PAPER

Special session: IO's role in covering environmental policy needs

How can an input-output model support local environmental policy? Opportunities, limitations and challenges

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1 Introduction

Historically, environmental policy was mainly focused on local problems (e.g. oil spills, polluted streams, air pollution by a factory, etc.), which could be looked at from a **territorial perspective** only. However, the current environmental challenges are often global. Nevertheless, the focus of most policies remains unchanged. How can we reduce the greenhouse gas emissions within our borders? How can we improve the resource efficiency of our businesses? It is necessary for local environmental policy to adapt to global challenges, like climate change and resource scarcity.

In 2017, the total worldwide extraction of raw materials amounted to more than 90 billion tons (IRP, 2019). From 2010 until 2017, the amount of raw materials extracted increased by about 20% and is expected to double again by 2050. The global extraction per capita increased from 11.0 tons per capita in 2010 to 12.1 tons per capita in 2017 (own calculation based on IRP, 2019 & UN, 2019). Material extraction greatly affects the environment. The extraction and processing of natural resources, the production of goods/services and the recovery of materials amounts to a big share of the greenhouse gas emissions. According to the OECD (2012), 50 to 65% of the greenhouse gas emissions within Mexico, Germany, Slovenia and Australia originate from material management activities (production of goods and fuels, transport of goods, food production/storage and waste management). European countries have focused on improving the resource efficiency within their economy, from a territorial perspective. However, more international trade enables the exchange between production facilities in other countries with lower resource efficiency (Wood et. al, 2018).

As such, the risk exists that more and more pressure on the climate and environment overall will be outsourced abroad to fulfil our needs. To highlight this issue, environmental impact should also be looked at from a **consumption perspective**. The material and carbon footprint of the consumption takes into account the impacts in the upstream supply chains and trade.

The Public Waste Agency of Flanders (OVAM) and the Flanders Environment Agency (VMM) commissioned the Flemish Institute for Technological Research (VITO) and the Federal Planning Bureau to develop the Flemish Environmentally Extended Input-Output model (EE-IO model), which is embedded in the multiregional EXIOBASE 2 IO model. This model was developed to determine the carbon and material footprint of the Flemish consumption. A better understanding of the material and carbon footprint of Flemish consumption is important when deciding on policy actions to enhance consumer and producer behaviour.

Together with VITO, OVAM is currently using the EE-IO model to better understand and measure the global and local effects of circular economy strategies. What does a circular economy mean for Flanders and what are the effects worldwide and within Flanders? What are good indicators to follow-up the transition to a circular economy? This paper describes some of the results of the Flemish EE-IO model, the opportunities, challenges and limitations in supporting local policy.

The Public Waste Agency of Flanders (OVAM) is dedicated to close material loops and dematerialise production and consumption from within Flanders. This change is a necessity due to various challenges: the scarcity of natural resources, the environmental impact of our current use of materials and the demand for new employment.

2 Methods

The Flemish EE-IO model was developed and improved between the period 2007-2012 by VITO and the Federal Planning Bureau. The first versions of the model were developed based on 2003 and 2007 data. Since 2017, the last model for 2010 is available.

The Flemish EE-IO model consists of a local input-output table for the region of Flanders, which is linked to multi-region input-output tables covering the rest of the global economy. The method describing the linking of a regional database to a world model is described in Christis et al. (2016). By combining a local input-output model and a multi-region input-output model, the analysis is based on the available local data, adapted to the local economic characteristics, and includes global sectoral data. A detailed description (in Dutch) of the Flemish EE-IO model for 2010 is found in Vercalsteren et al. (2017), commissioned by VMM. The IO models used are:

