Corporate Carbon Footprint under Tiered Hybrid Analysis. Application to a Spanish timber company

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DRAFT VERSION OF THE PAPER

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Abstract

The European Union advances steadily towards the stabilization of atmospheric greenhouse gas concentration. The diffuse sectors are now obliged to achieve reductions and new policies based on the carbon footprint are been encouraged. However, voluntary reporting of the so-called scope 3 emissions hinders its successful implementation. In this study we elaborate a tiered hybrid analysis able to both report emissions according to ISO/TR 14069 standard and achieve completeness in scope 3 emissions. Process analysis for scope 1 and scope 2 emissions is implemented together with multi regional input-output analysis for upstream scope 3 emissions. This novel approach is applied to the case of a Spanish timber company. Its total carbon footprint in 2011 was 998,746 Kg CO_2eq, of which 91% corresponds to scope 3 emissions. These emissions are globally distributed, 67% were related to European countries followed by China (12%). We identify and discuss pros and cons of this novel approach. Its implementation at European level could be highly effective in the reduction of global carbon emissions.

1. INTRODUCTION

The human influence on the climate system is clear (IPCC, 2013). This situation has encouraged international commitments based on the reduction of national greenhouse gases inventories. However, these inventories are based on production-based guidelines outlined by the Intergovernmental Panel on Climate Change (IPCC, 1996, 2006). Therefore, emissions embodied in international trade are not considered (Hertwich and Peters, 2009). Under this frame, several countries have reduced production-based emissions but global emissions continue to grow (Arto et al., 2012). The challenge of climate change requires the implementation of all the available strategies, new consumption-based perspectives (Lenzen et al. 2007) or shared responsibilities (Marques et al. 2013; Cadarso et al. 2012; or López et al. 2014) schemes are needed to counteract the international rise of embodied emissions in international trade. A clearer identification of responsible agents is crucial (Hoekstra and Wiedmann, 2014).

Carbon footprint (CF) is a consumption-based indicator capable of measuring both direct and indirect greenhouse gas emissions (GHG) produced by a specific activity (Hoesly et al., 2012; Wiedmann and Minx, 2008). It is an active research topic with a large number of methodologies currently underway in several countries (Peters, 2010; Wiedmann et al., 2011). Traditionally, inventories were made by conventional bottom-up methods that define and describe flows in physical and energy units (Majeau-Bettez et al., 2011). Recent advances use the environmentally extended input-output analysis (EEIO). It is a top-down approach that applies economic environmental accounting frameworks to define and describe flows in monetary units (Minx et al., 2009). Both approaches have significant positive and negative aspects (Alvarez and Rubio, 2015). The Greenhouse Gas Protocol Corporate Standard (WRI and WBCSD, 2004) classifies emission sources around three 'scopes': Scope 1 is direct emissions that occur from sources that are owned or controlled by the organization; Scope 2 accounts for indirect emissions from the generation of purchased electricity, heat or steam consumed by the organization; Scope 3 is all other indirect emissions which are a consequence of the activities of the company, but occur from sources not owned or controlled by the organization. Scope 3 emissions are particularly challenging to quantify, due to the large number of entities involved in those emissions. Streamlined methods would therefore help to estimate scope 3 emissions (Thurston and Eckelman, 2011). The progress made in EEIO analysis is among the most widely known, this approach allows the whole life-cycle impact of products and services to be captured across national and international supply chains.

New policies based on the CF and Environmental Footprint are been encouraged in Europe (European Commission, 2013). Most are regionally implemented due to the fact that the new effort-sharing directive affects both regulated sectors and diffuse sectors (406/2009/EC) -Diffuse sectors correspond to all economic activities that are not included under the emissions trading scheme-. These initiatives are currently in place in Spain. According to forecasts developed by the Spanish Officer of Climate Change, Spain is on track to breach its commitments. Specifically, it is expected that emissions in diffuse sectors will exceed the 2020 target by 54 Mt CO_2e (MAGRAMA, 2014). Among the large number of measures to set a new trend, the Royal Decree 163/2014, by which a Public National Register for CF projects is created (MAGRAMA, 2014b), stands out. Despite the efforts made in setting up this Public National Register it should be emphasized that the voluntary inclusion of scope 3 emissions hinders its effectiveness and successful implementation. Scope 3 emissions comprise the largest part of these emissions. As a local example, the CF released by the Ministry of Environment (2010-13) comes to 99% of Scope 3 emissions.

Hybrid methods may offer a solution that would exploit the advantages of both process analysis and input-output analysis for completeness and consistency in CF quantificaction (Suh and Huppes, 2005; Suh and Nakamura, 2007). These hybrid methods cover the entire spectrum of possible combinations from pure LCA to pure EEIO analysis (Suh et al., 2004). Overall, the possible hybrid analyses can be classified as: (1) The hybrid analysis levels, (2) Hybrid Analysis based on Input-output (Suh and Huppes, 2005; Zafrilla et al. 2014), (3) hybrid integrated analysis (Wiedmann et al., 2011) and (4) Analysis of structural path (Lenzen and Crawford, 2009). There are other proposals using input-output tables in physical units that are also considered hybrid analysis; however, these proposals differ from previous ones in that they do not use process data and therefore there is no "bottom-up" analysis (Wiedmann et al., 2011). Despite this advances, hybrid methods have not yet become standard practice for CF (Majeau-Bettez et al, 2011; Suh and Nakamura, 2007).

