Tools and indicators to assess consumption patterns

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ABSTRACT
A systematic approach towards lowering the environmental load from private consumption can only be attained when the impacts of the policy can be monitored. As an example the development of such a monitoring system developed by and for the Dutch government is presented. Some results are discussed.
An important innovation is the use of linked input output tables that cover the world wide trade and economy. This dataset is also implemented in an LCA tool, allowing researchers detailed analysis of for instance the distribution of environmental load over world regions. Another application is to apply this framework as a tool for designers. The paper explores some ideas on ways designers can be involved to manage impacts from consumption.

THE EFFECTIVENESS OF ECODESIGN
Since the early nineties the concept of ecodesign was embraced as an important approach to decrease the environmental load of products. The focus of ecodesign is to lower the environmental load all through the lifecycle of the product. An important assumption was that the load should be lowered per unit of function fulfillment. For instance, an environmentally sound car is thought to be a car that pollutes less per kilometer, an environmentally sound light source is an energy efficient light source. Although this seems a logical viewpoint, it misses an important point: improved product performance will often result in a change in consumer behavior. An energy efficient car is a perfect second car for the family, and why not light your garden with the new lamps. In other words, the often claimed win-win situation (lower cost and lower load) can have an important unexpected side effect, through the consumer behavior.

WHAT LIMITS THE ENVIRONMENTAL LOAD OF CONSUMPTION?
When we do not look at products per functional unit, but on a macro level, we can understand that in fact there are just a few factors that limit environmental load of consumption:

1. The cost of products set an important limit on consumption. In general consumers have a more or less fixed income, that increases a few percent per year. If inflation is lower than income increase, this means they can afford more products if products become cheaper to buy or use (the fuel efficient car), it means they can purchase or use more products.

2. The time consumers can spend is limited, in many cases, for instance when choosing between the use of a private car and public transport, time is a decisive factor. Time is also an important limiting factor for the holiday industries
3. Volume. Many people have a limited storage space. This is an important factor when deciding for a second car, but also favors the use of compact products, and is a motivation to rent, in stead of purchase tools.

Of these three factors, probably the most important and fundamental is the cost factor. This means that if we want to limit the environmental load by consumption we need to address the ratio between environmental load and value, and manage a transition from low value high polluting products to high value, low load products.

THE ENVIRONMENTAL LOAD PER UNIT OF VALUE IN ECONOMIC SECTORS.

In earlier research [2]we developed eco-indicators per unit of value added in the major industrial and service sectors in the Dutch economy (base year 1993). Added value is defined here as the difference between sales and purchases of the sector. Figure 1 provides an overview of the results with a few sectors highlighted.

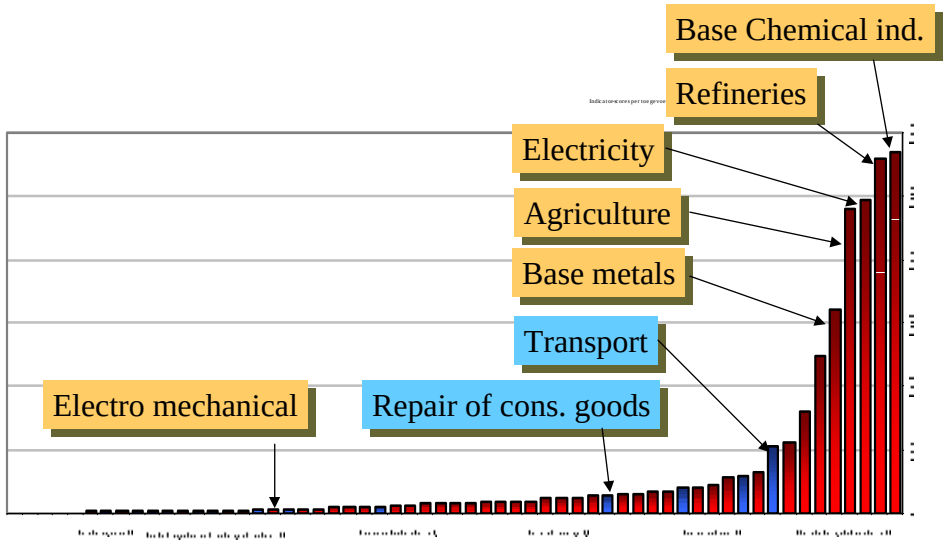

Figure 1 The environmental load from 63 economic sectors (expressed as Eco-indicator 99 points) divided by the value generated by a sector in the Netherlands. The blue columns represent service sectors, the red columns represent industrial sectors. A few sectors have been labeled as example.

