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(Towards) a complete database of peer-reviewed articles on environmentally extended input-output analysis

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(TOWARDS) A COMPLETE DATABASE OF PEER-REVIEWED ARTICLES ON ENVIRONMENTALLY EXTENDED INPUT-OUTPUT ANALYSIS

Summary: Environmentally extended input-output analysis (EE-IO) is one of the fastest growing fields in input-output analysis. This paper provides an overview 360 EE-IO articles that have appeared in peer-reviewed journals from 1969-2009. The paper shows that the field of EE-IO has experienced rapid growth since the mid-1990s. Last year (2009) was the most productive year to date, with 50 articles appearing in scientific journals.

The articles have been categorized in terms of the type of publication (empirical application or other), IO methods, environmental problems, country, authors, affiliations and journals. The 20 most cited papers (published after 1996) are also provided.

Based on this overview a number of tentative conclusions are drawn about the past 4 decades and possible future developments of the field of EE-IO..

Our database of EE-IO articles is not (yet) complete. For the period 1995-2009 I am assuming that I have been able to obtain about 75-85% of all published articles. However for the period before 1995 the coverage is probably only about 40-50%. Note also that, due to time constraints, I have used a narrow definition of EE-IO which includes only articles that investigate environmental pressures. As a result IO papers that investigate the economic ramifications of environmental issues or papers on environmental accounting are not included. In future versions of this paper I hope to expand and complete the overview.

Keywords: Environmentally extended input-output analysis, impact analysis, imputation analysis, embodied carbon, carbon footprint, dynamic input-output model, ecological footprint, life cycle assessment, life cycle inventory, structural decomposition analysis, key-sector analysis, structural path analysis.

1. Introduction

One of the most fruitful areas of input-output analysis has been the study of environmental issues. Since the pioneering work of the late 1960s and early 1970s a steady flow of studies have adopted environmentally extended input-output analysis (EE-IO). These studies have appeared in scientific journals, books, working papers, conference papers, PhD theses and reports. Since the middle of the 1990s the EE-IO field has experienced a marked surge. Year after year the quantity of publications has reached new highs.

Last year (2009) was truly an *annus mirabilis* in history of EE-IO. A record amount of 50 articles appeared in peer reviewed journals; the *Handbook of industrial ecology and input-output analysis* (Suh, 2009) was published; the new Miller and Blair (2009), with its special chapters for energy and environmental input-output analysis, was re-released; and a special issue of *Economic Systems Research* was dedicated to carbon footprints. In terms of the organisation of this scientific field, the International Society for Industrial Ecology started a special subject section on EE-IO. Given this level of visibility it came as no surprise that sustainability is the theme of the 18th input-output conference in Sydney.

But how did EE-IO get to this point? This paper hopes to provide insights into the origins and developments of EE-IO by providing an overview of all articles published in peer reviewed journals. The articles are categorized according to the type of study, the IO-methods which have been used, the environmental problems and countries that have been analysed as well as the authors, journals and institutions which have played an important part in the EE-IO history.

This paper is very much "work in progress". Producing such a database of articles will require a number of iterations, which is why I hope to receive many comments/suggestions/corrections/additions from the participants of the Sydney IO conference. I have included the details of all 360 articles in Appendix A so that it is easier to see which articles have been included.

2. Selection and collection of studies

One of the most difficult aspects of producing a database of EE-IO articles is defining which articles should be included. For this overview we have restricted ourselves to the following criteria:

- Only articles from English peer-reviewed journals are included.[1]

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[1] A number of very influential EE-IO book(chapter)s are excluded by this criterion: Leontief (1970); Isard (1972); Leontief and Ford (1972), Victor (1972); Ayres (1978), Miller and Blair (1985, 2009 (chapters 9 and 10)), Duchin et al. (1994); Suh (2009) to name but a few.

- 2009 is the last year which is included.[2]
- Only articles that analyse environmental pressures (emissions, energy or other resources) are included. This includes analyses of the intensity of environmental pressures (i.e. per unit output or value added).
- Corrigenda, errata, announcements and book reviews are excluded[3].
- Articles are included if they have one or more of the following characteristics:
    - The Leontief inverse is represented mathematically;
    - Empirical results are provided which show that the Leontief inverse has been applied (i.e they include indirect effects that are based on the fixed technical coefficient assumption);
    - The EE-IO literature, or a specific method, is reviewed;
    - Editorials of special issues and articles which provide a "way forward" for future work in EE-IO (including work on databases).

Of course there are always articles which are difficult to classify. We have found two notable areas which fall outside these criteria.

- Economic impacts. There are quite a few studies that analyse the economic aspects of environmental issues. Examples include the economic or employment impact of climate change or environmental policy as well as price changes due to increases in environmental taxes or energy price.[4] Note

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[2] Excluded: Alcántara et al. (2010); Arbex and Perobelli (2010); Duarte et al. (2010); Guo et al. (2010); Konan and Chan et al (2010); Lenzen et al. (2010); Lin and Sun (2010); Liu et al (2010); Peters et al (2010); Singh et al (2010); Su et al (2010); Tarancón et al (2010); Wiedmann et al (2010); Yu et al (2010); Yunfeng and Laike (2010); and Zhang (2010).

[3] Excluded: Proops (1994); Munksgaard et al (1995c); Suh (2006c); Koellner et al. (2008); Kerschner and Hubacek (2009b).

[4] The following articles might be considered: Aroca (2001); Berck and Hoffmann (2002); Bhagavan and Din (1980); Caldés et al. (2009); Castellano et al. (2008); Ciorba et al. (2004); Datta (2009); Dieter (2009); DiFrancesco and Anderson (1999); Feng et al. (2010); Ferrer and Ayres (2000); Fiorillo et al. (2007); Fofana et al. (2009); Grêt-Regamey and Kytzia (2007); heen and Andersen (1994); Hannon (1976); Heen (1991); Hristu-Varsakelis et al. (2010); Juliá and Duchin (2007); Kagawa et al (2009b); Kerkhof et al (2008); Kerschner and Hubacek (2009a); Ketkar (1983); Kolk (1983); Kulišić et al. (2007); Lager (1998); Lehr et al. (2008); Lipnowski (1976); Lixon (2008); Llop and Pié (2008); Llop (2008); Madlener and Koller (2007); Martin and Velazquez (1994); Midmore and Whittaker (2000); Morgenstern et al. (2004); Nakamura and Kondo (2006); Nansai et al. (2007); Nansai et al. (2008); Neuwahl et al. (2008); Nguyen (2008); Nishimura (2003); Pasurka Jr (1984); Perry (1974); Robinson (1985); Rose et al. (1982); Rose and Stevens (1988); San Cristóbal (2007); San Cristóbal and Biezma (2006); Schafer (1989); Spörri et al. (2007); Stillwell et al. (2000); Weisskoff (2000); Wier et al. (2005b); Yan et al. (1975); and Zhang and Folmer (1998).

that studies that investigate environmental pressures and economic impacts simultaneously are included in our overview.

- Environmental accounts. Despite the fact that environmental accounts are a very important data source for EE-IO, we have not included papers which deal only with the data structure and construction.[5] Papers that discuss environmental accounting *and* illustrate their use by applying EE-IO modelling techniques are included in the database.

The above categories were omitted due to time constraints, not because I feel that they belong outside the domain of EE-IO. I hope to add both categories to future versions of the paper.

Search strategy

To find the articles which adhered to the above restrictions we used Scopus as our main search tool. We searched through key words and looked in specific journals. In the second stage we looked at specific authors that scored four articles or more in the initial search.

All in all, the search yielded 425 articles. I have been able to obtain and confirm that 360 of these are EE-IO articles. It is these articles which are analysed in the remainder of the paper. The majority of the 65 articles on our "wish list" are probably EE-IO studies, based on the title, abstract or author. However, I have not been able to obtain a copy to confirm and classify the articles.

