	0.02	0.01	0.01	0.03	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.05	0.02	0.02	0.03	0.00	0.03	0.09	0.03	0.02	0.01	0.00	0.02	0.00	0.01	0.01	0.00
73	0.02	0.04	0.00	0.05	0.04	0.06	0.07	0.06	0.04	0.02	0.03	0.09	0.01	0.15	0.07	0.06	0.03	0.05	0.08	0.10	0.20	0.00	0.07	0.10	0.06	0.07	0.05	0.05	0.03	0.06	0.09	0.03	0.04	0.07	0.06	0.04	0.10	0.08	0.04	0.11	0.03	0.09	0.12	0.15	0.07	0.02	0.03	0.14	0.07	0.09	0.04	0.00
74-75	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.01	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00
85	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
91	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00
93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The Swedish Leontief inverse L_{tot} for 2005

SNI code	01	02	05	10-12	13-14	15-16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	40	41	45	50-52	55	60	61	62	63	64	65	66	67	70	71	72	73	74-75	80	85	90	91	92	93	95
01	1.21	0.01	0.01	0.03	0.00	0.29	0.01	0.03	0.12	0.00	0.01	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.06	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.03	0.00	0.00
02	0.01	1.07	0.02	0.08	0.01	0.01	0.01	0.01	0.00	0.23	0.11	0.01	0.07	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.01	0.00	0.02	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00
05	0.00	0.00	1.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-12	0.08	0.04	0.15	1.15	0.04	0.04	0.03	0.02	0.02	0.03	0.04	0.02	1.00	0.05	0.03	0.06	0.08	0.03	0.02	0.02	0.02	0.00	0.02	0.02	0.02	0.03	0.21	0.07	0.02	0.03	0.02	0.02	0.06	0.14	0.13	0.04	0.01	0.00	0.00	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.01	0.01	0.00
13-14	0.01	0.00	0.01	0.02	1.04	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.02	0.01	0.01	0.04	0.17	0.04	0.02	0.02	0.01	0.00	0.01	0.02	0.01	0.02	0.02	0.01	0.01	0.03	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
15-16	0.17	0.00	0.01	0.02	0.00	1.29	0.01	0.01	0.17	0.01	0.02	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.22	0.01	0.04	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.00
17	0.00	0.00	0.08	0.00	0.00	0.00	1.12	0.19	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.01	0.00	0.00	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.03	0.03	0.10	0.22	0.02	0.02	0.02	0.01	0.01	1.23	0.06	0.01	0.20	0.02	0.02	0.03	0.03	0.02	0.02	0.01	0.01	0.00	0.01	0.02	0.04	0.10	0.05	0.05	0.02	0.10	0.01	0.01	0.02	0.04	0.04	0.02	0.01	0.00	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.05	0.00
21	0.01	0.01	0.01	0.01	0.01	0.04	0.02	0.02	0.02	0.01	1.16	0.13	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
22	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.02	0.02	0.02	0.02	1.23	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.00	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.02	0.01	0.02	0.01	0.02	0.05	0.05	0.02	0.03	0.01	0.02	0.03	0.05	0.01	0.00
23	0.07	0.04	0.15	0.05	0.03	0.04	0.03	0.02	0.02	0.03	0.04	0.02	1.08	0.05	0.03	0.06	0.05	0.02	0.02	0.02	0.01	0.00	0.01	0.02	0.02	0.02	0.22	0.04	0.02	0.03	0.02	0.02	0.06	0.14	0.14	0.04	0.01	0.00	0.00	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.01	0.01	0.00
24	0.09	0.01	0.04	0.05	0.03	0.06	0.19	0.05	0.10	0.03	0.09	0.05	0.05	1.25	0.32	0.06	0.04	0.03	0.04	0.04	0.03	0.00	0.04	0.04	0.04	0.07	0.03	0.02	0.06	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.02	0.02	0.03	0.01	0.01	0.02	0.02	0.01	0.02	0.03	0.00
25	0.02	0.01	0.01	0.05	0.01	0.04	0.02	0.03	0.01	0.02	0.02	0.02	0.04	0.03	1.08	0.03	0.02	0.02	0.04	0.05	0.02	0.00	0.03	0.06	0.03	0.04	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.02	0.01	0.01	0.01	0.00
26	0.01	0.00	0.01	0.01	0.02	0.01	0.02	0.01	0.00	0.02	0.01	0.00	0.01	0.01	0.01	1.10	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.07	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
27	0.03	0.02	0.03	0.03	0.04	0.02	0.05	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.07	0.06	1.48	0.26	0.15	0.14	0.10	0.00	0.09	0.13	0.10	0.16	0.07	0.02	0.04	0.06	0.02	0.01	0.01	0.02	0.03	0.01	0.02	0.01	0.00	0.01	0.02	0.03	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.00
28	0.02	0.02	0.04	0.04	0.05	0.03	0.02	0.02	0.02	0.07	0.02	0.02	0.04	0.02	0.04	0.05	0.06	1.17	0.15	0.07	0.04	0.00	0.06	0.10	0.10	0.08	0.05	0.01	0.08	0.08	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.03	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.00
29	0.06	0.07	0.02	0.05	0.13	0.03	0.03	0.02	0.03	0.04	0.05	0.02	0.05	0.02	0.04	0.03	0.05	0.04	1.20	0.03	0.02	0.00	0.05	0.08	0.05	0.05	0.03	0.03	0.03	0.05	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.00	0.01	0.01	0.05	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.00
30	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.09	0.12	1.34	0.00	0.16	0.05	0.06	0.02	0.01	0.02	0.02	0.04	0.02	0.01	0.01	0.02	0.02	0.01	0.05	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	1.12	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.03	0.00	0.00	0.00	0.01	0.00
34	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.06	0.01	0.01	0.00	0.01	1.56	0.02	0.02	0.01	0.01	0.01	0.01	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.03	0.01	0.02	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.00
35	0.00	0.01	0.11	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	1.27	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.04	0.11	0.14	0.03	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.01	0.05	0.00	0.00	0.01	0.00	0.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.03	0.01	1.15	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.04	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	0.05	0.02	0.02	0.04	0.04	0.04	0.03	0.02	0.03	0.04	0.08	0.02	0.05	0.03	0.04	0.03	0.05	0.03	0.02	0.02	0.02	0.00	0.02	0.02	0.02	0.03	0.03	1.07	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.00	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.03	0.02	0.03	0.01	0.00
41	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
45	0.04	0.03	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.02	0.02	0.02	0.02	0.02	0.04	0.06	1.02	0.02	0.03	0.01	0.02	0.02	0.02	0.04	0.02	0.04	0.02	0.12	0.02	0.02	0.02	0.05	0.02	0.01	0.02	0.03	0.03	0.02	0.00
50-52	0.12	0.05	0.12	0.07	0.08	0.10	0.07	0.06	0.07	0.07	0.09	0.05	0.07	0.05	0.08	0.09	0.16	0.09	0.11	0.10	0.08	0.00	0.08	0.12	0.09	0.09	0.06	0.03	0.04	0.08	1.04	0.09	0.10	0.05	0.09	0.06	0.04	0.01	0.01	0.02	0.04	0.06	0.04	0.04	0.03	0.02	0.03	0.11	0.04	0.06	0.05	0.00
55	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	1.01	0.01	0.01	0.02	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.03	0.02	0.02	0.01	0.00
60	0.05	0.02	0.08	0.13	0.08	0.08	0.08	0.11	0.04	0.12	0.14	0.06	0.12	0.04	0.05	0.12	0.07	0.05	0.05	0.04	0.04	0.00	0.03	0.06	0.04	0.08	0.11	0.03	0.03	0.06	0.06	0.04	1.20	0.12	0.13	0.40	0.03	0.01	0.01	0.01	0.02	0.05	0.03	0.03	0.03	0.04	0.01	0.07	0.06	0.03	0.02	0.00
61	0.01	0.00	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.00	0.01	0.01	0.01	0.01	1.21	0.02	0.06	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
62	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.02	1.03	0.07	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00
63	0.06	0.02	0.09	0.17	0.08	0.11	0.10	0.12	0.05	0.14	0.17	0.07	0.16	0.05	0.06	0.15	0.09	0.06	0.06	0.05	0.04	0.00	0.04	0.07	0.05	0.10	0.14	0.03	0.03	0.04	0.08	0.05	0.07	0.29	0.33	1.13	0.03	0.01	0.01	0.01	0.02	0.05	0.03	0.03	0.02	0.02	0.01	0.05	0.02	0.03	0.02	0.00
64	0.02	0.02	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.10	0.02	0.03	0.03	0.02	0.02	0.02	0.03	0.03	0.04	0.00	0.03	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.03	1.23	0.03	0.02	0.06	0.02	0.03	0.04	0.04	0.05	0.02	0.01	0.03	0.04	0.07	0.02	0.00
65	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.02	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	1.06	0.08	0.03	0.06	0.02	0.02	0.02	0.02	0.01	0.01	0.03	0.02	0.02	0.02	0.00
66	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.01	0.02	0.00	0.01	0.00	0.00	1.06	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
67	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	0.03	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.07	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.00	0.05	0.06	0.05	0.04	0.05	0.03	0.03	0.03	0.08	0.16	0.04	0.04	0.06	0.05	0.08	0.08	0.03	0.16	1.07	0.06	0.07	0.08	0.10	0.12	0.08	0.05	0.03	0.11	0.09	0.00
71	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.02	0.01	0.04	0.02	0.01	0.01	0.03	0.03	0.14	0.04	0.03	0.01	0.00	0.02	0.01	1.02	0.01	0.02	0.01	0.01	0.01	0.03	0.02	0.02	0.01	0.00
72	0.02	0.02	0.02	0.03	0.02	0.03	0.04	0.05	0.03	0.02	0.03	0.04	0.03	0.04	0.03	0.03	0.04	0.03	0.05	0.05	0.06	0.00	0.04	0.06	0.04	0.04	0.05	0.02	0.03	0.02	0.03	0.02	0.03	0.05	0.04	0.04	0.08	0.03	0.03	0.05	0.02	0.05	1.12	0.06	0.04	0.02	0.01	0.04	0.02	0.03	0.02	0.00
73	0.12	0.09	0.09	0.16	0.13	0.18	0.18	0.17	0.14	0.12	0.14	0.21	0.16	0.27	0.20	0.16	0.14	0.15	0.22	0.24	0.39	0.00	0.19	0.29	0.17	0.19	0.14	0.11	0.10	0.14	0.16	0.12	0.12	0.19	0.18	0.13	0.22	0.13	0.07	0.18	0.10	0.17	0.21	1.24	0.13	0.06	0.07	0.24	0.13	0.17	0.10	0.00
74-75	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01	1.01	0.03	0.02	0.01	0.00	0.02	0.01	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	1.01	0.01	0.00	0.01	0.00	0.00	0.00
85	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	1.01	0.00	0.00	0.01	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.01	0.01	0.01	0.01	0.01	0.00	1.04	0.00	0.01	0.00	0.00
91	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1.00	0.00	0.00	0.00
92	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.01	0.00	0.01	0.01	1.11	0.01	0.00
93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