- The Flemish regional IO tables (data 2010) compiled by the Federal Planning Bureau (Federal Planning Bureau, 2016). The monetary tables contain an inter-industry matrix, a final demand matrix, and a value added matrix for 124 sectors. The environmental extension data for the region of Flanders is gathered from the regional and federal authorities and includes greenhouse gas emissions and resource extraction (biomass, metals, non-metallic minerals and fossil energy carriers). Expenditures by households are subdivided based on the COICOP-nomenclature (Classification of Individual Consumption According to Purpose) into 69 consumption categories and 12 consumption domains. Expenditure accounts for Flanders are gathered from the Household Budget Survey (HBS) (Statbel, 2017). This dataset provides revenues, expenses and assets (in EUR) per capita, per household and totals for the Flanders Region.
- Exiobase version 2 (2007 data, industry-by-industry tables) is a global EE-MRIO database for 163 sectors in 43 countries & 5 regions produced in the context of the project 'Compiling and Refining of Economic and Environmental Accounts' (CREEA) (Wood et al. 2015).

Recently, VITO has also used Exiobase version 3 (2010 data) (Stadler et. al 2018) as the world model. However, the results presented here are based on the Flemish regional EE IO model linked to Exiobase version 2, if not stated otherwise.

The carbon and material footprint of the Flemish consumption refers to the greenhouse gas emissions and the extraction of raw materials, respectively, associated with the Flemish final consumption. The final consumption consists of the final consumption by Flemish households and governments, investments by Flemish households, governments and companies and stock changes. For open economies, footprints are determined both by local and global specific characteristics. The Flemish EE-IO model doesn't only allow calculating the environmental footprint of the Flemish consumption, but also mapping the geographical allocation of the environmental pressure throughout the entire production chain and comparing the geographical distribution of the created employment and added value.

3 Results

The carbon footprint is discussed in detail by Vercalsteren et al. (2017) (in Dutch, with an English summary). In the paper, the following results are presented:

- The relationship between the carbon footprint and the material footprint;
- The allocation of the environmental impact of the Flemish household consumption to different consumption domains;
- How dependent Flanders is on the rest of the world for its consumption;
- One example of how a circular economy strategy and its impacts can be modelled with the Flemish EE IO model.

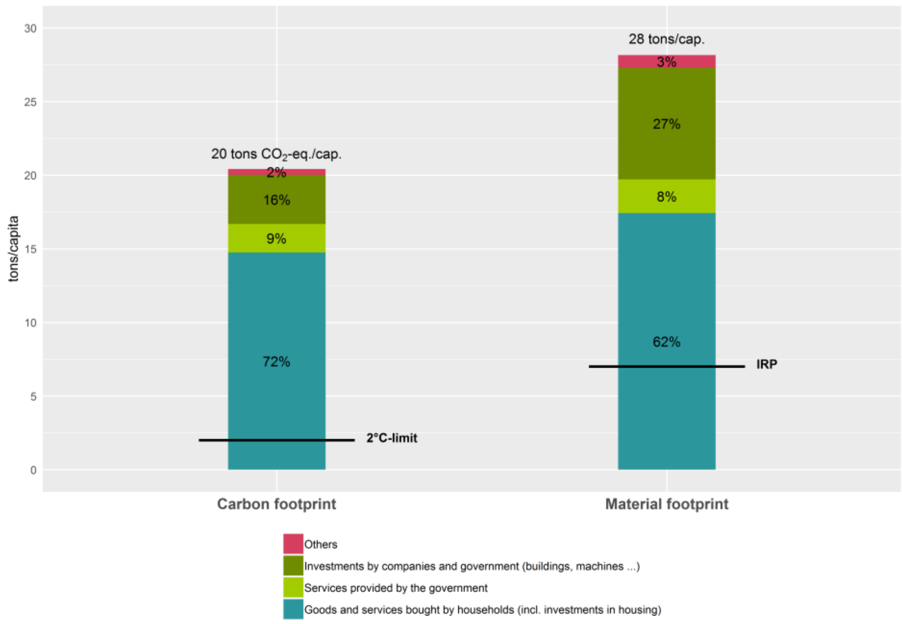

Figure 1 – Carbon and material footprint of the total Flemish consumption (data 2010)

In 2010, the carbon footprint of the Flemish consumption amounted to 20 tons CO_2-eq. per capita. Almost three quarters of the carbon footprint is linked to the goods and service bought by households. About 20% of carbon footprint from Flemish households occurs in the use-phase (heating & transport). The other 80% of the emissions occurs during the production and transport of consumed goods and services.