The coverage in our database is therefore incomplete. It is also biased towards the more recent years. For the period after 1995 it was relatively easy to obtain electronic versions of the papers from either Scopus or through other means. However, it was not as easy for the period before 1995. Of the 65 articles on the "wish list", 38 are for the period 1969-1995, suggesting that the coverage of the articles for this period is around 60%. For the period after 1995 we are looking for 27 articles, implying a total coverage of about 90%. Of course these are not exact measure because items on the wish list may turn out not to be EE-IO and other articles may be found. Nevertheless, I am estimating that the coverage is fairly good (75-85%) for the period after 1995 and less so (about 40-50%) for the period before 1995.[6]

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[5] Excluded: Alarcon (2000); Daly (1968); De Haan and Keuning (1996); De Haan (1999); Forssell (1998); Fujimori and Matsuoka (2007); Ike (1999); Mazzanti et al. (2008); Palm and Larsson (2007); Smith (2007); Vardon et al. (2007); and Vaze (1999).

[6] Given the incomplete database and the articles which we have already uncovered for the year 2010 as well as economic analyses and environmental accounts, I am assuming for the moment that the "full" database will have approximately 500-600 journal articles.

Despite the bias in our database I am confident that the trends that we discuss in the next section will hold even when the database is completed. In some instances, where I am not certain, I will indicate this in the text.

3. Overall results

In total we have confirmed and classified 360 EE-IO articles in peer reviewed journals with a total of 436 contributing authors from over 218 institutions[7] in 32 countries. The literature has covered a very broad range of environmental pressures and has been applied to 43 countries.

Figure 1 shows the number of articles published in each year. In the mid 1990s the amount of EE-IO articles started to grow significantly. The last year in the database (2009) was truly an extraordinary year, with a total yield of 50 articles.

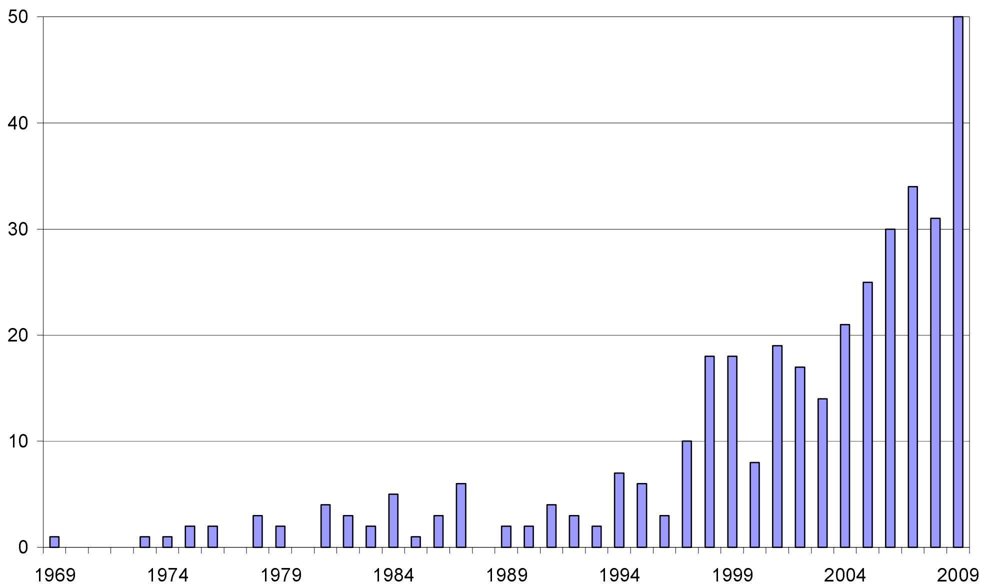


Figure 1. Number of EE-IO articles (1969-2009)

It is quite difficult to categorize the documents into theoretical or empirical contributions because many EE-IO have both a theoretical and empirical dimension.. I have therefore recorded all publications that have an empirical application. Figure 2 confirms the empirical tradition which IO has always had. Over 81% of all articles in the 40-year history include calculations of real-world data. Only a very small percentage is purely mathematical theory. The “other” category includes literature reviews, editorials of special issues, articles on the “way forward” and quite a few papers which are based on numerical examples.

[7] For each author we took the first affiliation mentioned in the article.

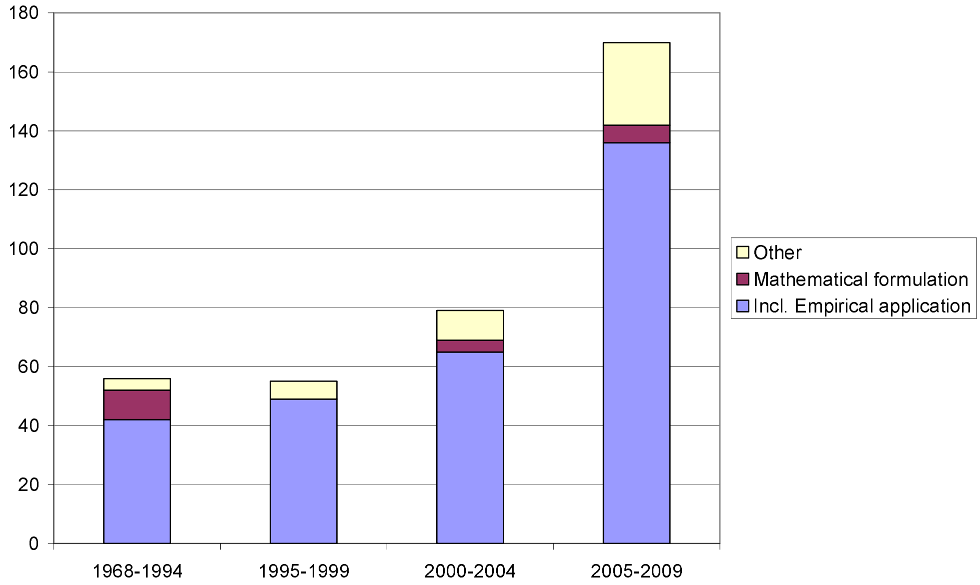


Figure 2. A rough categorization of EE-IO articles

A small note about the time periods in Figure 2 warranted because we will be using this breakdown in the remainder of the paper. We have chosen to bundle all papers from before the surge (pre 1995). This corresponds to about 50 articles in our database. We have split the period of quick expansion (1995-2009) into three 5-year periods to gain insight into what has influenced the growth over the more recent period.

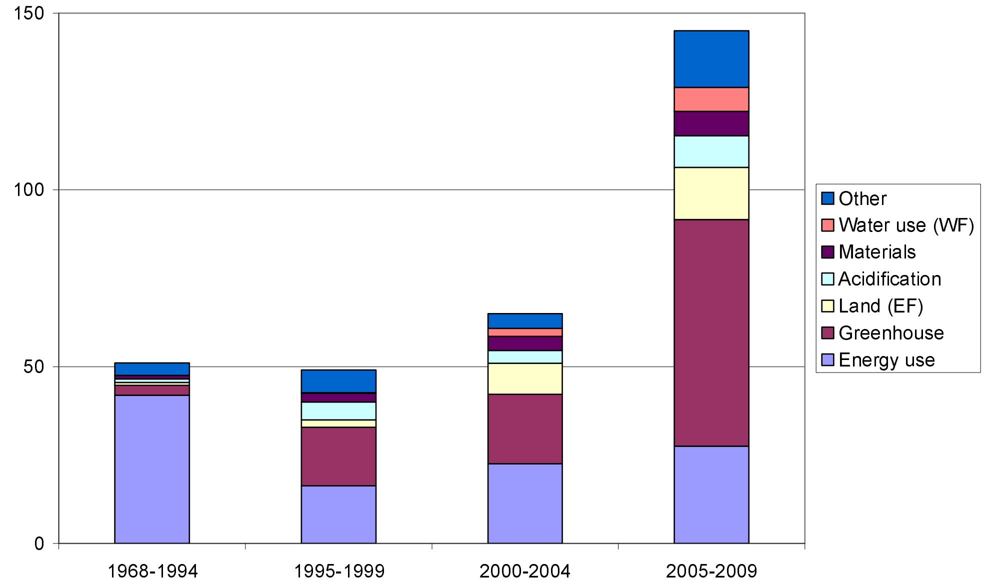
4. Environmental problems

In the 40 year history of EE-IO new environmental problems have emerged, and in some cases (e.g. ozone depletion), have slowly vanished from the scientific agenda. Figure 3 shows the coverage of environmental issues in the EE-IO database.[8]

The results show that EE-IO in the 1970s to the early 90s was almost exclusively dedicated to the analysis of energy consumption. However, the EE-IO literature has adapted and diversified. Of course, global warming has been the main area of research in the last couple of years with nearly 50% of the articles in 2005-2009 dedicated to this topic. However, investigations of land issues, particularly ecological footprint analysis, have also increased rapidly. EE-IO has also diversified to analyse a very broad range of “other“ environmental pressures[9].