Consumption-based environmental impact per environmental variable and per consumed product due to Swedish final demand in 2005, PPP approach

Environmental variable \ SNI code	01	02	05	10-12	13-14	15-16	17	18	19	20	21	22	23	24	25	26	27	28
Oil	3.34	-0.13	0.37	-0.10	-0.03	10.70	0.45	0.99	0.29	0.54	0.34	0.63	2.37	1.22	0.17	0.37	-0.14	1.04
Coal	0.27	0.00	0.01	-0.01	-0.01	1.35	0.14	0.13	0.07	0.06	0.08	0.13	0.33	2.43	0.11	0.44	-0.03	0.23
Gas	0.84	-0.01	0.04	-0.03	-0.01	4.05	0.25	0.27	0.11	0.10	0.08	0.17	5.27	1.67	0.14	0.11	-0.12	0.60
Total fossil fuels	4.45	-0.15	0.41	-0.15	-0.05	16.10	0.84	1.39	0.47	0.70	0.51	0.93	7.97	5.32	0.43	0.92	-0.30	1.87
CO2	1 779 214	-41 099	163 658	-68 621	-15 392	5 979 072	359 438	639 106	202 937	286 662	207 764	368 449	2 517 616	1 638 305	170 049	599 672	-203 248	1 030 137
CH4	307 095	-189	331	-2 959	-60	378 225	2 543	13 410	13 553	1 274	953	2 388	57 494	11 007	1 151	819	-529	4 352
N2O	12 209	-13	17	-102	-4	17 409	98	437	462	69	56	110	1 992	957	57	54	-21	156
CO2eq	12 013 018	-49 001	176 000	-162 355	-17 800	19 318 622	443 227	1 056 053	630 780	334 797	245 232	452 752	4 342 445	2 166 207	211 884	633 507	-220 838	1 169 781
SO2	2 188	-45	704	-290	-62	20 323	1 245	4 130	624	1 534	1 268	2 556	7 932	4 530	558	1 219	-650	4 211
NOx	6 840	-201	2 395	-335	-91	28 224	1 118	3 671	767	1 745	1 166	2 275	7 692	4 068	498	1 039	-394	3 132
CO	108 495	-218	987	-1 777	-54	152 774	3 115	9 848	6 038	4 051	4 134	4 179	34 912	10 948	1 494	1 461	-1 243	7 615
NMVOC	17 049	-96	175	-258	-15	33 118	565	1 480	991	640	762	831	13 868	5 198	340	268	-121	1 028

Environmental variable \ SNI code	29	30	31	32	33	34	35	36	37	40	41	45	50-52	55	60	61	62	63
Oil	3.11	1.16	0.86	0.00	0.63	3.85	0.44	1.48	0.00	3.16	0.00	10.31	9.98	2.97	4.54	1.14	1.92	6.53
Coal	0.75	0.27	0.22	0.00	0.20	1.06	0.13	0.36	0.00	3.28	0.00	2.37	1.35	0.42	0.20	0.01	0.03	0.25
Gas	1.64	0.58	0.43	0.00	0.36	1.93	0.19	0.65	0.00	3.31	0.00	2.68	2.57	0.86	0.81	0.08	0.24	0.93
Total fossil fuels	5.50	2.01	1.52	0.00	1.19	6.84	0.75	2.49	0.00	9.75	0.00	15.36	13.90	4.24	5.54	1.23	2.20	7.72
CO2	2 953 278	1 106 330	811 050	0.00	604 557	3 474 566	380 599	1 285 091	0.00	4 252 037	0.00	6 384 773	5 231 304	1 596 478	1 672 775	423 265	788 748	3 010 845
CH4	16 583	7 103	6 251	0.00	4 241	21 632	1 881	7 298	0.00	14 296	0.00	26 168	43 204	52 559	9 500	935	2 427	11 857
N2O	522	199	168	0.00	138	653	64	271	0.00	900	0.00	1 480	1 942	2 402	399	51	107	514
CO2eq	3 463 319	1 317 225	994 502	0.00	736 403	4 131 342	439 855	1 522 480	0.00	4 831 207	0.00	7 393 099	6 740 499	3 444 948	1 995 846	458 618	872 733	3 419 062
SO2	12 320	5 930	3 897	0.00	2 290	15 229	1 363	6 254	0.00	6 332	0.00	16 392	22 976	6 771	3 424	7 114	1 488	28 987
NOx	9 812	4 296	3 049	0.00	1 942	12 386	1 221	5 169	0.00	8 197	0.00	24 454	26 489	9 292	11 331	6 990	3 502	26 584
CO	25 344	11 058	7 770	0.00	5 627	28 330	3 481	13 268	0.00	23 493	0.00	41 640	45 122	24 670	9 475	1 420	5 286	18 286
NMVOC	3 525	1 500	1 111	0.00	924	4 221	486	1 844	0.00	3 624	0.00	8 555	9 188	5 140	2 571	389	970	3 827

Environmental variable \ SNI code	64	65	66	67	70	71	72	73	74-75	80	85	90	91	92	93	95
Oil	1.19	0.33	0.20	0.02	7.44	1.19	1.56	1.93	5.05	3.06	4.21	0.00	1.12	1.70	0.48	0.00
Coal	0.18	0.07	0.05	0.00	1.75	0.10	0.32	0.44	0.72	0.52	1.37	0.00	0.19	0.31	0.08	0.00
Gas	0.32	0.11	0.07	0.00	2.43	0.22	0.50	0.63	1.29	0.89	1.90	0.00	0.34	0.49	0.12	0.00
Total fossil fuels	1.69	0.51	0.33	0.02	11.62	1.51	2.39	3.01	7.06	4.47	7.48	0.00	1.65	2.50	0.69	0.00
CO2	677 000	202 525	129 505	8 758	4 730 230	523 798	993 677	1 167 445	2 619 931	1 689 951	2 905 541	0.00	617 604	936 129	249 056	0.00
CH4	5 543	2 336	872	106	69 121	3 555	8 533	9 574	20 176	21 552	42 214	0.00	5 238	15 356	1 727	0.00
N2O	209	77	35	4	1 783	167	314	406	794	850	1 758	0.00	219	939	75	0.00
CO2eq	858 146	275 438	158 724	12 108	6 734 549	650 333	1 270 355	1 494 433	3 289 754	2 405 970	4 337 034	0.00	795 393	1 549 544	308 478	0.00
SO2	2 606	813	374	30	13 405	2 019	4 208	5 529	7 940	5 666	9 345	0.00	1 976	3 083	738	0.00
NOx	3 283	933	475	39	17 575	2 979	4 415	6 118	10 720	7 704	10 895	0.00	2 854	4 065	993	0.00
CO	6 984	2 069	1 123	86	34 450	4 082	9 557	9 658	23 564	16 005	29 787	0.00	5 278	10 423	2 686	0.00
NMVOC	1 224	388	199	17	6 890	844	1 737	2 035	4 570	3 270	6 560	0.00	1 092	2 106	512	0.00

Unit: TWh/year (oil, coal, gas and total fossil fuels) or ton/year (emissions).