Clearly the bulk industry sectors create relatively high load per unit of value. This is of course not really surprising. A little more surprising is the observation that service sectors do not always perform better than industrial sectors. For instance the repair of consumer goods is a relatively poorly performing sector, mostly due to the intensive use of small delivery vans.

The ratio is not the only important factor, also the magnitude of the activity is important. Figure 2 provides an alternative presentation, using the E2 vector [2], to plot the environmental load against the added value. The slope of the vector indicates the ratio, the length indicates the magnitude of the sector.

In this representation we se that there are just a few sectors responsible for the high added value or environmental load. Service sectors seem to add much value and low environmental load.

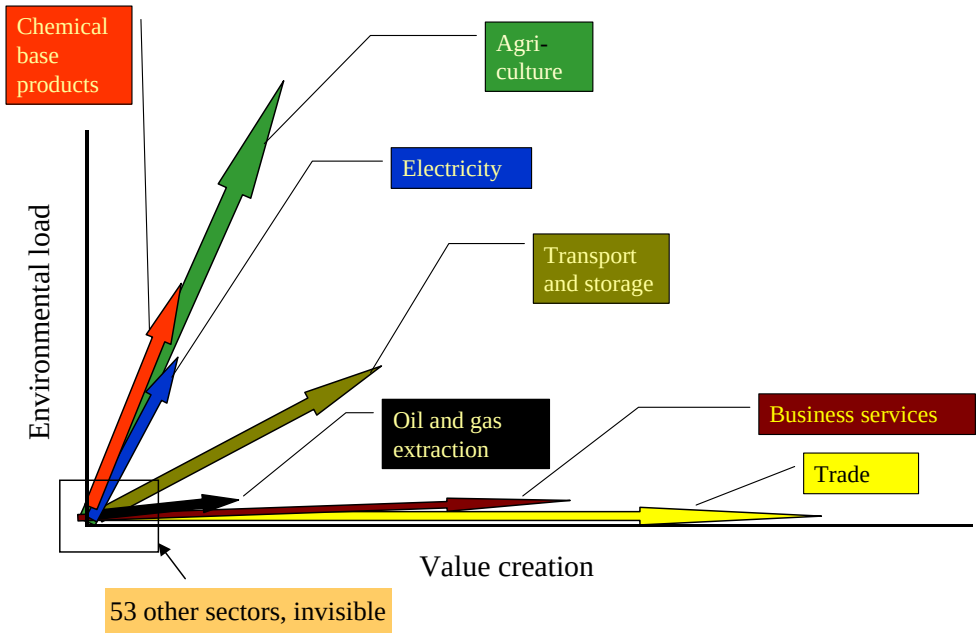

Figure 2: the environmental load plotted against the value creation, using the E2 vectors. The slope of the vector represents the ration between load and value, the length represents the magnitude. For sustainable economic growth the steepness of the vectors should decline, or the flat vectors should grow

Of course this representation can also be misleading, the apparently very favorable service sectors use much of the unfavorable sectors, such as electricity. In fact it is more useful to follow the whole chain throughout the economy, by linking sales and purchases, and carrying the environmental load per transaction with it. In this way we can perform a so-termed environmental input output analysis.

DATA COLLECTION THROUGH INPUT-OUTPUT

Each economy has an economic input output table, that specifies the value of the purchases between sectors within the country and abroad (the imports), as well as the supplies to other sectors and the exports. Furthermore all other major costs and revenues are specified.
These tables have been used by several LCA experts to compile input output (I/O) databases; see [1] for a general overview. Environmental data per sector is divided by the added value, resulting in an environmental load per unit of value. These ratio's can be used to link the environmental load to all supplies through the economy, enabling us to get a total environmental load of the outputs of all sectors.