[8] Note that 310 of the 360 articles explicitly discuss one or more environmental pressures. If a paper tackles multiple environmental problems it is weighed accordingly i.e. is the paper covers 3 pressures each is assigned a weight of 1/3. Figure 3 therefore adds up to 310.

[9] The category “Other” includes to Air quality, Ecosystem pressures, Eutrophication, Heavy metal, Ozone depletion, Waste and Water & soil contamination.



EF- Including ecological footprint, WF – Including water footprint

Figure 3. Coverage of environmental problems

One notable development is that the recent literature includes more studies that investigate multiple environmental pressures simultaneously. Before 1995 nearly 90% of the studies investigated a single type of environmental pressure, while after 1995 this percentage dropped to 66%. For example, many studies investigate energy use and the emission of greenhouse house gasses simultaneously.

5. Geographical scope

Our database of EE-IO articles includes results for 43 countries. In Figure 4 a breakdown is given for the countries which are investigated.[10]

The figure shows that the pre-1995 period was dominated by applications for the United States. More recently, Europe has taken the lead in terms of the number of EE-IO applications. The increased attention for China is also clear from the growing amount of publications over the last 15 years. This is a marked shift compared to the period running up to 1995, where studies for China were very rare.

It is still relatively rare that several countries are investigated simultaneously. For the entire 40-year period about 90% of articles study a single country. This

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[10] Note that 268 of the 360 articles have results for one or more countries. This does not mean that all these results are at the national level. Many studies provide EE-IO analysis for cities, regions or processes (IO-LCA). If a paper has an application for multiple countries it is weighed accordingly i.e. is the paper covers 3 countries each is assigned a weight of 1/3. Figure 3 therefore adds up to 268.

percentage is fairly constant over time. This is perhaps a reflection of the interest of the researchers and their research questions. However, it is also likely to be a symptom of the poor availability of internationally-harmonized EE-IO data sets. The situation is changing somewhat because the last decade has seen a number of articles which explicitly take a global perspective[11]. Also a number of large scale projects have started recently to produce valuable multiregional EE-IO databases. We will return to this point later on.

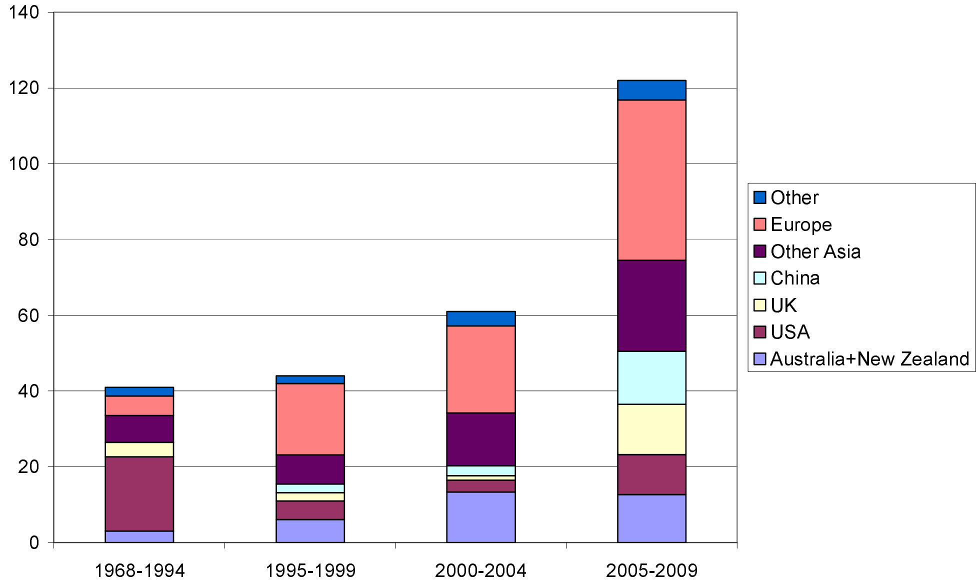

Figure 4. Coverage of countries and regions

6. EE-IO methods

A variety of different EE-IO methods can be applied to gain insights into the environmental pressures. Figure 5 shows the prevalence of each method in the EE-IO database: [12]

- General EE-IO. These are usually theoretical papers that discuss or develop the general EE-IO model.
- Imputation. These include all the studies that investigate "multiplier" (direct and indirect environmental pressures per unit final demand) but also articles

[11] Andrew and Lennox (2009); Atkinson and Hamilton (2002); Hertwich and Peters (2009); Kratena (2004); Peters and Hertwich (2008); Proops et al., (1999); Strømman et al. (2009); and Wilting and Vringer (2009)

[12] Note that 356 of the 360 articles discuss an EE-IO method. If a paper discusses more than 1 method it is weighed accordingly i.e. is the paper covers 2 methods each is assigned a weight of 1/2. Figure 5 therefore adds up to 356.

that use the multiplier to attribute the environmental pressures to final demand categories, per region, city or production processes (through IO-life cycle analysis). This method is known under various names such as "embodied carbon" or the "carbon footprint".

- Structural decomposition analysis (SDA). In these studies the changes in environmental pressures are attributed to economic growth, structural changes and technological developments. An intercountry-SDA variety also exists in which the differences between countries are analysed.
- Models. In this category we include scenario studies which simulate future development based on dynamic input-output models. There are however also static models which provide insights about systems changes when certain model specifications alter.
- Other. This category includes key sector analysis and structural path analysis.

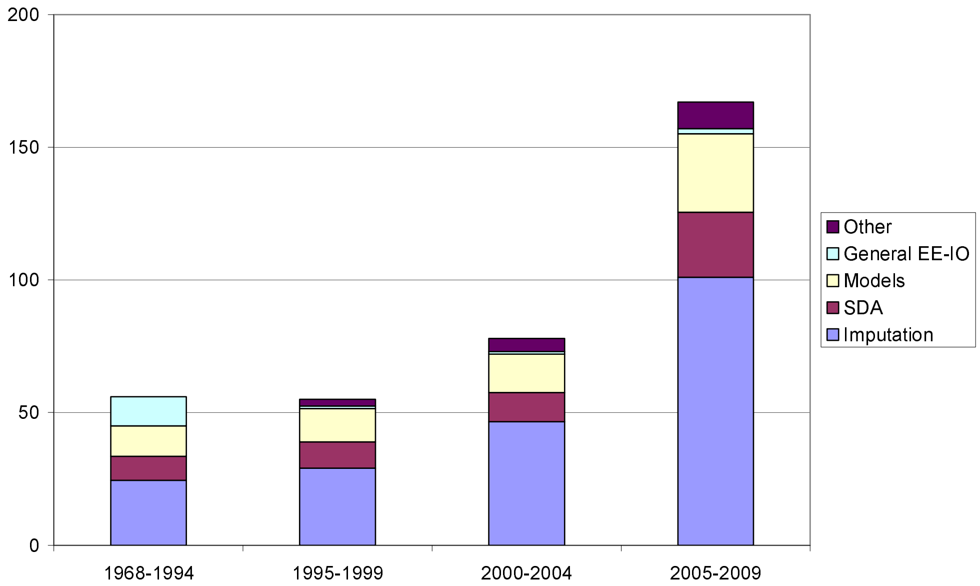

Figure 5. Coverage of EE-IO models

Although all categories have exhibited substantial growth, Figure 5 shows that multiplier/imputation analysis remains the dominant strain. It is therefore interesting to take a closer look at this type of type of model because a number of sub-categories exist. Figure 6 shows five varieties:

- General. These are all studies in which environmental pressures are imputed to all final demand categories or overall multipliers per unit of final demand are calculated.[13]

[13] In future version of this paper I may split multiplier analysis (i.e. environmental pressure per unit final demand) from imputation to the absolute value of final demand.