The material footprint of the Flemish consumptions amounts to 28 tons per capita in 2010. As for the carbon footprint, most of the material footprint is linked to the goods and service bought by households. Based on the global data on resource extraction (IRP, 2019) and the population data (UN, 2019), the Flemish consumption was responsible for only 0.23% of the global extraction of the resources. However, the population of Flanders is only 0.09% of the global population. The mass composition of the material footprint by the four major primary material groups is: 40% non-metallic minerals, 31% biomass, 21% fossil energy carriers and 8% metals.

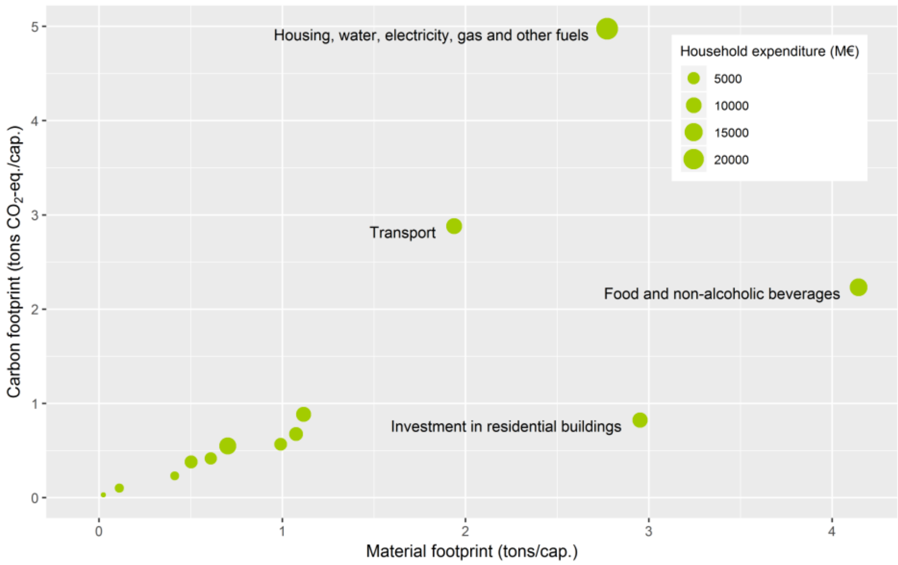

Figure 2 - Material and carbon footprints of household consumption in Flanders divided in 12 consumption domains (data 2010). Investments in household housing are no real household expenditures, as those payments are spread across multiple years via mortgage or rentals. The category is added to include the footprint of the construction of housing.

Three household consumption domains have both a high carbon and material footprint: housing, transport and food. Three quarters of the material footprint of goods and services bought by households is linked to these three types of consumption. The same consumption domains are responsible for 70% of the material footprint of household consumption.

There is a relatively strong correlation between the material footprint and the carbon footprint (Pearson correlation coefficient = 0.6825). The high correlation can be partly explained by the use of primary fossil energy carriers.