Towards a system of interconnected IO tables that span the world

A yet unsolved problem is how to deal with imports and exports. Traditionally LCA practitioners that used IO datasets have used the assumption that the environmental load per unit of added value for imports and exports are identical [1]. An apple in Europe has the same load as an apple in the USA. However, it is clear that there are some problems in assuming that the environmental load connected to an agricultural product produced in the EU has the same load as a product produced in developing countries. Some research indicates that, especially for trade with non OECD countries, the environmental load per unit of value is an order of magnitude higher compared to production in OECD countries [2]

In a large economy such as the USA, the lack of specific data for imports may not be too relevant for most sectors, but when smaller, and more trade oriented economies are analyzed this may lead to significant distortions. This paper describes how we can link a national IO table to a set of three

international IO tables that span the world economy. We believe that this approach can be generalized, so that other researchers can add their own National IO table.

The environmental load from consumption

The dataset presented here is the result of a project commissioned by the Dutch government. The project originates from the desire to be able to trace the impacts of its policy on the environmental load of private consumption on a national level. For that purpose, a system has been developed that links consumer expenditure to the environmental load it creates. The intention is to update the system every 5 years and to monitor the trends.

DIRECT AND INDIRECT ENVIRONMENTAL LOAD

It is important to distinguish between direct and indirect environmental load caused by consumption.

- The direct environmental load is defined as the load that occurs after a product or service has been purchased by the consumer. IO databases cannot cover such load, they trace economic flows up to the point the consumer purchases the product.
- The indirect environmental load is the load that occurs before the product or service has been purchased. Basically this is the load produced by economic activities. This load can assessed in IO databases

This distinction can be clarified with a simple example. When the consumer purchases paint to decorate his own house, the *indirect* environmental load is the load associated with the production of the paint, the packaging and the distribution, The *direct* environmental load is the load that comes from the emission of solvents. The direct environmental load is *not* the same as the imp[acts from using products (often called the “use phase” in Ecodesign or LCA). For instance electricity consumption is regarded as indirect, the consumer purchases the electricity. Similarly, the production of fuels for a private car is regarded as indirect load but the exhaust gasses from the car is regarded as direct environmental load.

This distinction seems slightly artificial, it is however very useful, as the indirect environmental load can be well covered with environmental input output tables

Consumption patterns

In most countries a detailed analysis of consumer expenditure is available. Such a statistic specifies average expenditure by consumers over a large range of products and services. For this project we used the data from the Central bureau of Statistics [3] on expenditure over 350 products and services. Some products occur several times in the list. For instance car use for recreation and car use for shopping are kept separate.

The products and services can be analyzed for the direct environmental load. To determine the indirect environmental load a link was made to 105 industrial sectors as defined in the Dutch economic input output table. As we will see these Dutch sectors are also linked to input output tables in other parts of the world.

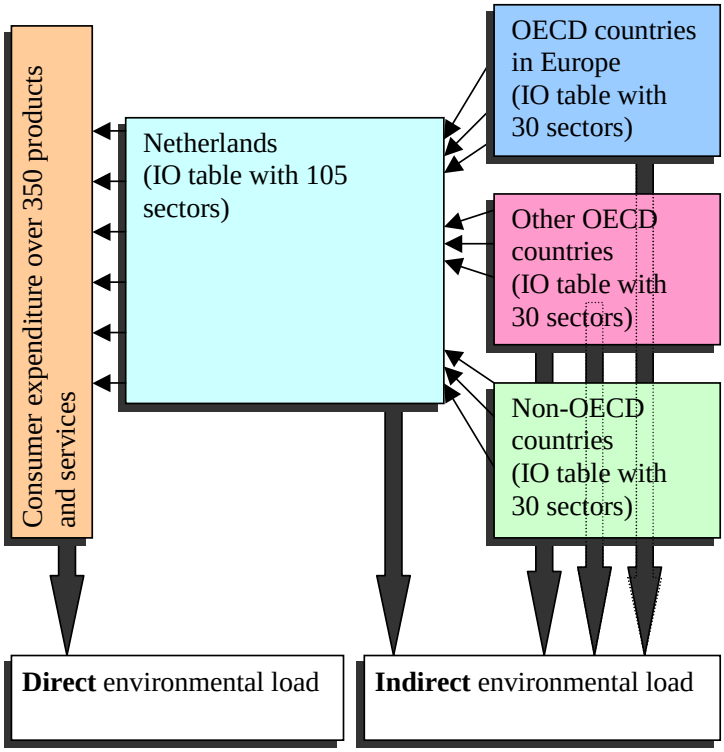

Fig. 3 Overview of the financial flows throughout the economies to the Dutch consumption pattern.