- Consumption. In this case the study focuses on the environmental pressures embodied in the consumption of households. A couple of articles focus on government consumption.
- Ecological footprint. In this case the land use (ecological footprint) is attributed to a region. Is sometimes simply a special case of the imputation to households.
- IO-LCA. In this method input-output techniques are combined with life cycle assessment (LCA) to analyse the emission of a production process, technology or other study object.
- Trade. In this case environmental pressures that are embodied in imports and or exports are calculated.

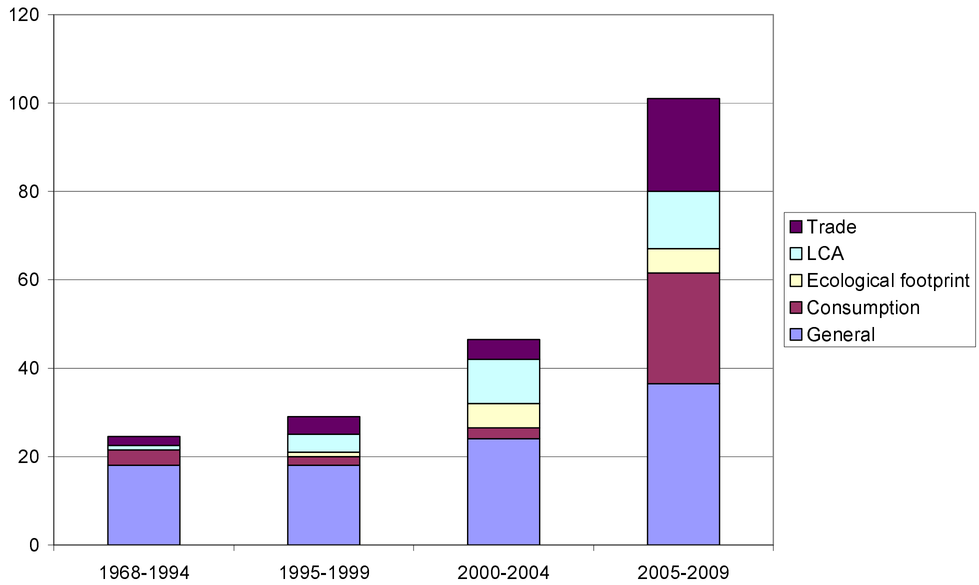

Figure 6. Types of EE-IO imputation models

Figure 6 shows that the general imputation analysis has remained the dominant strain but that the more specific studies for consumption (including ecological footprint) and IO-LCA also show significant increases. The imputation to imports and exports has increased significantly over the last 5 years. This area has been characterised by a lively debate on the production vs. consumption perspective of environmental responsibility.

7. Journals, Authors and Affiliation

Figure 7 shows the publication journal of the 360 articles. Six journals, which account for nearly 75% of the output, are specified: *Ecological Economics* (87 articles), *Energy Policy* (62); *Economic Systems Research* (47); *Journal of Industrial Ecology* (22) and *Structural Change and Economic Dynamics* (15).

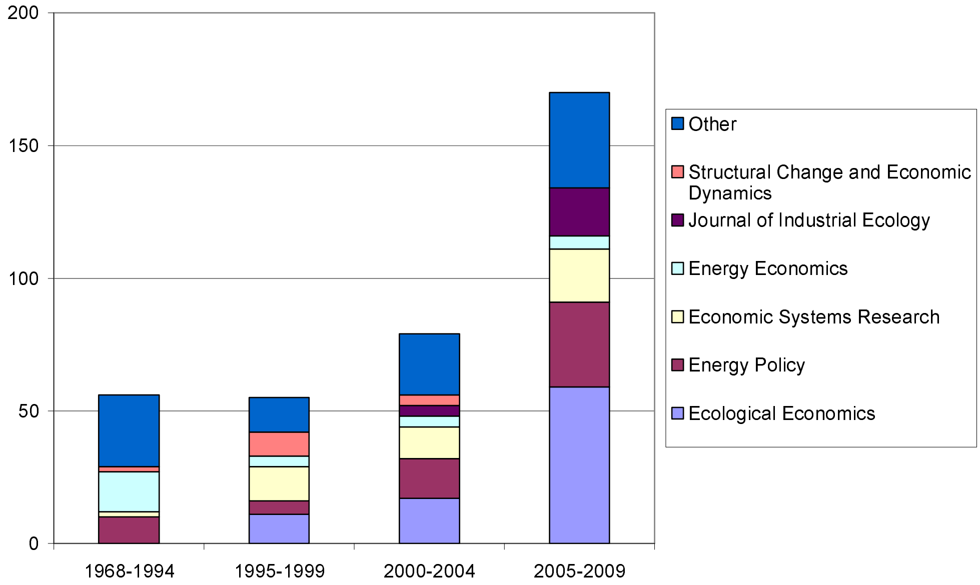

Figure 6. Number of articles in EE-IO journals

The figure shows that *Ecological Economics* is the main contributor to the surge in articles in the 1995-2009 periods. *Energy Policy* and *Economic System Research* have contributed to a lesser extent. It is interesting to note that *Energy Economics*, which was an important outlet in the early period, only has a couple of EE-IO articles per year nowadays. Note that the EE-IO output has diversified significantly. In the 1969-1994 period, EE-IO articles appeared in 15 journals. For the period 1995-2009 it was 45, which is also a reflection of the growth of scientific publications in general and of environmental issues in particular.

Ecological Economics is one of the most influential outlets for ecological economists. It has experienced exponential growth since its inception in 1989 from about 20-30 articles in the early 1990s to about 300 articles per year in the late 1990s (Source: Scopus)[14]. Nevertheless, the share of EE-IO articles has remained fairly constant (4-5%) over the last decade. A tentative conclusion would be that EE-IO has profited from the increased attention for environmental issues but has not necessarily increased in importance in the field of ecological economics.

Since we have not yet completed the database it is a bit premature to provide the number of articles and citations per author and institution. However, a number of tentative conclusion can be drawn:

- Manfred Lenzen (University of Sydney) really dominates the field with over 52 articles (864 pages). He is therefore involved in 14% (!) of all the articles in the database. His work has been cited more than 1150 times.
- The following authors occur in our database more than 10 times: G.P. Peters; S. Suh; K. Hubacek; E.G. Hertwich; S. Kagawa; T.O. Wiedmann;

[14] Note that this includes all output including announcements, errata and book reviews.

B.M. Hannon; R. Wood; S.D. Casler; and J. Munksgaard. Note that because the database is skewed, the list is biased in favour of the more recent authors.

- We have registered over 20 contributions[15] to the literature for the following institutions: University of Sydney (Australia), Norwegian University of Science and Technology (Norway), University of Groningen (The Netherlands), University of Illinois (United States), University of York (United Kingdom), National Institute for Environmental Studies (Japan) and the National Cheng Kung University (Taiwan).
- We have registered over 40 contributions from institutions from the following countries: United States, United Kingdom, The Netherlands, Australia, Japan, Spain and Norway.

8. Most cited papers (published after 1996)

Scopus is capable of detailed analysis of the citations of articles. However, the database is known to be reliable only from 1996 onwards.

Table 1 shows the 20 articles in our database that are cited most (Source: Scopus June 2010). The list shows that IO-LCA and input-output analysis of the ecological footprint are strains of the EE-IO literature with a high impact factor.