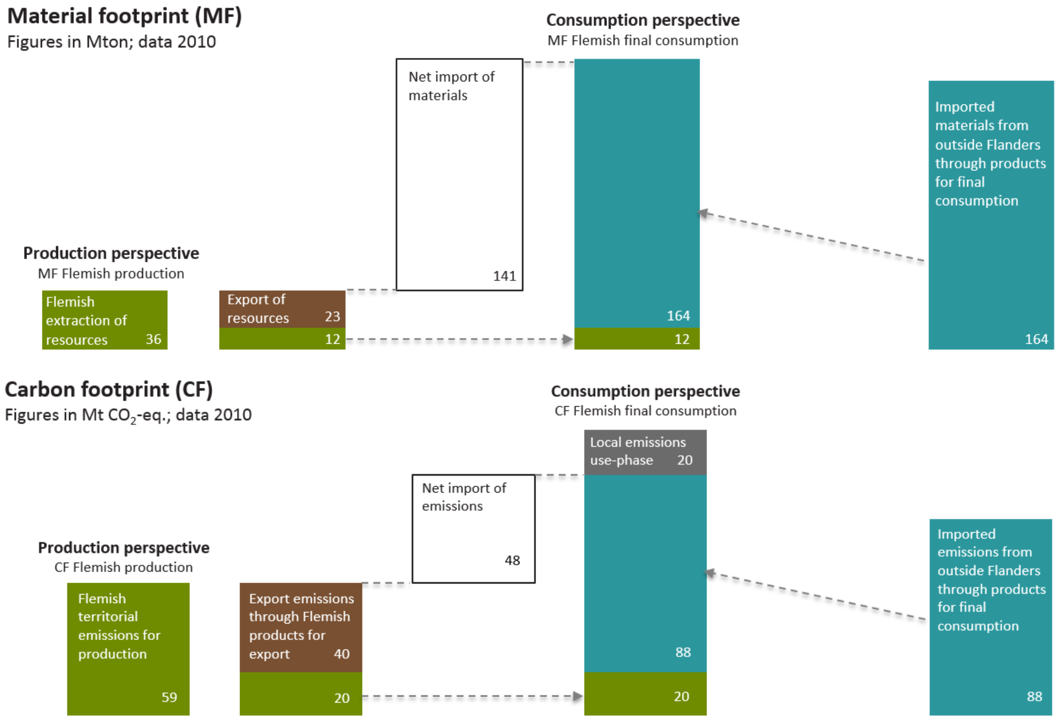

Figure 3 – Greenhouse gas emissions and material extraction; the production perspective and the consumption perspective for the region of Flanders

In 2010, the Flemish consumption had a material footprint of 176 million tons or 28 tons per capita. 164 million tons or 93% of the materials were extracted outside of the Flanders region. Within Flanders, 36 million ton of primary materials were extracted. Only 12 million of the materials extracted in Flanders ended up in products and services consumed by Flanders. The other 23 million ton was exported outside of Flanders through products for export and direct export. The material footprint from the consumption perspective was 5 times bigger than from the production perspective.

Similarly, the greenhouse gas emissions for Flemish consumption mainly occur outside of Flanders (69%). As such, Flanders is a net importer of greenhouse gas emission and resource extraction through its consumption.

VITO developed at tool visualising the material footprint of the goods and services bought by households on a world map (in Dutch): https://public.tableau.com/shared/WX3FYBZ42?:display_count=yes.