Main consumption-based results for all environmental variables

Variables																	
Year and revision:	1993a	1994a	1995a	1996a	1997a	1998a	1999a	2000a	2001a	2002a	2003a	2000b	2001b	2002b	2003b	2004b	2005b
Year (numerical value):	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004	2005
Economy																	
Population:	8 718 561	8 780 745	8 826 939	8 840 998	8 846 062	8 850 974	8 857 874	8 872 109	8 895 960	8 924 958	8 958 229	8 872 109	8 895 960	8 924 958	8 958 229	8 993 531	9 029 572
GDP:	252 469	262 850	273 230	277 308	285 094	296 957	310 674	324 762	328 840	336 996	344 782	324 762	328 840	336 996	344 782	359 240	370 733
GDP/capita (dollar/capita/year):	28 958	29 935	30 954	31 366	32 228	33 551	35 073	36 605	36 965	37 759	38 488	36 605	36 965	37 759	38 488	39 944	41 058
Domestic final demand:	251 157	260 569	267 392	270 561	276 040	289 280	300 470	313 016	313 682	318 663	325 069	313 016	313 682	318 663	325 069	332 008	341 727
Domestic final demand/capita (dollar/capita/year):	28 807	29 675	30 293	30 603	31 205	32 683	33 921	35 281	35 261	35 705	36 287	35 281	35 261	35 705	36 287	36 916	37 845
Exports:	73 077	82 952	92 289	96 419	109 705	119 401	128 020	143 102	144 000	145 795	151 900	143 102	144 000	145 795	151 900	168 419	179 551
Imports:	71 358	80 391	86 111	89 122	100 263	111 553	117 274	131 124	128 866	127 210	132 027	131 124	128 866	127 210	132 027	140 759	150 544
Trade balance:	1 719	2 562	6 178	7 296	9 443	7 848	10 746	11 978	15 134	18 585	19 872	11 978	15 134	18 585	19 872	27 660	29 006
Exports, IO:[1]	104 528	124 007	146 980	147 972	166 921	177 449	187 732	213 826	223 717	220 748	225 017	218 087	228 489	225 295	227 946	247 187	266 288
Imports, IO:[1]	86 381	98 265	106 593	103 793	112 889	129 551	136 389	157 096	166 507	161 341	166 076	159 199	170 379	166 464	167 629	175 185	191 246
IO trade balance:[1]	18 147	25 743	40 387	44 178	54 032	47 898	51 343	56 731	57 210	59 407	58 941	58 888	58 110	58 832	60 316	72 002	75 042
Total domestic output:[1]	364 491	395 178	429 394	438 004	462 638	484 805	512 468	554 579	576 368	586 103	599 520	561 978	585 435	596 474	610 257	643 556	680 942
Output caused domestically and abroad due to final demand (incl. exports): [1]	497 503	549 729	604 629	608 287	653 167	697 844	736 668	826 058	875 096	868 912	885 673	840 513	892 113	888 688	896 537	961 920	1 034 323
Output caused domestically and abroad due to dom. final demand: [1]	346 344	369 435	389 007	393 825	408 606	436 907	461 125	497 848	519 158	526 696	540 579	503 090	527 325	537 642	549 941	571 554	605 901
Oil																	
Consumption-based use, total:	150.22	156.06	153.37	158.68	148.64	152.31	150.96	146.85	143.24	143.60	145.04	152.52	149.91	150.44	154.61	157.60	153.59
- of which is in Sweden:	53.55	57.70	53.93	61.05	54.12	56.70	54.31	49.04	49.41	50.08	52.82	50.85	51.43	52.17	56.02	51.42	51.10
- abroad (PPP):[2]	27.67	29.52	30.28	30.22	30.40	33.05	35.80	37.60	37.43	37.21	37.09	41.47	42.08	41.96	43.46	52.04	52.87
- direct use:	69.00	68.84	69.16	67.42	64.11	62.55	60.85	60.21	56.40	56.30	55.13	60.21	56.40	56.30	55.13	54.14	49.62
Use due to direct imports (PPP):	18.14	19.58	21.50	21.61	22.76	25.31	26.03	27.21	28.66	27.94	28.16	30.69	31.83	31.91	34.28	40.50	43.15
Consumption-based use, total/capita (MWh/cap/year): [2]	17.23	17.77	17.38	17.95	16.80	17.21	17.04	16.55	16.10	16.09	16.19	17.19	16.85	16.86	17.26	17.52	17.01
Consumption-based use (MER), total:[3]	161.04	167.53	165.26	170.67	160.80	165.59	165.51	162.35	159.00	159.64	161.45	169.62	167.63	168.52	173.84	181.23	178.28
Consumption-based use, swe. int., total:	149.28	156.15	152.11	158.79	146.87	150.48	146.60	140.69	136.82	136.52	139.34	145.73	142.70	142.45	147.93	147.74	142.23
- of which is abroad:	26.73	29.61	29.01	30.33	28.64	31.22	31.44	31.44	31.01	30.13	31.38	34.67	34.87	33.97	36.78	42.19	41.51
Intensity ratio (PPP):[4]	1.04	1.00	1.04	1.00	1.06	1.06	1.14	1.20	1.21	1.24	1.18	1.20	1.21	1.24	1.18	1.23	1.27
Intensity ratio (MER):[4]	1.44	1.38	1.45	1.39	1.49	1.48	1.60	1.69	1.71	1.77	1.70	1.69	1.71	1.77	1.70	1.79	1.87
Use in Sweden due to exports:	39.87	46.61	48.14	52.59	53.17	55.86	54.00	54.52	56.36	53.98	60.23	52.66	54.29	51.84	57.00	61.13	60.56
Use in Sweden due to direct exports:	25.29	29.17	30.16	32.40	34.13	35.84	34.73	35.75	36.81	34.82	39.98	32.88	33.63	31.83	35.22	39.70	38.39
Physical trade balance:[5]	12.20	17.08	17.87	22.37	22.77	22.81	18.20	16.92	18.93	16.77	23.14	11.20	12.21	9.88	13.54	9.08	7.69
Physical trade balance, direct:	7.15	9.59	8.66	10.79	11.38	10.53	8.70	8.54	8.15	6.88	11.82	2.20	1.81	-0.08	0.94	-0.81	-4.76
Production-based use, incl. bunkers (Statistics Sweden):	162.42	173.15	171.24	181.06	171.41	175.12	169.16	163.77	162.17	160.37	168.18	163.77	162.17	160.37	168.18	166.72	161.32
Production-based use, incl. bunkers (Swedish Energy Agency):	147.53	153.79	154.93	157.69	158.22	160.27	159.16	155.58	153.18	151.39	157.67	155.58	153.18	151.39	157.67	159.78	155.03
Coal																	
Consumption-based use, total:	25.98	26.26	25.46	25.74	23.14	23.45	19.94	21.19	20.22	21.04	21.67	20.54	19.81	20.82	21.25	22.90	22.74
- of which is in Sweden:	13.06	12.82	11.30	13.76	9.89	10.63	8.48	8.30	8.42	9.80	10.30	8.29	8.43	9.84	10.33	10.25	8.04
- abroad (PPP):[2]	12.93	13.44	14.16	11.98	13.25	12.82	11.46	12.89	11.79	11.24	11.37	12.25	11.38	10.98	10.92	12.65	14.70
- direct use:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Use due to direct imports (PPP):	7.02	7.80	9.52	8.84	9.78	9.24	7.71	8.96	8.51	8.31	8.96	8.90	8.45	8.28	8.82	9.08	11.30
Consumption-based use, total/capita (MWh/cap/year): [2]	2.98	2.99	2.88	2.91	2.62	2.65	2.25	2.39	2.27	2.36	2.42	2.32	2.23	2.33	2.37	2.55	2.52
Consumption-based use (MER), total:[3]	31.04	31.48	31.02	30.49	28.44	28.60	24.59	26.50	25.18	25.88	26.70	25.59	24.60	25.55	26.08	28.65	29.61
Consumption-based use, swe. int., total:	19.29	19.52	17.66	20.33	16.04	17.05	13.20	14.16	14.14	15.94	16.40	13.86	13.95	15.84	16.19	16.46	14.28
- of which is abroad:	6.23	6.70	6.36	6.57	6.14	6.42	4.72	5.86	5.72	6.14	6.11	5.57	5.52	6.00	5.86	6.21	6.24
Intensity ratio (PPP):[4]	2.07	2.01	2.23	1.82	2.16	2.00	2.43	2.20	2.06	1.83	1.86	2.20	2.06	1.83	1.86	2.04	2.36
Intensity ratio (MER):[4]	2.88	2.78	3.10	2.55	3.02	2.80	3.41	3.11	2.93	2.62	2.69	3.11	2.93	2.62	2.69	2.96	3.46
Use in Sweden due to exports:	7.19	7.76	7.95	9.01	8.06	8.27	5.87	6.97	7.42	8.02	8.20	6.99	7.41	7.98	8.16	8.57	8.89
Use in Sweden due to direct exports:	3.68	3.99	4.41	4.81	4.71	4.78	3.19	4.06	4.39	4.61	4.65	4.09	4.41	4.62	4.70	4.96	5.79
Physical trade balance:[5]	-5.73	-5.68	-6.22	-2.96	-5.19	-4.55	-5.59	-5.92	-4.37	-3.22	-3.18	-5.27	-3.97	-3.00	-2.75	-4.09	-5.81
Physical trade balance, direct:	-3.35	-3.81	-5.11	-4.03	-5.06	-4.46	-4.52	-4.90	-4.13	-3.70	-4.31	-4.81	-4.04	-3.66	-4.12	-4.12	-5.51
Production-based use, incl. bunkers (Statistics Sweden):	20.25	20.58	19.24	22.77	17.95	18.91	14.35	15.27	15.84	17.82	18.50	15.27	15.84	17.82	18.50	18.82	16.93
Production-based use, incl. bunkers (Swedish Energy Agency):	2.80	2.84	2.92	3.14	3.24	3.25	3.63	3.54	3.97	3.75	4.46	3.54	3.97	3.75	4.46	4.62	4.54