Note that Scopus does provide some insight into older EE-IO classics. For example, Hannon (1973), Bullard and Herendeen (1975) and Wyckoff and Roop (1994) score 108, 82, 57 citations respectively. With these numbers they would easily be in the top-20 of articles. However, we have chosen not to use these because the Scopus citation tracker is incomplete for these years. A poignant example is the fact that no citations are recorded for Ayres and Kneese (1969).

9. Conclusions and further research

In this paper we have discussed a preliminary version of a database of EE-IO articles. The database contains 360 confirmed EE-IO publications spanning a 40-year period. The EE-IO literature really started to grow fast after the mid-1990s. 1990 was truly an exceptional year with 50 articles in peer-reviewed journals.

We have shown that the literature was dominated by multiplier analysis of energy use for US applications early period. In the decades that followed the field has matured to include a variety of methods which are applied to many countries and environmental themes.

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[15] A contribution is registered for each author. In other words if an article was authored by 2 people from the same institute it is counted as 2 "contributions" by that institution.

Table 1. Top-20 cited papers in the EE-IO database

	Cited by	Reference	Journal	Method
1.	128	Suh et al., 2004	Environmental Science and Technology	IO-LCA
2.	115	Lenzen and Murray., 2001	Ecological Economics	Ecological footprint
3.	113	Bicknell et al., 1998	Ecological Economics	Ecological footprint
4.	102	Lenzen, 2001a	Journal of Industrial Ecology	IO-LCA
5.	94	Brown. and Herendeen, 1996	Ecological Economics	Imputation
6.	91	Lenzen, 1998a	Energy Policy	Imputation
7.	79	Munksgaard and Pedersen, 2001	Energy Policy	Imputation
8.	77	Treloar, 1997	Economic Systems Research	IO-LCA
9.	62	Machado, G. et al., 2001	Ecological Economics	Imputation to trade
10.	62	Wiedmann et al., 2006	Ecological Economics	Ecological footprint
11.	60	Lenzen, 2001b	Economic Systems Research	Imputation
12.	59	Suh and Huppes, 2005	Journal of Cleaner Production	IO-LCA
13.	56	Hubacek and Giljum, 2003	Ecological Economics	Ecological footprint
14.	55	Suh, 2004a	Ecological Economics	IO-LCA
15.	48	Peters and Hertwich, 2008a	Environmental Science and Technology	Imputation to trade
16.	54	Lenzen et al., 2004a	Economic Systems Research	Imputation to trade
17.	52	Hoekstra and van den Bergh, 2003	Energy Economics	SDA
18.	51	Hertwich, 2005	Environmental Science and Technology	IO-LCA
19.	51	McDonald and Patterson, 2004	Ecological Economics	Ecological footprint
20.	49	Wiedmann et al., 2007	Ecological Economics	Imputation to consumption
	49	Lenzen and Munksgaard, 2002	Renewable Energy	IO-LCA
	49	Ferng, 2001	Ecological Economics	Ecological footprint

The importance of global warming, the ecological footprint methodology, input-output life cycle assessment, the issue of carbon embodied in trade and the emergence of the *Ecological Economics* journal are important factors in the increase of interest in EE-IO.

Data availability and the way forward

Despite the growth of EE-IO over the last 15 years, it is my impression that the IO literature is still held back by data availability. Very many of the studies in our database are case studies of a single environmental pressure for a single (rich) country for a single year. However, if EE-IO is to capture a prominent place in environmental economics it must be able to contribute to large environmental economic research questions such as the Environmental Kuznets Curve, Carbon Leakage or the Pollution Haven Hypothesis. Generic statements about these important questions can only be given by studying time series for several countries as is done in the literature on environmental (macro-)economics.

Interestingly the data situation is already improving and is likely to improve in the near future, perhaps a result of renewed interest in EE-IO. So far 6 studies[16] in the database take a global perspective. Many of the publications are based on the GTAP model which includes a global EE-IO database. New EU-projects such as EXIOPOL, WIOD[17] and a renewed interest of Eurostat in input-output data[18] will further enhance the availability of harmonized IO data for multiple countries. With these data sources EE-IO will be able to do even more to answer the core questions in environmental economics.

Based on my own personal assessment of the literature I do want to make a number of tentative recommendations:

1. Invest in time series. Economic, structural and technological changes occur over a long period. It is therefore imperative that if we want to understand the driving forces of environmental pressures that we look at long term developments using historical EE-IO datasets that span several decades or more. Already a number of countries have these datasets and are using them to their benefit.[19]
2. Invest in IO-data for developing countries. EE-IO studies are usually restricted to developed countries, partly because they are of interest, but also because these have readily available IO-data. However, for many important sustainability issues the developing world is very important (resource depletion, deforestation, poverty). Although it is true that the data situation is not very good, it is not true that there is no data at all for these countries. However, it will take time to harmonize the available data or perhaps construct data from other economic sources.
3. Invest in multiregional datasets. It is imperative that IO datasets with a global dimension are produced. The WIOD project will go very far to resolve this problem since it will publish MRIO data in current prices and prices of the previous year for the period 1995-2008 for more than 35 regions.
4. Broaden the scope to sustainability. Environmental sustainability is just one of the aspects which are of scientific interest. However, input-output

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[16] Andrew and Lennox (2009); Atkinson and Hamilton (2002); Hertwich and Peters (2009); Kratena (2004); Peters and Hertwich (2008); Proops et al., (1999); Strømman et al. (2009); and Wilting and Vringer (2009)

[17] See www.exiopol.org and www.wiod.org.

[18] Think for example of the EUKLEMS database.

[19] Denmark: Wier (1998); Wier and Hasler (1999); China: Guan *et al.* (2008); Cao *et al.* (2008); India: Mukhopadhyay and Forssell (2005); Australia (Wood, 2009; Wood et al., 2009) span 20-30 years. The large outlier is Sweden (Kander and Lindmark (2006)) which analyses an 82-year (!) period, starting in 1916. Van der Helm et al. (2010) will introduce an application for the Netherlands (1960-2008) at the Sydney Conference.

analysis is perfectly suited to investigate other aspects of sustainability simultaneously and a the EE-IO has along tradition of doing this. The next recommendation is also related to this point.

5. Connect to other satellite accounting systems. EE-IO is based on the environmental accounts, which is one of the satellite account of the national accounting system. However there are many satellite accounts and many statistical institutes are now producing labour accounts, agricultural accounts, tourism satellite accounts, growth accounts etc. This raises the rather interesting prospect of combing the analysis of two or more satellites. For example, it is surprising to see that environmental pressures of tourism has never been investigated in the EE-IO literature. This could quite easily be done by using the data from the environmental accounts and the tourism satellite account (TSA).

A new project at the Groningen Growth and Development Centre will try to make a modest contribution to some of the data issues raised above. Our main aim is to create a database of historical input-output and environmental data. We also aim to gather as much data as possible on developing countries. For more information or a data contribution feel free to contact me.

Way forward for the EE-IO database

Of course the analysis of the literature is just a quick scan so far. There are a couple of directions which I am considering for the EE-IO database:

- Add categories for which the publications are classified (periods investigated, sector disaggregation, spatial scale (studies for regions, cities or other); specific IO model (augmented Leontief, hybrid analysis). Also record specific model details such as direct emissions from households or the inclusion of investment as intermediates in the imputation analysis.
- Add the EE-IO publications which looks at economic impacts and environmental accounting
- Add other publications such as books, book chapters and PhD-theses.
- Produce a meta analysis is which the result of the studies are used to produce generic statements.

