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On the feasibility of a consumer-based allocation method in national GHG inventories

Dario Caro[a], Simone Bastianoni[a,*], Simone Borghesi[b], Federico Maria Pulselli[a]

[a] Department of Earth, Environmental and Physical Sciences, Ecodynamics Group, University of Siena, Pian dei Mantellini 44, 53100 Siena, Italy
[b] Department of Political and International Sciences, University of Siena, Via Mattioli 10, 53100 Siena, Italy

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ABSTRACT

The Intergovernmental Panel on Climate Change (IPCC) has defined a comprehensive method for taking into account greenhouse gases (GHGs) emissions released from different countries. The geographical or producer-based perspective currently used in the IPCC framework does not consider (and may therefore encourage) delocalization of production from industrialized to other countries, thus allocating responsibility for emissions associated with goods and services, consumed in one country but produced elsewhere, exclusively to the producer. The Environmentally Extended Input–Output (EEIO) analysis has long been recognized as a useful tool for attributing GHG emissions or resource use to final consumers in a consistent accounting framework. While it is clear that there are several advantages to using a consumer-based perspective with the EEIO analysis, questions regarding the implementation of this methodology have arisen, and its adoption in dealing with GHGs inventory has so far been limited. Here, we propose a formalization, in order to evaluate GHG emissions associated with goods and services that are traded internationally, based on a systemic approach that places the responsibility on consumer countries, and weighs imported and exported goods by applying national carbon intensity factors. The use of these aggregate indicators is appropriate to have a reference point for a worldwide application of this tool in order to implement policies for GHG emission reduction.

The Kyoto Protocol was an important step for the challenge of international climate change. However, it has brought about weak results for a number of reasons, including insufficient GHG reduction, application to a limited number of nations, pros and cons in the use of flexible mechanisms (see, for example, Barrett, 1998; Cooper, 2001; Prins and Rayner, 2007; Brook et al., 2007; den Elzen and Höhne, 2008). As a consequence, national economies, companies and single producers have often found solutions to limit their costs, to the detriment of the overall effectiveness of the protocol. One of these consequences, for example, has been the progressive delocalization of industrial activity in developing countries, which also depends on the way in which emission responsibility is assigned at the national level.

The debate on how to monitor greenhouse gases (GHGs) released from countries has become more and more relevant in recent years, and is focused on the implications of the producer- and consumer-based perspective on emissions allocation (Munksgaard and Pedersen, 2001; Peters and Hertwich, 2008a). The Intergovernmental Panel on Climate Change (IPCC) has defined a comprehensive method to standardize GHG inventories in order to account for GHGs released and absorbed in national systems (IPCC, 2006). The method adopts a geographical or producer-based perspective, which considers emissions produced within system boundaries. The IPCC method is widely used and provides punctual measures of GHG emissions at national level. However it shows an incomplete picture of the emissions that can be attributed to the economy (Ghertner and Fripp, 2007), and a real problem emerges for the allocation of emissions related to products involved in international trade (i.e. produced in one country but consumed elsewhere). In short, the geographical (i.e. producer) perspective implies that the countries where the finished products are actually consumed take no responsibility for the environmental impacts generated by the producer countries, thus ignoring the international trade effect (Bastianoni et al., 2004).

Consequently, the scientific community has focused on an alternative consumer-based perspective that could complement the geographical/producer-based one by including all driving forces for GHG emissions associated with consumption (consumer perspective) (Davis et al., 2011). In particular, several authors have highlighted the need to include an import-export evaluation in emission inventories focusing on the localization of emissions, especially those embodied in international trade (e.g. Bastianoni et al., 2004; Liu and Wang, 2009; Peters et al., 2012).

* Corresponding author. Tel.: +39 0577234358; fax: +39 0577232004.
E-mail addresses: simone.bastianoni@unisi.it, bastianoni@unisi.it (S. Bastianoni).

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In this regard, the Environmentally Extended Input–Output (EEIO) analysis has long been recognized as a useful tool for attributing GHG emissions or resource use to final demand (i.e. total consumptions by households, private and public national bodies and government) in a consistent accounting framework (Wiedmann, 2009). Consumer-based GHG profiles estimated with EEIO models include, in monetary terms, imports as process vectors responsible for GHG emissions, as well as the indirect emissions in the total supply chain, assigning these to each consumer country as they directly solicit the production of imported goods and services.

While it is clear that there are several advantages to using a consumer-based perspective with the EEIO analysis (Peters and Hertwich, 2006), some questions arise concerning the feasibility of the actual implementation of this methodology. Although the EEIO framework has been approved within the scientific community as an alternative to the IPCC inventory, Lenzen et al. (2012) have highlighted that its adoption when dealing with GHGs inventory in international agreements has so far been limited by a number of implementation issues: EEIO models are labor-intensive; EEIO tables do not cover the entire world and are not always available as a long, continuous time series; currently, EEIO databases only provide results, without accompanying estimates of reliability and uncertainty.