Year and revision:	1993a	1994a	1995a	1996a	1997a	1998a	1999a	2000a	2001a	2002a	2003a	2000b	2001b	2002b	2003b	2004b	2005b
Year (numerical value):	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004	2005
Gas																	
Consumption-based use, total:	35.40	36.99	37.04	37.01	36.97	36.55	36.30	37.70	36.78	38.03	37.84	37.24	36.76	38.20	37.61	41.89	42.41
- of which is in Sweden:	9.42	9.43	9.42	9.26	9.08	11.32	10.75	8.99	10.36	11.18	10.68	9.03	10.37	11.26	10.72	10.61	9.96
- abroad (PPP):[2]	24.90	26.44	26.41	26.40	26.60	23.75	24.04	27.36	24.80	25.43	25.42	26.86	24.77	25.54	25.16	28.95	30.15
- direct use:	1.08	1.12	1.21	1.35	1.28	1.47	1.51	1.35	1.62	1.41	1.73	1.35	1.62	1.41	1.73	2.33	2.31
Use due to direct imports (PPP):	20.36	21.30	20.77	21.57	20.09	17.39	17.96	21.37	19.70	21.59	23.17	21.40	19.80	21.71	22.74	23.77	27.07
Consumption-based use, total/capita (MWh/cap/year): [2]	4.06	4.21	4.20	4.19	4.18	4.13	4.10	4.25	4.13	4.26	4.22	4.20	4.13	4.28	4.20	4.66	4.70
Consumption-based use (MER), total:[3]	45.14	47.26	47.41	47.48	47.61	46.09	46.07	48.98	47.23	48.99	49.08	48.31	47.19	49.21	48.74	55.03	56.49
Consumption-based use, swe. int., total:	19.00	19.49	19.16	19.24	19.36	21.01	20.38	18.76	20.78	21.52	20.96	18.65	20.78	21.63	20.91	23.39	23.23
- of which is abroad:	8.49	8.93	8.53	8.64	8.99	8.22	8.12	8.42	8.80	8.93	8.54	8.27	8.79	8.96	8.45	10.45	10.97
Intensity ratio (PPP):[4]	2.93	2.96	3.10	3.06	2.96	2.89	2.96	3.25	2.82	2.85	2.98	3.25	2.82	2.85	2.98	2.77	2.75
Intensity ratio (MER):[4]	4.08	4.11	4.31	4.27	4.14	4.05	4.17	4.59	4.00	4.08	4.29	4.59	4.00	4.08	4.29	4.03	4.03
Use in Sweden due to exports:	10.64	10.46	10.22	11.14	11.67	9.88	10.66	11.59	12.62	12.35	11.90	11.55	12.61	12.28	11.86	13.49	14.45
Use in Sweden due to direct exports:	7.34	7.01	6.58	7.44	7.73	6.28	7.05	8.00	8.62	8.27	7.96	8.03	8.70	8.33	8.06	9.54	10.65
Physical trade balance:[5]	-14.26	-15.98	-16.19	-15.26	-14.93	-13.88	-13.38	-15.77	-12.18	-13.08	-13.53	-15.31	-12.16	-13.26	-13.30	-15.46	-15.69
Physical trade balance, direct:	-13.02	-14.29	-14.19	-14.13	-12.36	-11.12	-10.91	-13.37	-11.08	-13.32	-15.21	-13.36	-11.10	-13.38	-14.68	-14.24	-16.42
Production-based use, incl. bunkers (Statistics Sweden):	21.15	21.01	20.85	21.75	22.04	22.67	22.92	21.93	24.60	24.95	24.31	21.93	24.60	24.95	24.31	26.43	26.72
Production-based use, incl. bunkers (Swedish Energy Agency):	14.70	15.12	15.77	16.00	15.32	15.01	14.55	15.61	16.67	17.20	17.10	15.61	16.67	17.20	17.10	17.33	16.35
Total fossil fuels																	
Consumption-based use, total:	211.61	219.31	215.87	221.42	208.74	212.31	207.20	205.74	200.24	202.66	204.55	210.30	206.48	209.46	213.47	222.39	218.75
- of which is in Sweden:	76.03	79.95	74.65	84.06	73.09	78.66	73.54	66.33	68.19	71.06	73.80	68.17	70.24	73.27	77.07	72.28	69.10
- abroad (PPP):[2]	65.50	69.40	70.85	68.60	70.26	69.62	71.30	77.85	74.02	73.89	73.89	80.58	78.22	78.48	79.54	93.65	97.72
- direct use:	70.08	69.96	70.37	68.76	65.40	64.03	62.36	61.55	58.02	57.71	56.86	61.55	58.02	57.71	56.86	56.46	51.92
Use due to direct imports (PPP):	45.52	48.67	51.79	52.02	52.62	51.95	51.69	57.54	56.87	57.84	60.29	60.99	60.07	61.89	65.85	73.36	81.53
Consumption-based use, total/capita (MWh/cap/year): [2]	24.27	24.98	24.46	25.05	23.60	23.99	23.39	23.19	22.51	22.71	22.83	23.70	23.21	23.47	23.83	24.73	24.23
Consumption-based use (MER), total:[3]	237.22	246.27	243.69	248.64	236.86	240.28	236.17	237.83	231.40	234.50	237.24	243.52	239.42	243.28	248.66	264.91	264.37
Consumption-based use, swe. int., total:	187.57	195.16	188.92	198.37	182.27	188.54	180.18	173.61	171.75	173.98	176.70	178.23	177.43	179.92	185.02	187.59	179.74
- of which is abroad:	41.46	45.25	43.90	45.54	43.78	45.86	44.27	45.72	45.54	45.20	46.03	48.51	49.18	48.94	51.09	58.84	58.72
Intensity ratio (PPP):[4,6]	1.58	1.53	1.61	1.51	1.60	1.52	1.61	1.70	1.63	1.63	1.61	1.66	1.59	1.60	1.56	1.59	1.66
Intensity ratio (MER):[4,6]	2.20	2.13	2.25	2.10	2.25	2.13	2.26	2.40	2.31	2.34	2.32	2.35	2.26	2.29	2.25	2.31	2.44
Use in Sweden due to exports:	57.71	64.83	66.31	72.75	72.91	74.01	70.53	73.09	76.40	74.35	80.33	71.20	74.30	72.09	77.02	83.18	83.90
Use in Sweden due to direct exports:	36.31	40.17	41.14	44.65	46.58	46.90	44.96	47.80	49.82	47.70	52.59	45.01	46.74	44.77	47.98	54.20	54.84
Physical trade balance:[5]	-7.78	-4.58	-4.54	4.15	2.65	4.39	-0.77	-4.76	2.37	0.47	6.44	-9.38	-3.93	-6.38	-2.52	-10.47	-13.82
Physical trade balance, direct:	-9.22	-8.51	-10.64	-7.36	-6.04	-5.05	-6.73	-9.73	-7.05	-10.14	-7.70	-15.98	-13.33	-17.12	-17.87	-19.16	-26.69
Production-based use, incl. bunkers (Statistics Sweden):	203.82	214.74	211.33	225.57	211.40	216.69	206.43	200.97	202.61	203.13	210.99	200.97	202.61	203.13	210.99	211.96	204.97
Production-based use, incl. bunkers (Swedish Energy Agency):	165.02	171.75	173.62	176.82	176.78	178.53	177.34	174.73	173.82	172.33	179.23	174.73	173.82	172.33	179.23	181.72	175.92
CO2																	
Consumption-based emissions, total:	69 270 919	71 442 356	71 258 184	71 654 627	68 203 098	71 294 355	70 625 908	71 363 109	69 605 738	70 888 362	72 546 818	73 028 996	72 085 043	73 372 501	75 871 499	80 505 326	80 358 841
- of which is in Sweden:	23 059 794	24 067 594	22 741 874	25 077 731	22 101 061	23 640 598	22 326 899	20 377 784	20 920 699	21 792 943	22 910 628	20 827 791	21 371 963	22 344 854	23 775 151	22 715 430	22 014 454
- abroad (PPP):[2]	27 688 591	28 900 156	29 966 906	28 470 245	28 881 582	30 807 439	31 911 945	34 807 201	33 488 761	34 014 956	34 858 118	36 023 081	35 516 802	35 947 184	37 318 277	43 253 948	45 026 111
- direct use:	18 522 534	18 474 605	18 549 404	18 106 651	17 220 456	16 846 319	16 387 063	16 178 124	15 196 278	15 080 463	14 778 071	16 178 124	15 196 278	15 080 463	14 778 071	14 535 948	13 318 277
Emissions due to direct imports (PPP):	18 324 780	19 679 536	21 368 103	21 269 774	21 816 027	23 460 856	23 340 282	25 509 140	25 681 573	26 081 577	27 132 635	27 210 587	27 242 343	27 950 119	29 957 662	33 629 090	36 617 303
Consumption-based emissions, total/capita (ton/cap/year): [2]	7.95	8.14	8.07	8.10	7.71	8.05	7.97	8.04	7.82	7.94	8.10	8.23	8.10	8.22	8.47	8.95	8.90
Consumption-based emissions (MER), total:[3]	80 097 999	82 665 026	83 021 726	82 947 821	79 760 511	83 674 152	83 591 690	85 710 765	83 705 218	85 547 330	87 967 043	87 877 842	87 038 371	88 864 175	92 380 028	100 143 224	101 381 058
Consumption-based emissions, swe. int., total:	55 267 728	57 351 275	55 999 876	57 899 492	53 490 947	55 697 699	53 484 313	51 976 962	51 213 411	51 986 178	53 393 430	52 965 655	52 578 897	53 396 574	55 366 335	56 315 708	54 124 675
- of which is abroad:	13 685 400	14 809 076	14 708 598	14 715 110	14 169 430	15 210 782	14 770 350	15 421 054	15 096 434	15 112 772	15 704 730	15 959 740	16 010 657	15 971 256	16 813 113	19 064 330	18 791 945
Intensity ratio (PPP):[4]	2.02	1.95	2.04	1.93	2.04	2.03	2.16	2.26	2.22	2.25	2.22	2.26	2.22	2.25	2.22	2.27	2.40
Intensity ratio (MER):[4]	2.81	2.71	2.84	2.70	2.85	2.84	3.04	3.19	3.15	3.22	3.20	3.19	3.15	3.22	3.20	3.30	3.51
Emissions in Sweden due to exports:	19 120 930	21 353 798	22 106 565	23 843 698	23 730 338	24 294 388	23 141 704	23 885 421	24 979 688	24 499 651	26 215 609	23 422 979	24 513 915	23 933 907	25 341 427	27 694 651	27 419 284
Emissions in Sweden due to direct exports:	11 822 167	13 047 903	13 465 848	14 520 269	14 931 942	15 314 942	14 652 297	15 418 275	16 152 244	15 539 389	16 831 496	14 721 484	15 422 607	14 834 426	15 671 354	17 717 097	17 634 112
Physical trade balance:[5]	-8 567 660	-7 546 358	-7 860 341	-4 626 547	-5 151 244	-6 513 051	-8 770 241	-10 921 780	-8 509 074	-9 515 306	-8 642 509	-12 600 102	-11 002 886	-12 013 277	-11 976 850	-15 559 297	-17 606 827
Physical trade balance, direct:	-6 502 612	-6 631 633	-7 902 255	-6 749 505	-6 884 084	-8 145 914	-8 687 986	-10 090 866	-9 529 329	-10 542 188	-10 301 140	-12 489 103	-11 819 736	-13 115 693	-14 286 308	-15 911 993	-18 983 190
Production-based emissions, incl. bunkers (Statistics Sweden):	60 703 305	63 895 997	63 397 843	67 028 080	63 051 855	64 781 305	61 855 666	60 441 329	61 096 665	61 373 057	63 904 309	60 441 329	61 096 665	61 373 057	63 904 309	64 956 079	62 762 135
Production-based emissions, excl. bunkers (UNFCCC):	56 609 164	59 122 083	58 543 742	62 043 940	57 389 656	58 091 130	55 180 297	53 913 489	54 669 133	55 714 084	56 400 495	53 913 489	54 669 133	55 714 084	56 400 495	55 785 642	53 186 634