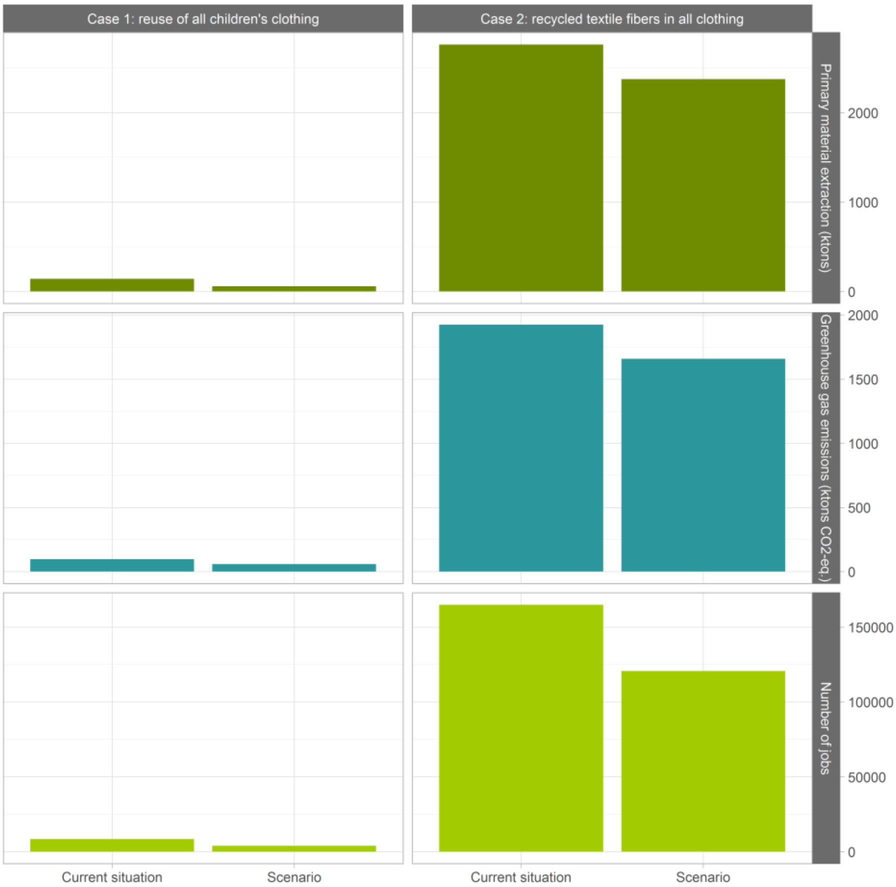

Figure 4 – The impact of 2 circular economy strategies for textile consumption on the materials footprint, the material footprint and jobs created: Case 1 – children's clothing 0-3y. in a leasing system & Case 2 – 56% recycled textile fibres in all clothing (Christis et al., 2018).

With the Flemish EE IO model, two different circular economy scenarios where modelled for the textile consumption by Flemish households. The first case looked at the impact of a leasing system for all children's clothing (0-3 year-olds). The second case looked at the impact of replacing 56% of the textile fibres with recycled textile fibres. The leasing system was modelled using an existing leasing sector in the EE IO model for consumer articles. The collection and recycling of textile was modelled by combining the EE IO model with an existing LCA analysis for recycled jeans. Since the scope of both cases is different (children's clothing vs. all clothing), the impact of both cases cannot be compared to each other.

If all children's clothing (0-3 year-olds) is leased in the region of Flanders, less clothing is necessary. As such, the worldwide emissions drop with about 39 kt CO_2-eq. or 40%. This equates to about 18,000 cars less on the road. The amount of primary resources drops with 84 kt or 60%. Worldwide employment for producing our children's clothing also decreases with about 4,500 jobs or 53%, mainly in the agricultural sector. However, within Flanders, the leasing of children's clothing creates jobs. As the leasing sector for children's clothing is located in Flanders, approximately 375 new jobs are created within the region. On the other hand, these leasing activities cause an additional greenhouse gas emission of 8 kt CO2 eq. within Flanders.

Similar effects are observed when replacing 56% of the textile fibres with recycled fibres. As such, less textile production is required due to recycling. The greenhouse gas emissions associated with our clothing consumption drops worldwide by 265 kt CO2 eq. or 14%. This corresponds to about 120,000 fewer cars on the road. The amount of primary raw materials needed drops by 386 kt per year or 14%. Worldwide employment for producing our clothing also declines, with about 44,000 jobs or 27%, mainly in the agricultural sector. However, locally the recycling of our clothing creates jobs. If the textile recycling sector was located in Europe, 2,400 new jobs in Europe would be created. However, these recycling activities do cause an additional greenhouse gas emission of 82 kt CO2 eq. within Europe.

4 Opportunities

Thanks to the results of the EE IO modelling, Flanders is starting to widen its scope of policy making towards a consumer perspective. By 2021, the Circular Economy Policy Research Centre (SuMMa)[1] is set to develop a monitoring dashboard of the circular economy for the region of Flanders. The key roles in this tool will be played by the carbon and material footprint of Flemish consumption. The SuMMa has already provided a conceptual framework for this CE monitor (Alaerts et al. 2019), which focuses on the consumption domains with a high material and carbon footprint (**Figure 2**): food, housing and transport.