Selection of environmental stressors

The Dutch government specified a list of 20 elementary flows or "stressors". These are:

- Emissions of CO2, CO, CH4, NOx, SOx, N2O, HFC's/ HCFC's, non methane VOC, benzene, PAHs, heavy metals, nitrogen, phosphate, PM10 (dust),
- Land use, water consumption, wood use, fish extraction, use of pesticides.
- Truck, Car and Moped kilometers, especially to assess the nuisance caused by noise

Direct environmental load

The 350 products and services have been screened to determine if they result in any direct environmental load. About 20% of these have a direct environmental load. LCA databases and other sources are used to determine the direct environmental load. An analysis showed that the major contributions to the direct environmental load are associated with (top 4 only, in descending order):

- Car driving for work and recreation
- Wood and Coal, used in fireplaces and old stoves
- Heating
- Cleaning

Of course this ranking also depends on weighting across impact categories, here equal weights were used of all elementary flows (emissions, resource use etc.)

Indirect environmental load in the Netherlands

The Dutch input output matrix has 105 sectors. The National "emission registry" system maintains a detailed data inventory for industrial activities. This database has been used to run queries that produce datasheets per sector. Significant amounts of work were needed to convert the data to a

format that is consistent with the definition of the stressors and the sectors. For a number of stressors, such as land use, other data sources needed to be used.

Indirect load outside the Netherlands

The "rest of the world" is split up into three regions:

- OECD countries in Europe
- Other OECD countries
- Non OECD countries

For each of these regions, thirty sectors were defined that were taken from the DIMITRI [4] and EDGAR [5] database. These databases already have data on Energy use, CO2, NOx and SOx per country and per sector, so it is relatively easy to create datasets for these stressors per region. To cover the other stressors a wide range of sources has been consulted. In order to focus the efforts, an analysis was made using the GTAP [6] database to identify which countries or regions contribute most to an industrial activity. The focus was to find data for these countries and regions first, and extrapolate this data over the whole region. Of course the data collection was not complete, and often extrapolations have had an important influence.

SOME RESULTS

The results of the procedures described above can be summarized in a few graphs. First we analyze the relative share of the different "consumption domains" to a selected set of impact category indicators. A domain is defined as a group of purchases. Instead of the individual emission an aggregation has been made, mostly using the CML 2001 impact assessment method [7].
Figure 5 shows that for most impact categories food plays a dominant role in the consumption patterns. Recreation and working expenditure are quite heavily dominated by expenditure on car transport. This shows that the use of cars is also an important contribution to the load.