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Appendix A. The 360 articles in the EE-IO database

Title	Reference	Journal
The carbon content of Japan-US trade	Ackerman, F. et al., 2007	Energy Policy
Input-output analysis of energy requirements. An application to the Scottish economy in 1973	Al-Ali, H.M., 1979	Energy Economics
Analysing materials and energy flows in an industrial district using an enterprise input-output model	Albino, V. et al., 2003	Economic Systems Research
Comparison of energy intensities in European Union countries. Results of a structural decomposition analysis	Alcántara, V. and Duarte, R., 2004	Energy Policy
"Key" sectors in final energy consumption: An input-output application to the Spanish case	Alcántara, V. and Padilla, E., 2003	Energy Policy
Input-output subsystems and pollution: An application to the service sector and CO2 emissions in Spain	Alcántara, V. and Padilla, E., 2009	Ecological Economics
Energy and CO2 emissions in Spain. Methodology of analysis and some results for 1980-1990	Alcántara, V. and Roca, J., 1995	Energy Economics
A three-perspective view of greenhouse gas emission responsibilities in New Zealand	Andrew, R. and Forgie, V.E., 2008	Ecological Economics
Approximation and regional aggergation in the multi-regional input-output analysis for national carbon footprint accounting	Andrew, R. et al., 2009	Economic Systems Research
The Leontief Pollution model: A systematic formulation	Arrous, J., 1994	Economic Systems Research
International trade and the 'ecological balance of payments'	Atkinson, G. and Hamilton, K., 2002	Resources Policy
Production, Consumption, and Externalities	Ayres, R.U. and Kneese, A.V., 1969	American Economic Review
The effects of environmental fiscal reform in Germany: A simulation study	Bach, S. et al., 2002	Energy Policy
Analysis and forecast of the state of environmental protection in Russia: A Dynamic Input-Output Model	Baranov, A.O. et al., 1997	Environmental and Resource Economics
Assessing the energy intensities of imports	Battjes, J.J. et al., 1998	Energy Economics
Energy and output implications of income redistribution in Brazil	Behrens, A., 1984	Energy Economics
Description and application of the EAP computer program for calculating life-cycle energy use and greenhouse gas emissions of household consumption items	Benders, R.M.J. et al., 2001	International Journal of Environment and Pollution
Environmental assessment of two waste incineration strategies for Central Norway	Bergsdal, H. et al., 2005	International Journal of Life Cycle Assessment
Considering the effects of imprecision and uncertainty in ecological footprint estimation: An approach in a fuzzy environment	Beynon, M.J. and Munday, M., 2008	Ecological Economics
New methodology for the ecological footprint with an application to the New Zealand economy	Bicknell, K.B. et al., 1998	Ecological Economics
Distribution of the generation of air pollution	Bingham, T.H. et al., 1987	Journal of Environmental Economics and Management
Embodied energy analysis and EMERGY analysis: A comparative view	Brown, M.T. and Herendeen, R.A., 1996	Ecological Economics
The energy cost of goods and services	Bullard III, C.W. and Herendeen, R.A., 1975	Energy Policy
Composition of greenhouse gas emissions in Spain: An input-output analysis	Butnar, I. and Llop, M., 2007	Ecological Economics
Empirical relationships between the energy and information segments of the US economy: An input-output approach	Campos Machado, A. and Miller, R.E., 1997	Energy Policy
Environmental accounting of eco-innovations through environmental input-output analysis: The case of hydrogen and fuel cells buses	Cantono, S. et al., 2008	Economic Systems Research
Total embodied energy requirements and its decomposition in China's agricultural sector	Cao, S. et al., 2008	Ecological Economics

Applying physical input-output tables of energy to estimate the energy ecological footprint (EEF) of Galicia (NW Spain)	Carballo Penela, A. and Sebastián Villasante, C., 2008	Energy Policy
Input composition and the energy-output ratio	Casler, S.D. and Afrasiabi, A., 1993	Structural Change and Economic Dynamics
Economic structure, fuel combustion, and pollution emissions	Casler, S.D. and Blair, P.D., 1997	Ecological Economics
Readjustment potentials in industrial energy efficiency and structure	Casler, S.D. and Hannon, B.M., 1989	Journal of Environmental Economics and Management
Carbon dioxide emissions in the U.S. economy: A structural decomposition analysis	Casler, S.D. and Rose, A., 1998	Environmental and Resource Economics
Energy input-output analysis. A simple guide	Casler, S.D. and Wilbur, S., 1984	Resources and Energy
DOLLAR, ENERGY, AND LABOR COST DIFFERENTIALS IN LEADED VS. UNLEADED GASOLINE.	Casler, S.D. et al., 1987	Energy systems and policy
Decomposing change in energy input-output coefficients	Casler, S.D. et al., 1991	Resources and Energy
CORRECTING INPUT-OUTPUT COEFFICIENTS FOR CAPITAL DEPRECIATION.	Casler, S.D., 1983	Energy systems and policy
Budget reallocation and the peace dividend: energy and pollution tradeoffs	Casler, S.D., 1991	Energy Policy
Why does energy intensity fluctuate in China?	Chai, J. et al., 2009	Energy Policy
Structural decomposition of industrial CO2 emission in Taiwan: An input-output approach	Chang, Y.F. and Lin, S.J., 1998	Energy Policy
Comprehensive evaluation of industrial CO2 emission (1989-2004) in Taiwan by input-output structural decomposition	Chang, Y.F. et al., 2008	Energy Policy
A structural decomposition analysis of changes in energy demand in Taiwan: 1971-1984	Chen, C.Y. and Rose, A., 1990	Energy Journal
Sources of change in industrial electricity use in the Taiwan economy, 1976-1986	Chen, C.Y. and Wu, R.-H., 1994	Energy Economics
Industrial structure and source of carbon dioxide emissions in East Asia: Estimation and comparison	Chung, H.-S., 1998	Energy and Environment
Energy requirements of households in Brazil	Cohen, C. et al., 2005	Energy Policy
Energy requirements of households in Brazil	Cohen, C. et al., 2005	Energy Policy
The environmental impacts of consumption at a subnational level: The ecological footprint of Cardiff	Collins, A. et al., 2006	Journal of Industrial Ecology
A note on energy requirements Calculations using the 1968 and 1974 UK input-output tables	Common, M.S. and McPherson, P., 1982	Energy Policy
Accounting for changes in Australian carbon dioxide emissions	Common, M.S. and Salma, U., 1992	Energy Economics
Embodied energy and economic value in the United States economy: 1963, 1967 and 1972	Costanza, R. and Herendeen, R.A., 1984	Resources and Energy
Generalized Fisher index or Siegel-Shapley decomposition?	de Boer, P., 2009	Energy Economics
A structural decomposition analysis of pollution in the Netherlands	De Haan, M., 2001	Economic Systems Research
International comparisons of domestic energy consumption	de Nooij, M. et al., 2003	Energy Economics
Three strategies to overcome the limitations of life-cycle assessment	De Udo Haes, H.A. et al., 2004	Journal of Industrial Ecology
Sustainable economic structures	Dellink, R. et al., 1999	Ecological Economics
The energy cost of goods and services in the Federal Republic of Germany	Denton, R.V., 1975	Energy Policy
An empirical examination of the pollution haven hypothesis for India: Towards a green Leontief paradox?	Dietzenbacher, E. and Mukhopadhyay, K., 2007	Environmental and Resource Economics
Mixing oil and water? Using hybrid input-output tables in a structural decomposition analysis	Dietzenbacher, E. and Stage, J., 2006	Economic Systems Research
Waste treatment in physical input-output analysis	Dietzenbacher, E., 2005	Ecological Economics
A dynamic Leontief model with non-renewable resources	Dobos, I. and Floriska, A., 2005	Economic Systems Research
The carbon footprint of UK households 1990-2004: A socio-economically disaggregated, quasi-multi-regional input-output model	Druckman, A. and Jackson, T., 2009	Ecological Economics
Measuring progress towards carbon reduction in the UK	Druckman, A. et al., 2008	Ecological Economics
Water use in the Spanish economy: An input-output approach	Duarte, R. et al., 2002	Ecological Economics
Prospects for the recycling of plastics in the United States	Duchin, F. and Lange, G.-M., 1998	Structural Change and