Year and revision:	1993a	1994a	1995a	1996a	1997a	1998a	1999a	2000a	2001a	2002a	2003a	2000b	2001b	2002b	2003b	2004b	2005b
Year (numerical value):	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004	2005
CH4																	
Consumption-based emissions, total:	920 080	918 983	926 034	859 975	865 883	961 898	980 850	978 908	1 011 835	1 060 068	1 031 452	958 094	997 731	1 049 532	1 020 682	1 201 099	1 235 599
- of which is in Sweden:	257 218	246 476	237 272	224 399	210 118	221 386	217 526	205 766	197 499	195 971	188 358	208 338	200 165	198 957	190 730	198 588	192 474
- abroad (PPP):[2]	648 595	658 651	674 330	620 910	641 900	726 974	750 952	760 687	802 403	851 901	830 727	737 302	785 632	838 378	817 585	990 218	1 030 223
- direct use:	14 267	13 856	14 432	14 666	13 866	13 538	12 372	12 454	11 933	12 197	12 367	12 454	11 933	12 197	12 367	12 293	12 902
Emissions due to direct imports (PPP):	319 001	327 600	329 891	323 338	348 555	370 592	387 883	381 207	430 989	472 730	450 043	358 479	405 804	453 796	422 160	475 255	525 176
Consumption-based emissions, total/capita (kg/cap/year): [2]	106	105	105	97	98	109	111	110	114	119	115	108	112	118	114	134	137
Consumption-based emissions (MER), total:[3]	1 173 700	1 174 754	1 190 743	1 106 270	1 122 749	1 254 029	1 285 960	1 292 466	1 349 664	1 427 201	1 398 941	1 262 013	1 328 499	1 410 837	1 382 358	1 650 671	1 716 599
Consumption-based emissions, swe. int., total:	393 856	381 786	372 882	352 720	339 575	362 244	359 475	347 100	344 760	345 060	330 746	345 709	344 598	345 873	331 062	362 604	358 798
- of which is abroad:	122 371	121 454	121 178	113 655	115 591	127 320	129 578	128 879	135 329	136 892	130 021	124 917	132 500	134 719	127 964	151 723	153 422
Intensity ratio (PPP):[4]	5.30	5.42	5.56	5.46	5.55	5.71	5.80	5.90	5.93	6.22	6.39	5.90	5.93	6.22	6.39	6.53	6.71
Intensity ratio (MER):[4]	7.37	7.53	7.75	7.63	7.78	8.00	8.15	8.34	8.43	8.91	9.22	8.34	8.43	8.91	9.22	9.49	9.85
Emissions in Sweden due to exports:	54 162	61 638	66 362	77 490	89 891	72 109	69 093	72 538	80 305	72 818	73 256	69 965	77 637	69 830	70 883	64 084	63 500
Emissions in Sweden due to direct exports:	19 724	22 815	22 219	31 423	38 873	21 571	18 710	20 705	25 014	21 221	24 245	20 167	24 323	20 919	23 431	13 484	12 785
Physical trade balance:[5]	-594 433	-597 013	-607 968	-543 420	-552 008	-654 865	-681 859	-688 150	-722 098	-779 082	-757 471	-667 337	-707 996	-768 548	-746 702	-926 134	-966 723
Physical trade balance, direct:	-299 277	-304 784	-307 672	-291 915	-309 682	-349 021	-369 173	-360 502	-405 975	-451 508	-425 798	-338 311	-381 481	-432 877	-398 729	-461 770	-512 391
Production-based emissions, incl. bunkers (Statistics Sweden):	325 647	321 970	318 066	316 555	313 875	307 033	298 991	290 758	289 737	280 986	273 981	290 758	289 737	280 986	273 981	274 965	268 876
Production-based emissions, excl. bunkers (UNFCCC):	340 031	336 400	332 284	330 654	327 845	319 960	312 789	304 165	302 734	294 263	287 722	304 165	302 734	294 263	287 722	288 751	282 738
N2O																	
Consumption-based emissions, total:	46 485	46 567	46 161	43 054	42 858	47 515	46 373	45 862	45 813	47 485	45 505	45 103	45 365	47 260	45 300	52 294	52 503
- of which is in Sweden:	19 884	19 351	18 448	17 572	15 909	17 267	16 682	15 972	15 106	15 493	15 135	16 192	15 393	15 752	15 398	15 945	15 527
- abroad (PPP):[2]	25 406	26 120	26 475	24 210	25 667	28 993	28 472	28 689	29 593	30 860	29 197	27 710	28 859	30 378	28 729	35 162	35 855
- direct use:	1 194	1 096	1 238	1 272	1 282	1 255	1 219	1 201	1 114	1 131	1 173	1 201	1 114	1 131	1 173	1 187	1 121
Emissions due to direct imports (PPP):	14 609	15 157	15 386	14 792	16 314	17 238	17 287	17 286	18 921	19 789	17 878	16 247	17 621	18 652	17 059	19 372	20 675
Consumption-based emissions, total/capita (kg/cap/year): [2]	5.33	5.30	5.23	4.87	4.84	5.37	5.24	5.17	5.15	5.32	5.08	5.08	5.10	5.30	5.06	5.81	5.81
Consumption-based emissions (MER), total:[3]	56 419	56 710	56 554	52 657	53 129	59 165	57 941	57 687	58 272	60 784	58 421	56 526	57 516	60 352	58 009	68 257	69 244
Consumption-based emissions, swe. int., total:	35 970	35 310	34 187	32 525	31 180	34 114	33 038	32 482	31 607	32 334	31 289	32 180	31 512	32 346	31 312	34 832	34 322
- of which is abroad:	14 891	14 864	14 501	13 681	13 989	15 592	15 138	15 309	15 386	15 709	14 981	14 787	15 005	15 464	14 741	17 700	17 674
Intensity ratio (PPP):[4]	1.71	1.76	1.83	1.77	1.83	1.86	1.88	1.87	1.92	1.96	1.95	1.87	1.92	1.96	1.95	1.99	2.03
Intensity ratio (MER):[4]	2.37	2.44	2.54	2.47	2.57	2.61	2.65	2.65	2.73	2.81	2.81	2.65	2.73	2.81	2.81	2.89	2.98