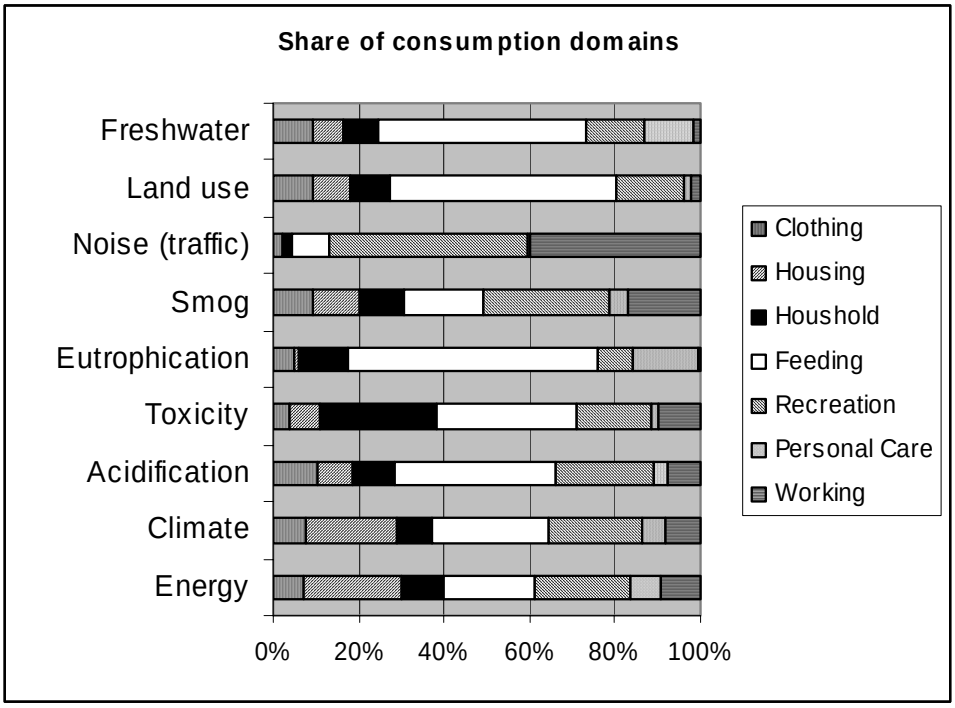

Fig. 5 Share of the consumption domains over the environmental impact categories (direct and indirect, all regions)

Another result is the analysis of the direct versus the indirect environmental load. This shows that especially road noise is associated with direct environmental load. This is partly a distortion due to the fact that truck kilometers and car kilometers are considered to have the same impact. Indirect load is dominant in most other impact categories.

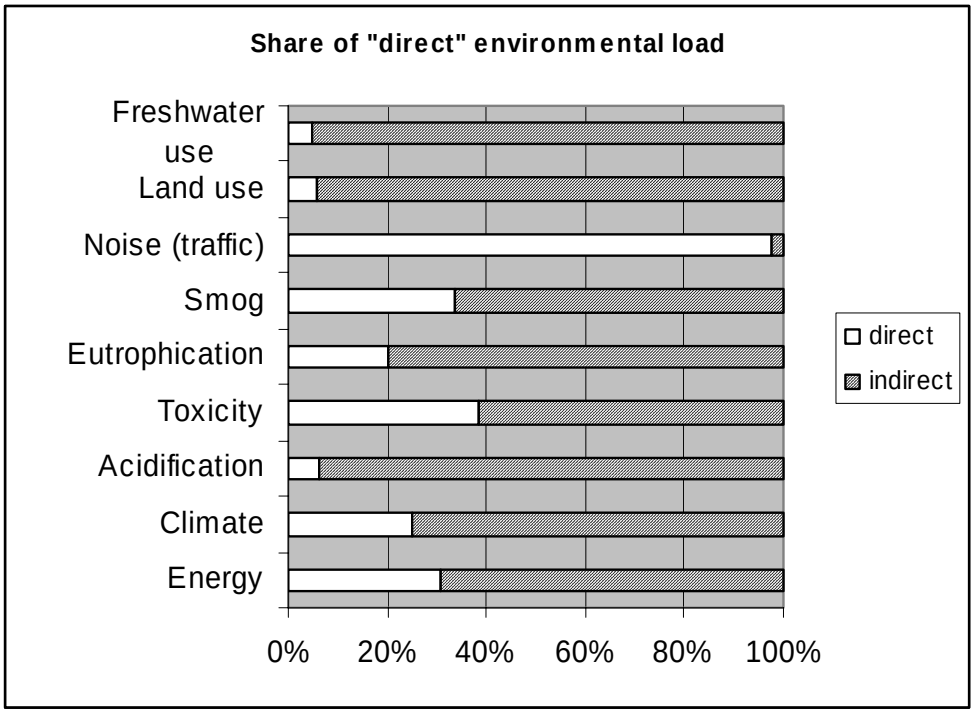

Fig. 6 Share of the "direct" environmental load, caused by the consumer, in relation to the indirect load that is caused by economic activities (all regions).

Another view is obtained when we analyze the relative contribution of the load from the regions. Here we can see that the Non OECD have a relatively high contribution, especially in land-use and acidification. This is remarkable, as the value of the imports of this region is relatively modest. The Netherlands get 66% of the imports from Europe and only 17% from the Non OECD countries. The contribution of toxic emissions within the Netherlands is remarkably high. One explanation is that the share of direct consumption of household (which occurs always in the Netherlands) is high for toxicity.