		Economic Dynamics
Industrial input-output analysis: Implications for industrial ecology	Duchin, F., 1992	Proceedings of the National Academy of Sciences of the United States of America
Sustainable consumption of food: A framework for analyzing scenarios about changes in diets	Duchin, F., 2005	Journal of Industrial Ecology
What environmental pressures are a region's industries responsible for? A method of analysis with descriptive indices and input-output models	Eder, P. and Narodoslawsky, M., 1999	Ecological Economics
Intensities of energy usage an international and intertemporal comparison	Edwards, R. and Parikh, A., 1978	Energy Policy
An illustrative application of the CRITINC framework to the UK	Ekins, P. and Simon, S., 2003	Ecological Economics
Environmental assessment of Swedish agriculture	Engstro□m, R. et al., 2007	Ecological Economics
Exploring techno-economic scenarios in an input-output model	Faber, A. et al., 2007	Futures
Using composition of land multiplier to estimate ecological footprints associated with production activity	Ferng, J.-J., 2001	Ecological Economics
Toward a scenario analysis framework for energy footprints	Ferng, J.-J., 2002	Ecological Economics
Allocating the responsibility of CO2 over-emissions from the perspectives of benefit principle and ecological deficit	Ferng, J.-J., 2003	Ecological Economics
Local sustainable yield and embodied resources in ecological footprint analysis - A case study on the required paddy field in Taiwan	Ferng, J.-J., 2005	Ecological Economics
Human freshwater demand for economic activity and ecosystems in Taiwan	Ferng, J.-J., 2007	Environmental Management
Applying input-output analysis to scenario analysis of ecological footprints	Ferng, J.-J., 2009	Ecological Economics
The use of EIO-LCA in assessing national environmental policies under the Kyoto Protocol: The Portuguese economy	Ferrão, P. and Nhambiu, J., 2006	International Journal of Technology, Policy and Management
Integrating sustainable chain management with triple bottom line accounting	Foran, B. et al., 2005	Ecological Economics
Introduction: Input-output and the environment	Forssell, O. and Polenske, K.R., 1998	Economic Systems Research
The generation of residual flows in Norway: an input-output approach	Førsund, F.R. and Strøm, S., 1976	Journal of Environmental Economics and Management
A Miyazawa analysis of interactions between polluting and non-polluting sectors	Fritz, O.M. et al., 1998	Structural Change and Economic Dynamics
Trade liberalization and pollution: an input-output study of carbon dioxide emissions in Mexico	Gale IV, L.R., 1995	Economic Systems Research
A consistent input-output formulation of shared producer and consumer responsibility	Gallego, B. and Lenzen, M., 2005	Economic Systems Research
Why has the energy-output ratio fallen in China?	Garbaccio, R.F. et al., 1999	Energy Journal
Trading away damage: Quantifying environmental leakage through consumption-based, life-cycle analysis	Ghertner, D.A. and Fripp, M., 2007	Ecological Economics
Alternative approaches of physical input-output analysis to estimate primary material inputs of production and consumption activities	Giljum, S. and Hubacek, K., 2004	Economic Systems Research
Beyond the simple material balance: A reply to Sangwon Suh's note on physical input-output analysis	Giljum, S. et al., 2004	Ecological Economics
An interindustry analysis of structural change and energy use linkages in the Saskatchewan economy	Gould, B.W. and Kulshreshtha, S.N., 1986	Energy Economics
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ENERGY USE IN MANUFACTURING: EARLY STRUCTURAL AND TECHNOLOGICAL ADJUSTMENT TO THE 1973-74 ENERGY PRICE SHOCK.	Gowdy, J.M. and Miller, J.L., 1987b	Energy systems and policy
Labour productivity and energy intensity in Australia 1974-87. An input-output analysis	Gowdy, J.M., 1992	Energy Economics

Assessment of regional trade and virtual water flows in China	Guan, D. and Hubacek, K., 2007	Ecological Economics
A new and integrated hyrdo-economic accounting and analytical framework for water resources: A case study for North China	Guan, D. and Hubacek, K., 2008	Journal of Environmental Management
The drivers of Chinese CO2 emissions from 1980 to 2030	Guan, D. et al., 2008	Global Environmental Change
The sustainability of logging in Indonesia's tropical forests: A dynamic input-output analysis	Hamilton, C., 1997	Ecological Economics
The role of the four electric power sectors in the Korean national economy: An input-output analysis	Han, S.-Y. et al., 2004	Energy Policy
Structural changes and energy consumption in the Japanese economy 1975-85: An input-output analysis	Han, X. and Lakshmanan, T.K., 1994	Energy Journal
UPDATING ENERGY AND LABOR INTENSITIES FOR NON-INPUT-OUTPUT YEARS.	Hannon, B.M. and Casler, S.D., 1985	Energy systems and policy
DOLLAR, ENERGY, AND EMPLOYMENT COSTS OF PROTEIN CONSUMPTION.	Hannon, B.M. et al., 1979	Energy systems and policy
ENERGY-CONSERVATION TAX: IMPACTS AND POLICY IMPLICATIONS.	Hannon, B.M. et al., 1981	Energy systems and policy
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The structure of ecosystems	Hannon, B.M., 1973	Journal of Theoretical Biology
Input-output economics and ecology	Hannon, B.M., 1995	Structural Change and Economic Dynamics
The use of analogy in biology and economics from biology to economics, and back	Hannon, B.M., 1997	Structural Change and Economic Dynamics
Ecological pricing and economic efficiency	Hannon, B.M., 2001	Ecological Economics
A model for forecasting the economic and environmental impact of energy policy	Harris, C.C. et al., 1984	Energy Economics
Input-output simulations of energy, environment, economy interactions in the UK	Hawdon, D. and Pearson, P., 1995	Energy Economics
A classroom simulation to teach economic input-output life cycle assessment	Hawkins, T.R and Matthews, D.H, 2009	Journal of Industrial Ecology
A mixed-unit input-output model for environmental life-cycle assessment and material flow analysis	Hawkins, T.R et al., 2007	Environmental Science and Technology
SWEEA-Swedish environmental and economic accounts	Hellsten, E. et al., 1997	Structural Change and Economic Dynamics
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Energy cost of living, 1972-1973	Herendeen, R.A. et al., 1981	Energy
Input-output techniques and energy cost of commodities	Herendeen, R.A., 1978	Energy Policy
Energy analysis and EMERGY analysis - A comparison	Herendeen, R.A., 2004	Ecological Modeling
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Structural decomposition analysis of physical flows in the economy	Hoekstra, R. and van den Bergh, J.C.J.M., 2002	Environmental and Resource Economics
Comparing structural and index decomposition analysis	Hoekstra, R. and van den Bergh, J.C.J.M., 2003	Energy Economics
Constructing physical input-output tables for environmental modeling and accounting: Framework and illustrations	Hoekstra, R. and van den Bergh, J.C.J.M., 2006a	Ecological Economics
The impact of structural changes on physical flows in the economy: Forecasting and backcasting models using Structural Decompoition Analysis	Hoekstra, R. and van den Bergh, J.C.J.M., 2006b	Land Economics
Sensitivity analysis of total CO2 emission intensities estimated	Hondo, H. et al., 2002	Applied Energy