Emissions in Sweden due to exports:	6 681	7 535	7 869	9 125	10 474	9 217	8 405	8 884	9 309	8 606	8 913	8 664	9 022	8 347	8 650	8 041	8 011
Emissions in Sweden due to direct exports:	3 620	4 026	3 937	4 905	5 768	4 763	4 182	4 542	4 718	4 189	4 543	4 444	4 591	4 098	4 409	3 441	3 356
Physical trade balance:[5]	-18 726	-18 585	-18 606	-15 085	-15 193	-19 776	-20 067	-19 805	-20 284	-22 255	-20 284	-19 046	-19 836	-22 030	-20 079	-27 121	-27 844
Physical trade balance, direct:	-10 989	-11 131	-11 450	-9 888	-10 546	-12 476	-13 105	-12 744	-14 203	-15 600	-13 335	-11 803	-13 031	-14 554	-12 650	-15 931	-17 319
Production-based emissions, incl. bunkers (Statistics Sweden):	27 759	27 982	27 555	27 969	27 665	27 739	26 306	26 057	25 529	25 230	25 221	26 057	25 529	25 230	25 221	25 173	24 659
Production-based emissions, excl. bunkers (UNFCCC):	26 684	26 880	26 435	26 844	26 552	26 506	25 085	24 842	24 307	24 046	23 976	24 842	24 307	24 046	23 976	23 907	23 431
CO2eq[7]																	
Consumption-based emissions, total:	103 002 857	105 176 816	105 014 785	103 060 791	99 672 576	106 223 823	105 599 309	106 137 299	105 056 341	107 870 036	108 313 978	107 131 035	107 100 685	110 063 394	111 348 770	121 939 386	122 582 436
- of which is in Sweden:	34 625 535	35 242 361	33 443 352	35 237 384	31 445 325	33 642 576	32 066 290	29 650 155	29 751 164	30 711 250	31 558 028	30 222 550	30 347 218	31 405 947	32 553 901	31 828 665	30 869 911
- abroad (PPP):[2]	49 185 041	50 829 113	52 335 177	49 014 450	50 318 189	55 061 580	56 508 254	59 675 176	59 512 966	61 471 576	61 354 542	60 096 517	60 961 255	62 970 236	63 393 461	74 948 650	77 775 797
- direct use:	19 192 281	19 105 341	19 236 256	18 808 957	17 909 062	17 519 667	17 024 765	16 811 968	15 792 211	15 687 210	15 401 408	16 811 968	15 792 211	15 687 210	15 401 408	15 162 071	13 936 729
Emissions due to direct imports (PPP):	29 552 460	31 257 646	33 065 590	32 645 480	34 193 012	36 587 132	36 844 666	38 873 275	40 597 784	42 143 435	42 125 757	39 775 174	41 226 862	43 261 824	44 111 278	49 614 896	54 055 187
Consumption-based emissions, total/capita (ton/cap/year): [2]	11.81	11.98	11.90	11.66	11.27	12.00	11.92	11.96	11.81	12.09	12.09	12.08	12.04	12.33	12.43	13.56	13.58
Consumption-based emissions (MER), total:[3]	122 235 703	124 915 061	125 559 016	122 503 184	119 808 180	128 350 009	128 558 540	130 735 626	130 112 564	134 361 615	135 455 457	131 903 040	132 766 668	137 200 830	139 392 208	155 967 123	158 895 135
Consumption-based emissions, swe. int., total:	74 689 260	76 315 026	74 428 233	75 389 289	70 287 759	73 880 303	71 275 222	69 335 427	68 251 485	69 255 896	70 038 702	70 201 379	69 584 047	70 687 298	72 025 233	74 728 202	72 299 373
- of which is abroad:	20 871 444	21 967 323	21 748 625	21 342 948	20 933 372	22 718 060	22 184 167	22 873 305	22 708 110	22 857 436	23 079 266	23 166 861	23 444 617	23 594 141	24 069 924	27 737 467	27 492 733
Intensity ratio (PPP):[4,6]	2.36	2.31	2.41	2.30	2.40	2.42	2.55	2.61	2.62	2.69	2.66	2.59	2.60	2.67	2.63	2.70	2.83
Intensity ratio (MER):[4,6]	3.28	3.21	3.35	3.21	3.37	3.40	3.58	3.68	3.72	3.85	3.83	3.66	3.69	3.82	3.80	3.93	4.15
Emissions in Sweden due to exports:	22 329 319	24 984 084	25 939 671	28 299 784	28 864 993	28 665 845	27 198 282	28 162 794	29 551 756	28 696 603	30 516 984	27 577 943	28 941 152	27 988 030	29 511 431	31 533 188	31 236 061
Emissions in Sweden due to direct exports:	13 358 506	14 774 964	15 152 882	16 700 627	17 536 471	17 244 355	16 341 583	17 261 146	18 140 016	17 283 515	18 748 908	16 522 492	17 356 453	16 544 020	17 530 096	19 066 987	18 943 033
Physical trade balance:[5]	-26 855 721	-25 845 029	-26 395 505	-20 714 666	-21 453 196	-26 395 735	-29 309 972	-31 512 382	-29 961 210	-32 774 974	-30 837 559	-32 518 574	-32 020 103	-34 982 206	-33 882 031	-43 415 462	-46 539 736
Physical trade balance, direct:	-16 193 954	-16 482 682	-17 912 708	-15 944 853	-16 656 541	-19 342 777	-20 503 083	-21 612 129	-22 457 768	-24 859 919	-23 376 849	-23 252 683	-23 870 409	-26 717 804	-26 581 182	-30 547 909	-35 112 154
Production-based emissions, incl. bunkers (Statistics Sweden):	76 147 182	79 331 787	78 619 279	82 346 125	78 219 380	79 828 088	76 289 337	74 624 917	75 095 132	75 095 063	77 476 420	74 624 917	75 095 132	75 095 063	77 476 420	78 533 974	76 052 821
Production-based emissions, excl. bunkers (UNFCCC):	72 021 864	74 519 226	73 716 479	77 309 176	72 505 666	73 027 278	69 525 073	68 001 837	68 561 686	69 347 992	69 875 150	68 001 837	68 561 686	69 347 992	69 875 150	69 260 613	66 387 764