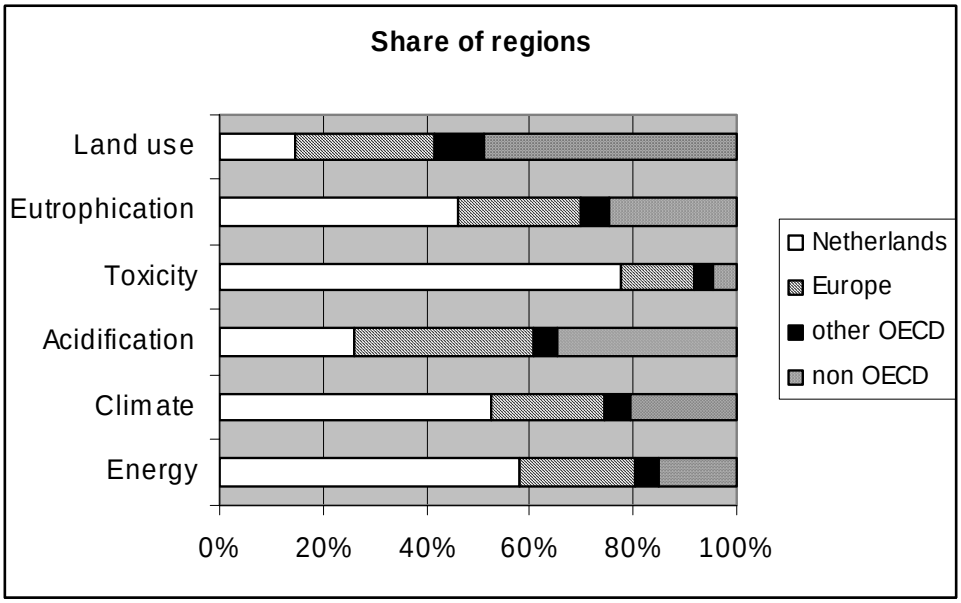

Fig.7 Share of the regions tot the environmental load (direct and indirect)

These results allow us to get an insight into the dominant and less dominant issues related to private consumption. For instance it seems that many LCA studies are focusing on products within the household consumption domain, while this study shows that this is not an important domain. There are other consumption domains that are much more important to focus on. Especially the environmental load related to the food production chain seems to deserve more attention.

IMPLICATIONS OF THE MONITORING SYSTEM

As the monitoring system has now just been started, we cannot present any trends yet. However in a few years when a second assessment will be made it will become quite clear what the trends of all efforts directed towards improving eco-efficiency are.
The system as it is now, already shows some very interesting results, like:

- The relatively high contribution of the direct environmental load in some impact categories; the load caused by consumers after obtaining a product is remarkable. It should be noted that direct environmental load is not the same as the use phase; important loadings from electricity use due to the use of products is considered indirect load.
- A relatively high contribution of the consumption domains Feeding and Housing, as well as recreation.
- The relatively high land use in Non OECD countries needed for the Dutch consumption

The system developed, shows the power of using the eco-efficiency ratio (value against load) to make assessments on the societal level. In stead of analyzing the environmental load per function performed by the product, we analyze the environmental load per added value, and as value addition is the main function of an economy, we have an analysis of the functionality of the economy.
An important implication is that governments can in fact try to influence consumption domains by developing policies that can address the issues that require priority. Another implication is that government can look at sectors it wants to stimulate or discourage. Finally the system can be used to assess trade between economic blocks, and more specifically trade with non OECD regions. Companies should be well aware that with such tools governments can focus their product policy more efficiently.

THE CPA TOOL (CONSUMPTION PATTERN ANALYSIS)

The dataset described above is also implemented in the SimaPro LCA tool. This allows for further analysis and the use of commonly accepted impact assessment methods. An example of the potential is given below where we took the example of meat, produced in the Netherlands.
The example shows for instance that the Non OECD sector play a relatively important role, while the value of the goods delivered is not so high.