Recent contributions, either at the level of policy support or basic research, have attempted to overcome these methodological weaknesses and divergences with the development of international data gathering guidelines and IO manuals (e.g., Eurostat, 2008) as well as multi-regional input output (MRIO) databases (Davis and Caldeira, 2010). The recent multi-regional EEIO database called "Exiobase", for example, proves to be at the cutting-edge in the reduction of data uncertainty (Tukker et al., 2009). Nevertheless, the implementation of the EEIO accounting framework has not yet been adopted in international agreements. In light of this situation, there is an urgent need to bridge the gap between the producer and consumer perspective, in order to stimulate efforts toward a consumer-based accounting that, as stated by several authors (Li and Hewitt, 2008; Peters and Hertwich, 2008b; Wei et al., 2011), will contribute to an actual reduction of global GHG emissions, if all countries are involved in the process.

We believe that the achievement of an overall national (rather than sectorial) emission re-allocation is a suitable way to trigger a first step toward a consumer-based perspective and highlight the actual responsibility of economic behavior and policy. We need to make assumptions in order to simplify and make calculations and aggregations feasible. Here we propose a formalization in order to evaluate GHG emissions associated with goods and services traded internationally, adopting a systems approach based on a consumer perspective.

The responsibility R_i of the GHG emissions of country i can be computed as follows:

$$R_i = DE_i - N_i + Q_i \tag{1}$$

where DE_i (Direct Emissions inside country i) are emissions recorded by the IPCC inventory, based on an exclusively geographical criterion, Q_i are emissions embodied in imported goods and N_i are those embodied in exported goods. All emissions are expressed in tons of equivalents of CO_2 (hereafter referred to as CO_2e). Eq. (1) therefore includes international trade in the GHG inventory from a consumer-based perspective: the importing country is considered responsible for the emissions of imported goods, while the producing country no longer counts emissions related to those goods.

It is also necessary to consider the country of origin of imported goods as well as the emissions related to their production. In other words, we need to give imported and exported goods an appropriate (though approximate) environmental weight. This can be done by applying carbon intensity coefficients (g, *expressed in* $CO_2e/[currency]$) (see e.g. Zhang, 2011), i.e. the ratio of a country's GHG emissions to its GDP. Associating g with import–export flows, we have:

$$N_i = g_i X_i \tag{2}$$

$$Q_i = \sum_{k \neq i} g_k M_{k,i} \tag{3}$$

where X_i is exports (in monetary terms) from country i, g_i is the carbon intensity of country i, $M_{k,i}$ represents imports (in monetary terms) by country i from country k, and g_k is the carbon intensity of country k, from which country i purchases the goods. From Eq. (1) we obtain:

$$R_i = DE_i - g_i X_i + \sum_{k \neq i} g_k M_{k,i} \tag{4}$$

The term $\left[\sum_{k \neq i} g_k M_{k,i} - g_i X_i\right]$ represents the amount of emissions (CO_2e) that should be algebraically added to each country's emission balance with respect to the current IPCC record.

Although we admit that the framework presented is less detailed than the EEIO framework (as it does not use a specific carbon intensity for each sector and does not include the indirect emissions), it is very easy, not labor-intensive to implement, and no further data is needed beyond those already available at the national level. Furthermore, the estimates of uncertainty could easily be included in the traditional IPCC uncertainty analysis (IPCC, 2000). This solution may not be ideal, but in our opinion, it is an effective advancement for the implementation of policies based on the consumer perspective. It could represent a relevant intermediate step toward the consumer-based perspective, in terms of practical feasibility. We believe that a systemic approach, in which carbon intensity plays the role of national indicator relative to production efficiency, in connection with the traditional IPCC inventories, may be a necessary step for soliciting appropriate incentives and policies.

According to the proposed allocation method, that can be called National Carbon Intensity (NCI) consumption-based accounting, importing goods from a country with higher carbon intensity implies higher responsibility for the importing nation. This should encourage consumer nations to find producers with good environmental performance, and exporter nations to reduce their carbon intensity in order to meet the demand for cleaner goods. Assigning responsibility to consumer countries in international trade would therefore induce all countries to improve their environmental performance. The efficacy of this new way of assigning responsibility for GHG emissions depends on the influence that consumers' choices have on producers. The choices of final consumers may stimulate the production of goods in countries with cleaner technologies and production processes, thus further enhancing the benefits of this approach. International agreements, regulations, policies, disciplinary measures and sanctions should be designed in order to influence production costs and market prices, directing production toward cleaner technologies.

In this case, the use of indicators as tools to evaluate changes in emission aggregates is a less detailed but more practical way to obtain adequate advantages and to generate significant policy implications than a consumer-based perspective obtained through direct and punctual measures (such as the EEIO). In particular, the NCI method can be supported by a limited number of data and, in those cases in which the IPCC's GHG accounting is already available, a public office or a policy maker can obtain a consumer-based integration of GHG inventory and a first level evaluation, just by using the regular national accounting systems and the common database.