Year and revision:	1993a	1994a	1995a	1996a	1997a	1998a	1999a	2000a	2001a	2002a	2003a	2000b	2001b	2002b	2003b	2004b	2005b
Year (numerical value):	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004	2005
SO2																	
Consumption-based emissions, total:	223 817	223 431	208 188	195 143	173 029	171 270	158 904	144 971	136 892	139 622	130 774	220 414	219 525	217 480	230 226	255 992	251 821
- of which is in Sweden:	39 658	38 967	31 755	32 013	27 147	28 439	24 005	18 710	17 756	18 190	20 367	22 887	22 579	22 218	26 035	22 322	21 824
- abroad (PPP):[2]	177 489	178 196	170 970	158 905	142 246	139 387	131 842	123 727	117 063	119 518	108 581	194 992	194 872	193 349	202 366	231 998	228 653
- direct use:	6 670	6 268	5 462	4 225	3 637	3 443	3 057	2 535	2 073	1 914	1 826	2 535	2 073	1 914	1 826	1 672	1 344
Emissions due to direct imports (PPP):	166 655	174 981	184 122	168 603	175 566	190 907	163 416	144 794	160 255	150 976	138 802	183 986	189 678	187 135	203 788	230 602	236 506
Consumption-based emissions, total/capita (kg/cap/year): [2]	25.67	25.45	23.59	22.07	19.56	19.35	17.94	16.34	15.39	15.64	14.60	24.84	24.68	24.37	25.70	28.46	27.89
Consumption-based emissions (MER), total:[3]	293 220	292 629	275 302	258 175	229 951	227 282	212 471	195 972	186 178	191 129	178 807	300 790	301 570	300 805	319 747	361 323	358 576
Consumption-based emissions, swe. int., total:	78 099	79 169	66 935	63 916	56 405	57 599	50 318	41 968	39 557	38 593	42 684	58 082	57 494	54 043	66 052	70 217	67 814
- of which is abroad:	31 771	33 933	29 718	27 678	25 621	25 717	23 256	20 724	19 728	18 490	20 492	32 660	32 841	29 911	38 191	46 223	44 647
Intensity ratio (PPP):[4]	5.59	5.25	5.75	5.74	5.55	5.42	5.67	5.97	5.93	6.46	5.30	5.97	5.93	6.46	5.30	5.02	5.12
Intensity ratio (MER):[4]	7.77	7.29	8.01	8.02	7.77	7.60	7.97	8.43	8.43	9.25	7.64	8.43	8.43	9.25	7.64	7.30	7.51
Emissions in Sweden due to exports:	81 218	88 271	84 498	81 995	88 650	90 370	85 853	83 075	82 578	74 009	92 676	78 896	77 753	69 979	87 007	101 961	102 319
Emissions in Sweden due to direct exports:	65 320	70 602	68 523	66 175	74 256	76 585	72 922	71 650	71 241	63 263	80 631	63 363	61 902	55 395	68 823	83 587	83 563
Physical trade balance:[5]	-96 271	-89 925	-86 473	-76 910	-53 595	-49 018	-45 989	-40 651	-34 485	-45 509	-15 905	-116 096	-117 120	-123 369	-115 358	-130 037	-126 334
Physical trade balance, direct:	-101 335	-104 380	-115 600	-102 428	-101 311	-114 322	-90 494	-73 143	-89 014	-87 714	-58 171	-120 623	-127 776	-131 740	-134 966	-147 015	-152 944
Production-based emissions, incl. bunkers (Statistics Sweden):	127 546	133 506	121 715	118 233	119 434	122 252	112 915	104 320	102 407	94 113	114 869	104 320	102 407	94 113	114 869	125 956	125 488
Production-based emissions, excl. bunkers (UNFCCC):	82 322	80 165	68 939	66 927	59 774	56 380	46 686	41 688	40 697	40 499	41 408	41 688	40 697	40 499	41 408	36 983	35 973
NOx																	
Consumption-based emissions, total:	319 885	327 032	311 124	306 168	285 886	292 026	285 146	270 313	257 496	253 393	245 081	318 400	310 910	304 133	314 313	337 723	327 968
- of which is in Sweden:	125 197	125 112	116 365	117 178	108 324	110 208	107 052	98 452	93 582	91 437	92 394	107 295	103 384	100 076	104 020	97 371	95 025
- abroad (PPP):[2]	102 469	106 388	105 197	104 575	100 684	111 206	113 581	113 133	112 100	112 800	108 176	152 378	155 710	154 901	165 781	200 105	196 345
- direct use:	92 219	95 532	89 561	84 415	76 878	70 612	64 513	58 727	51 815	49 156	44 512	58 727	51 815	49 156	44 512	40 247	36 598
Emissions due to direct imports (PPP):	75 316	83 292	89 125	86 954	95 609	115 930	105 362	99 510	110 817	106 139	106 687	124 858	131 887	132 063	151 147	183 887	191 963
Consumption-based emissions, total/capita (kg/cap/year): [2]	36.69	37.24	35.25	34.63	32.32	32.99	32.19	30.47	28.95	28.39	27.36	35.89	34.95	34.08	35.09	37.55	36.32
Consumption-based emissions (MER), total:[3]	359 954	368 345	352 419	347 650	326 176	336 714	331 294	316 947	304 693	302 005	292 935	381 211	376 467	370 888	387 650	428 573	419 640
Consumption-based emissions, swe. int., total:	278 124	285 813	267 394	262 823	243 032	242 891	234 713	217 840	204 153	195 601	194 151	247 725	236 815	224 771	236 261	244 834	234 510
- of which is abroad:	60 708	65 169	61 468	61 230	57 831	62 072	63 148	60 660	58 757	55 008	57 245	81 703	81 615	75 539	87 729	107 216	102 887
Intensity ratio (PPP):[4]	1.69	1.63	1.71	1.71	1.74	1.79	1.80	1.87	1.91	2.05	1.89	1.87	1.91	2.05	1.89	1.87	1.91
Intensity ratio (MER):[4]	2.35	2.27	2.38	2.39	2.44	2.51	2.53	2.63	2.71	2.93	2.73	2.63	2.71	2.93	2.73	2.71	2.80
Emissions in Sweden due to exports:	126 027	141 124	143 737	144 936	160 274	168 278	166 573	165 313	164 718	149 468	177 651	156 426	154 871	140 786	165 997	190 926	190 099
Emissions in Sweden due to direct exports:	89 194	100 189	101 446	102 363	118 204	125 712	123 513	123 688	123 350	110 605	137 569	108 699	106 749	96 222	116 407	140 724	138 862
Physical trade balance:[5]	23 558	34 736	38 539	40 361	59 590	57 072	52 992	52 179	52 619	36 668	69 476	4 048	-840	-14 115	216	-9 179	-6 246
Physical trade balance, direct:	13 878	16 897	12 322	15 409	22 596	9 782	18 150	24 178	12 533	4 466	30 882	-16 159	-25 138	-35 842	-34 740	-43 163	-53 102
Production-based emissions, incl. bunkers (Statistics Sweden):	343 443	361 768	349 663	346 529	345 476	349 098	338 138	322 492	310 115	290 061	314 557	322 492	310 115	290 061	314 557	328 568	321 745
Production-based emissions, excl. bunkers (UNFCCC):	273 750	279 800	267 076	260 233	245 492	234 489	224 034	211 908	202 207	196 488	190 725	211 908	202 207	196 488	190 725	181 505	175 240
CO																	
Consumption-based emissions, total:	1 208 857	1 238 570	1 178 749	1 141 887	1 172 348	1 219 775	1 125 380	1 081 409	1 082 329	1 090 522	1 051 506	1 070 411	1 076 954	1 087 571	1 051 251	1 139 088	1 145 208
- of which is in Sweden:	178 059	178 382	164 062	167 003	152 715	148 056	144 764	138 516	135 456	129 651	125 848	141 638	138 634	132 505	129 778	123 553	122 787
- abroad (PPP):[2]	405 114	439 403	400 076	393 243	475 041	569 152	507 154	490 135	531 875	553 650	517 480	476 016	523 323	547 845	513 296	632 719	643 994
- direct use:	625 684	620 786	614 610	581 641	544 592	502 567	473 462	452 758	414 997	407 221	408 178	452 758	414 997	407 221	408 178	382 816	378 427
Emissions due to direct imports (PPP):	212 203	236 290	219 765	223 989	283 425	325 567	287 783	279 508	313 802	338 199	313 713	272 753	304 284	332 099	314 063	364 947	387 186
Consumption-based emissions, total/capita (kg/cap/year): [2]	139	141	134	129	133	138	127	122	122	122	117	121	121	122	117	127	127
Consumption-based emissions (MER), total:[3]	1 367 270	1 409 202	1 335 799	1 297 874	1 362 443	1 448 486	1 331 437	1 283 444	1 306 260	1 329 121	1 280 424	1 266 627	1 297 283	1 323 668	1 278 319	1 426 351	1 445 881
Consumption-based emissions, swe. int., total:	880 674	879 261	851 110	821 911	769 123	728 775	696 352	669 205	629 127	614 254	609 754	670 082	631 039	616 298	613 072	591 138	588 566
- of which is abroad:	76 931	80 094	72 437	73 267	71 816	78 152	78 126	77 931	78 673	77 383	75 728	75 686	77 408	76 571	75 116	84 769	87 352
Intensity ratio (PPP):[4]	5.27	5.49	5.52	5.37	6.61	7.28	6.49	6.29	6.76	7.15	6.83	6.29	6.76	7.15	6.83	7.46	7.37
Intensity ratio (MER):[4]	7.33	7.62	7.69	7.50	9.26	10.21	9.13	8.88	9.61	10.24	9.86	8.88	9.61	10.24	9.86	10.85	10.81
Emissions in Sweden due to exports:	90 493	99 497	100 063	103 817	107 170	101 450	98 506	96 725	104 020	96 052	96 411	93 428	100 666	93 040	92 373	93 042	95 324
Emissions in Sweden due to direct exports:	49 990	54 615	53 939	55 881	59 284	54 517	53 020	51 780	56 974	51 985	52 741	50 436	55 780	51 085	50 691	50 453	50 394
Physical trade balance:[5]	-314 621	-339 905	-300 014	-289 426	-367 871	-467 702	-408 648	-393 410	-427 856	-457 598	-421 069	-382 587	-422 657	-454 805	-420 922	-539 677	-548 670
Physical trade balance, direct:	-162 213	-181 675	-165 826	-168 108	-224 141	-271 050	-234 763	-227 729	-256 827	-286 215	-260 972	-222 317	-248 504	-281 014	-263 372	-314 494	-336 792
Production-based emissions, incl. bunkers (Statistics Sweden):	894 238	898 665	878 735	852 461	804 477	752 073	716 732	687 999	654 473	632 924	630 437	687 999	654 473	632 924	630 437	599 500	596 627
Production-based emissions, excl. bunkers (UNFCCC):	885 905	889 621	867 704	840 100	789 200	723 419	698 693	665 510	627 039	610 987	614 096	665 510	627 039	610 987	614 096	583 675	581 914