A policy goal for the carbon and material footprint of the Flemish consumption is to clarify the challenges of the transition towards a circular economy. To limit the average global temperature rise to 2° C, global greenhouse gas emissions must be reduced by 2050 to an average of 2 tons per capita. The Flemish carbon footprint is currently ten times higher. The UNEP International Resource Panel (IRP 2014) estimated the sustainable consumption of primary raw materials at around 7 tons per capita, and assumes equal access to primary raw materials for everyone in the world without further increasing the use of raw materials. Moreover, according to UNEP, the raw material consumption of within Flanders is a factor 4 higher than what is sustainable.

The results of the EE IO modelling have shown that the way we deal with materials determines a large proportion of the greenhouse gas emissions. Local policy should focus on strategies that have a positive effect on both carbon and material footprint of the local consumption. Consumption

[1] https://vlaanderen-circulair.be/en/summa-ce-centre

domains with a high carbon footprint also have a high material footprint (**Figure 2**). The two scenarios for textile consumption show that circular economy strategies don't only have a big impact on material extraction, but also on the greenhouse gas emissions (**Figure 3**).

These results also show that if only the environmental impact within Flanders is considered, the effects of the circular economy on the environment may seem negative. The environmental policy must widen its scope to a consumption perspective to evaluate the impact of its strategic choices. By also considering the impact of Flemish consumption outside of Flanders, the global environmental benefits of the circular economy are made explicit.

5 Limitations & challenges

In this section we will discuss some of the limitations and challenges we have experienced when using EE-IO modelling for our policy work. These limitations and challenges will be discussed at the IIOA conference.

VMM and OVAM are currently looking at developing a more recent EE IO model for the region of Flanders, for 2015. While developing a regional EE IO model, we have experienced a significant difference between the year for which the model is developed and the date at which the model is delivered. This **time delay** is due to several factors:

- The development of the IO tables (IOTs) at the Federal level of Belgium demands a great amount of work. EU Member States transmit to Eurostat supply and use tables annually and input-output tables every five years. In Belgium, the Federal Planning Bureau (FPB) is in charge of IOTs. The IOTs for 2015 were published by the FPB in December 2018.
- The development of interregional IOTs requires more work from the FPB. For this Federal institution, regional IOTs are not high on the priority list since they are not legally bound to deliver these tables. The update of the interregional IOTs for 2015 is planned in the course of 2020, based on the national IOTs.
- Only after the interregional IOTs are delivered, EE IO model for the region of Flanders for 2015 can be developed by adding the local environmental extension tables and by linking the model to a global EE-MRIO database.

Since the world economy doesn't change much over a few years, the carbon or material footprint of the Flemish consumption from a few years ago is still relevant at the moment. Nevertheless, the conclusions and scenario modelling with EE-IO may be perceived as outdated by politicians and the general public. As such, the model doesn't suit to monitor the active policy. The material footprint from a consumption perspective can also be calculated with an economy-wide material flow account (EW-MFA), which does allow for an annual follow-up and trend analysis. However, EW-MFA doesn't offer great insights in the structure of the economy. Therefore, scenario modelling is not feasible.

Another challenge of using an EE IO model is the **need for trained experts** to be able to do understand and use the model in the correct way. This also means that developing and preforming analyses with an EE IO model can require **large expenses**.

Recently, VITO has also linked the Flemish IO model to the recent global EE-MRIO Exiobase version 3 (2010 data). The preliminary results show that linking the new Exiobase3 model to the Flemish IO model has a big impact. The difference in carbon footprint between the two calculations is 24%. As shown by Giljum et al. (2019), the use of **different global MRIO** can have a **large impact** on the footprint calculation, creating a barrier for broad policy uptake. In addition, when using non-institutional research model, there is also the risk that the development of the model will be discontinued. From a policy point of view, there is a need for a robust institutional global IO model whose **continuity** ought to be insured.

Another limitation is the **level of detail for sectors/products** that are described in an EE IO model. When developing scenarios within the EE IO model, there is often a need for external data. Some highly important products/sectors for modelling a circular economy are not specified or not sufficiently detailed: waste products, secondary materials, recycling sectors, repair services, leasing services, etc. Further disaggregation of the sectors with focus on the CE strategies (leasing, repair, reuse, recovery, recycling, etc) is necessary.

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