using an input-output table		
Evaluating the effects of embodied energy in international trade on ecological footprint in China	Hong, L. et al., 2007	Ecological Economics
MULTIOBJECTIVE PROGRAMMING AND INTERINDUSTRY MODEL FOR ENERGY-ECONOMIC PLANNING IN TAIWAN.	Hsu, G.J.Y. et al., 1987	Energy systems and policy
Energy multipliers for economic analysis. An input-output approach	Hsu, G.J.Y., 1989	Energy Economics
The role of input-output analysis for the screening of corporate carbon footprints	Huang, Y.A. et al., 2009	Economic Systems Research
Applying physical input-output analysis to estimate land appropriation (ecological footprints) of international trade activities	Hubacek, K. and Giljum, S., 2003	Ecological Economics
A scenario analysis of China's land use and land cover change: Incorporating biophysical information into input-output modeling	Hubacek, K. and Sun, L., 2001	Structural Change and Economic Dynamics
Economic and societal changes in China and their effects on water use: A scenario analysis	Hubacek, K. and Sun, L., 2009	Journal of Industrial Ecology
Environmental implications of urbanization and lifestyle change in China: Ecological and Water Footprints	Hubacek, K. et al., 2009	Journal of Cleaner Production
CO2 emissions vs. CO2 responsibility: An input-output approach for the Turkish economy	Ipek Tunc□, G. et al., 2007	Energy Policy
Luxury or 'lock-in'? An exploration of unsustainable consumption in the UK: 1968 to 2000	Jackson, T. and Papathanasopoulou, E., 2008	Ecological Economics
Energy demand, structural change and trade: A decomposition analysis of the Danish manufacturing industry	Jacobsen, H.K., 2000	Economic Systems Research
Integration of an economic input-output model and a linear programming technological model for energy systems analysis	James, D.E.deL. et al., 1986	Energy Economics
Linking economic and ecological models for a marine ecosystem	Jin, D. et al., 2003	Ecological Economics
A structural decomposition of energy consumption based on a hybrid rectangular input-output framework: Japan's case	Kagawa, S. and Inamura, H., 2001	Economic Systems Research
A spatial structural decomposition analysis of Chinese and Japanese energy demand: 1985-1990	Kagawa, S. and Inamura, H., 2004	Economic Systems Research
The invisible multipliers of joint-products	Kagawa, S. et al., 2002	Economic Systems Research
A simple multi-regional input-output account for waste analysis	Kagawa, S. et al., 2004	Economic Systems Research
The environmental and economic consequences of product lifetime extension: Empirical analysis for automobile use	Kagawa, S. et al., 2006	Ecological Economics
Measuring spatial repercussion effects of regional waste management	Kagawa, S. et al., 2007	Resources, Conservation and Recycling
The economic and environmental consequences of automobile lifetime extension and fuel economy improvement: Japan's case	Kagawa, S. et al., 2008	Economic Systems Research
Does product lifetime extension increase our income at the expense of energy consumption?	Kagawa, S. et al., 2009a	Energy Economics
Inter-industry analysis, consumption structure, and the household waste production structure	Kagawa, S., 2005	Economic Systems Research
Estimation of embodied CO2 emissions by general equilibrium model	Kainuma, M. et al., 2000	European Journal of Operational Research
The potential economic and environmental impact of a Public Benefit Fund in Louisiana	Kaiser, M.J. et al., 2004	Energy Policy
Economic, energy, and environmental impact of the Louisiana Energy Fund	Kaiser, M.J. et al., 2005	Energy Policy
Foreign trade and declining pollution in Sweden: a decomposition analysis of long-term structural and technological effects	Kander, A. and Lindmark, M., 2006	Energy Policy
An input-output analysis of Australian energy planning issues	Karunaratne, N.D., 1981	Energy Economics
Relating the environmental impact of consumption to household expenditures: An input-output analysis	Kerkhof, A.C. et al., 2009a	Ecological Economics

Determinants of variation in household CO2 emissions between and within countries	Kerkhof, A.C. et al., 2009b	Energy Policy
The Netherlands' NAMEA; presentation, usage and future extensions	Keuning, S.J. et al., 1999	Structural Change and Economic Dynamics
Changes in consumption patterns and environmental degradation in Korea	Kim, J.-H., 2002	Structural Change and Economic Dynamics
Measuring the environmental load of household consumption using some methods based on input-output energy analysis: A comparison of methods and a discussion of results	Kok, R. et al., 2006	Energy Policy
Waste input-output linear programming model with its application to eco-efficiency analysis	Kondo, Y. and Nakamura, S., 2005	Economic Systems Research
CO2 emissions in Japan: influences of imports and exports	Kondo, Y. et al., 1998	Applied Energy
Input-output analysis of material flows with application to iron, steel and zinc	Konijn, P. et al., 1997	Structural Change and Economic Dynamics
Urban sustainability technology evaluation in a distributed object-based modeling environment	Kraines, S.B. and Wallace, D.R., 2003	Computers, Environment and Urban Systems
Greenhouse gas emissions related to Dutch food consumption	Kramer, K.J. et al., 1999	Energy Policy
Impact of carbon dioxide emissions reduction on the Austrian economy	Kratena, K. and Schleicher, S., 1999	Economic Systems Research
'Ecological value added' in an integrated ecosystem-economy model - An indicator for sustainability	Kratena, K., 2004	Ecological Economics
From ecological footprint to ecological rent: An economic indicator for resource constraints	Kratena, K., 2008	Ecological Economics
The impact of demographic change on energy use and greenhouse gas emissions in Germany	Kronenberg, T., 2009	Ecological Economics
Economic dynamics in a simple model with exhaustible resources and a given real wage rate	Kurz, H.D. and Salvadori, N., 2000	Structural Change and Economic Dynamics
Estimation and control of Spanish energy-related CO2 emissions: An input-output approach	Labandeira, X. and Labeaga, J.M., 2002	Energy Policy
Applying an integrated natural resource accounts and input-output model to development planning in Indonesia	Lange, G.-M., 1998	Economic Systems Research
Structural decomposition of CO2 emissions from Taiwan's petrochemical industries	Lee, C.F. and Lin, S.J., 2001	Energy Policy
Devising an integrated methodology for analyzing energy use and CO2 emissions from Taiwan's petrochemical industries	Lee, C.F. et al., 2001	Journal of Environmental Management
Effects of carbon taxes on different industries by fuzzy goal programming: A case study of the petrochemical-related industries, Taiwan	Lee, C.F. et al., 2007	Energy Policy
Truncation error in embodied energy analyses of basic iron and steel products	Lenzen, M. and Dey, C.J., 2000	Energy
Economic, energy and greenhouse emissions impacts of some consumer choice, technology and government outlay options	Lenzen, M. and Dey, C.J., 2002	Energy Economics
An input-output analysis of Australian water usage	Lenzen, M. and Foran, B., 2001	Water Policy
Energy and CO2 life-cycle analyses of wind turbines-review and applications	Lenzen, M. and Munksgaard, J., 2002	Renewable Energy
A modified ecological footprint method and its application to Australia	Lenzen, M. and Murray, S.A., 2001	Ecological Economics
Environmental and social accounting for Brazil	Lenzen, M. and Schaeffer, R., 2004a	Environmental and Resource Economics
Interrelational income distribution in Brazil	Lenzen, M. and Schaeffer, R., 2004b	Developing Economics
Embodied energy in buildings: Wood versus concrete - Reply to Bo□rjesson and Gustavsson	Lenzen, M. and Treloar, G.J., 2002	Energy Policy
Differential convergence of life-cycle inventories toward upstream production layers: Implications for life-cycle assessment	Lenzen, M. and Treloar, G.J., 2003	Journal of Industrial Ecology
Wind turbines in Brazil and Germany: An example of geographical variability in life-cycle assessment	Lenzen, M. and Wachsmann, U., 2004	Applied Energy
Environmental impact assessment including indirect effects - A case study using input-output analysis	Lenzen, M. et al., 2003	Environmental Impact Assessment Review
CO2 multipliers in multi-region input-output models	Lenzen, M. et al., 2004a	Economic Systems

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Energy requirements of Sydney households	Lenzen, M. et al., 2004b	Ecological Economics
A comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India and Japan	Lenzen, M. et al., 2006	Energy
Shared producer and consumer responsibility - Theory and practice	Lenzen, M. et al., 2007	Ecological Economics
Primary energy and greenhouse gases embodied in Australian final consumption: an input-output analysis	Lenzen, M., 1998a	Energy Policy
Energy and greenhouse gas cost of living for Australia during 1993/94	Lenzen, M., 1998b	Energy
Total requirements of energy and greenhouse gases for Australian transport	Lenzen, M., 1999a	Transportation Research Part D: Transport and Environment
Greenhouse gas analysis of solar-thermal electricity generation	Lenzen, M., 1999b	Solar Energy
Errors in conventional and input-output-based life-cycle inventories	Lenzen, M., 2001a	Journal of Industrial Ecology
A generalized input-output multiplier calculus for Australia	Lenzen, M., 2001b	Economic Systems Research
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