Year and revision:	1993a	1994a	1995a	1996a	1997a	1998a	1999a	2000a	2001a	2002a	2003a	2000b	2001b	2002b	2003b	2004b	2005b
Year (numerical value):	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2000	2001	2002	2003	2004	2005
NMVOC																	
Consumption-based emissions, total:	319 674	316 764	299 518	293 918	289 412	284 322	274 339	268 462	261 274	263 365	260 030	268 465	262 121	265 210	262 262	282 314	278 581
- of which is in Sweden:	47 670	46 871	43 438	43 942	37 392	40 410	38 443	35 265	33 574	34 497	32 817	35 968	34 338	35 143	33 533	32 046	30 130
- abroad (PPP):[2]	86 735	89 777	83 473	87 389	93 908	94 378	94 183	100 549	104 007	107 463	104 386	99 849	104 090	108 663	105 901	126 310	125 013
- direct use:	185 269	180 115	172 608	162 588	158 112	149 534	141 712	132 648	123 693	121 405	122 828	132 648	123 693	121 405	122 828	123 957	123 438
Emissions due to direct imports (PPP):	63 341	62 904	59 266	61 796	65 379	62 119	64 557	70 928	75 866	81 456	83 595	70 549	74 887	81 265	83 238	90 332	94 379
Consumption-based emissions, total/capita (kg/cap/year): [2]	36.67	36.07	33.93	33.24	32.72	32.12	30.97	30.26	29.37	29.51	29.03	30.26	29.47	29.72	29.28	31.39	30.85
Consumption-based emissions (MER), total:[3]	353 590	351 627	332 286	328 583	326 991	322 247	312 605	309 909	305 063	309 676	306 208	309 623	305 946	312 039	309 109	339 660	336 948
Consumption-based emissions, swe. int., total:	262 003	255 866	242 337	234 120	221 786	214 814	205 431	194 383	182 820	181 668	181 334	194 903	183 605	182 602	182 423	185 894	182 990
- of which is abroad:	29 064	28 880	26 292	27 591	26 282	24 870	25 275	26 471	25 553	25 767	25 689	26 286	25 573	26 054	26 062	29 891	29 422
Intensity ratio (PPP):[4]	2.98	3.11	3.17	3.17	3.57	3.79	3.73	3.80	4.07	4.17	4.06	3.80	4.07	4.17	4.06	4.23	4.25
Intensity ratio (MER):[4]	4.15	4.32	4.42	4.42	5.00	5.32	5.24	5.36	5.78	5.97	5.86	5.36	5.78	5.97	5.86	6.14	6.23
Emissions in Sweden due to exports:	35 372	34 210	33 640	35 922	35 281	30 022	31 415	34 846	33 750	32 149	33 958	34 113	32 958	31 477	33 224	32 695	32 605
Emissions in Sweden due to direct exports:	24 014	22 154	21 341	23 027	22 991	18 579	20 133	23 182	22 220	21 071	22 896	22 845	21 858	20 825	22 510	22 379	22 035
Physical trade balance:[5]	-51 363	-55 568	-49 832	-51 466	-58 627	-64 356	-62 769	-65 703	-70 257	-75 314	-70 427	-65 736	-71 132	-77 185	-72 677	-93 616	-92 408
Physical trade balance, direct:	-39 327	-40 750	-37 926	-38 770	-42 387	-43 540	-44 423	-47 746	-53 646	-60 385	-60 699	-47 704	-53 029	-60 440	-60 728	-67 953	-72 344
Production-based emissions, incl. bunkers (Statistics Sweden):	268 311	261 196	249 686	242 452	230 785	219 966	211 570	202 759	191 017	188 051	189 603	202 759	191 017	188 051	189 603	188 712	186 187
Production-based emissions, excl. bunkers (UNFCCC):	266 719	259 412	247 494	240 276	229 239	216 708	209 001	200 317	188 477	185 791	187 736	200 317	188 477	185 791	187 736	186 287	183 998

Unit: Million dollars/year in constant prices, TWh/year (oil, coal, gas and total fossil fuels) or ton/year (emissions), if not otherwise indicated.

[1] N.B. These variables are in current prices.

[2] Using world average intensities based on GDP PPP (purchasing power parity exchange rates).

[3] Using world average intensities based on GDP MER (market exchange rates).

[4] Ratio between the world intensity and the Swedish intensity.

[5] Use or emissions caused by exports in Sweden, less use or emissions which our domestic final demand causes abroad.

[6] For the aggregate fossil fuels and CO2eq, the intensity ratios are calculated afterwards since the aggregates are built upon own aggregation and not the ready-made aggregates available in the environmental accounts.

[7] These emissions are an aggregate of CO2, CH4 and N2O (weighted by 1, 21 and 310 respectively); the remaining greenhouse gases (HFCs, PFCs and SF6) are not included. The same applies for the official UNFCCC value.