The use of such dataset opens new possibilities, and in fact provides the basis for a new tool that we would like to cal Consumption Pattern Assessment, or CPA. LCA was of course primary used to assess products and provide designers assistance in recognizing environmentally preferable design alternatives. The CPA tool can be used to assess consumption patters. One can compare different lifestyles, one can even try to assess the impact of providing products that do influence lifestyles.

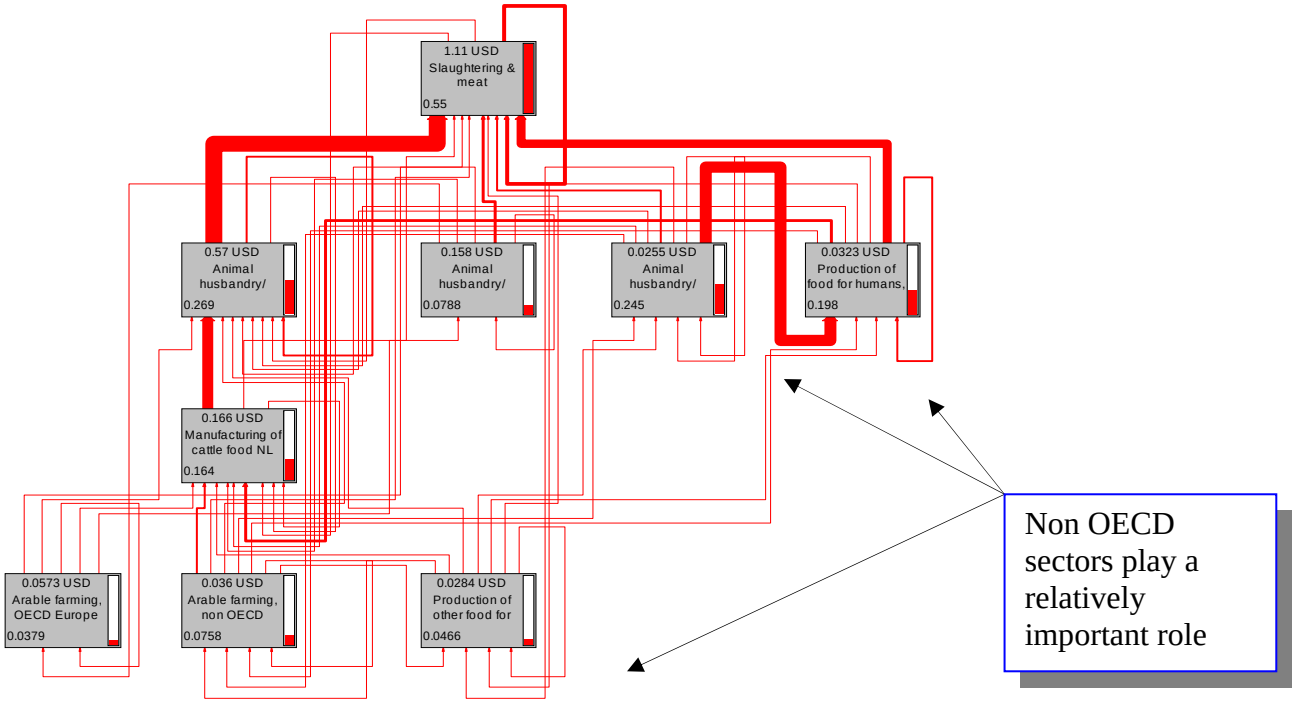

Fig.8 Analysis of the Slaughtering sector. Only the sectors with the highest contribution to the total environmental load (Eco-indicator99) are represented. The line thickness also indicates the environmental load

RESEARCH QUESTIONS AND RECOMMENDATIONS:

This paper attempts to explore new directions for a better understanding of sustainable consumption. We would like to conclude with some recommendations:

1. We have shown it is possible to develop a monitoring system to study the trends in the environmental load of consumption. Currently a Danish system is developed that will use the same principles (and partially the same data), but will also explore the use of dynamic, or marginal analysis. We believe it is very useful to extend the scope from countries to continents, or even the world
2. The Consumption Pattern Assessment tool should be further developed
3. We should explore possibilities to provide tools to designers that take into account the consumption pattern dynamics

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