These developments can be implemented taking into account the agreements reached within the publication of the technical specification (ISO/TS 14069:2013 Greenhouse gases -- Quantification and reporting of greenhouse gas emissions for organizations -- Guidance for the application of ISO 14064-1). This standard is widely used for the quantification of the corporate CF. It classifies the overall emissions into 23 detailed categories as described. Therefore, it helps to take steps towards establishing categories inside scope 3 emissions, which allows us to be closer to comparable calculations.

In this situation, both hybrid analysis and ISO/TS 16069:2013 present a clear opportunity to solve the weaknesses of current CF implementations such as the Spanish Public National Register of CF Projects. This work aims to develop a hybrid analysis and to apply this proposal to a Spanish timber company in order to show a case study and serve as guide for future effective implementation.

2. MATERIALS AND METHODS

Case Study

The Spanish timber company is specialized in parquets and wood flooring. It is located in the Guadalajara province. It is a family-owned businesses that has become one of the leading companies in the sector. It stands on 9.7 ha, divided into forest (4.8 ha) and built-up land (4.9 ha). The operational boundaries of the study are determined by all the activities controlled by the company. The operational expenses and investments for the year 2011 under study are 767,391 euros. Detailed financial data were obtained from the different responsible units. In many cases it was necessary to interpret specific invoices in order to assign them correctly to the different accounting and consumption categories. Table 1 show the information used according to general consumption categories.

Table 1. General consumption categories

			Value	Units	Price (no VAT added)
SCOPE 1	mobile combustion	gasoline	0		
		diesel	20,467.85	liters	
		E10 (1)	0		
		E85 (1)	0		
		B30 (1)	0		
		B100 (1)	0		
		LNG	0		
		GNC	0		
		GLP	0		
	stationary combustion	Natural Gas	0		
		Oil C	0		
		butane gas	0		
		propane gas	0		
		Fuel oil	0		
		generic GLP	0		
		national coal	0		
		Imported coal	0		
		Petroleum coke	0		
SCOPE 2	Energy consumption	Electricity	119,017.00	kWh	
SCOPE 3	Mobile combustion	gasoline	0		
		diesel	25,932.77	€	1.267
		E10 (1)	0		
		E85 (1)	0		
		B30 (1)	0		
		B100 (1)	0		
		LNG	0		
		GNC	0		
		GLP	0		
	Stationary combustion	Natural Gas	0		
		Oil C	0		
		butane gas	0		
		propane gas	0		
		Fuel oil	0		
		generic GLP	0		
		national coal	0		
		Imported coal	0		
		Petroleum coke	0		
	Energy consumption	Electricity	19,518.79	€	0.164

Source: Own elaboration from company data, WIOD and Spanish Office for Climate Change.

Method description

Among all proposals for hybrid analysis, the tiered hybrid analysis is selected for this study as we consider it the easiest and most effective. It is based on matrix analysis where the conventional input-output table in monetary units is extended with databases derived from both process analysis in physical units and input-output analysis in monetary units. Therefore there are three clearly defined areas without correlation between them. The equation 1 shows its representation.

Equation 1 $$E = \begin{bmatrix} e^{p} & e^{p\rightarrow io} & e^{io} \end{bmatrix} \begin{bmatrix} C^{p} & 0 & 0 \\ 0 & C^{p\rightarrow io} & 0 \\ 0 & 0 & (I-A)^{-1} \end{bmatrix} \begin{bmatrix} y^{p} \\ y^{p\rightarrow io} \\ y^{io} \end{bmatrix}$$

Where:

E: Total emissions from the firm’s activity.

e^{p}, $e^{p\rightarrow io}$ and e^{io}: Direct emissions related to "p" processes, "io" economic sectors and “p→io” processes related economic sectors.

C^{p}, $C^{p\rightarrow io}$: Matrices of technical coefficients related to "p" processes and “p→io” processes related economic sectors.

$(I-A)^{-1}$: Leontief inverse.

y^p, $y^{p\rightarrow io}$ and y^{io}: Activity vectors related to “p” processes (in physical units), "io" economic sectors (in economic units) and “p→io” processes related economic sectors (in economic units).

As can be seen equation 1, there are three multipliers that come together to build final total emissions. These are emissions factors, coefficient matrices and activity data. Starting with activity data, these are the flows that can be included in physical, energy or monetary units. In this proposal, activity data concerning scopes 1 and 2 must be entered in physical units in "Y^p". The economic value associated with this activity’s scopes 1 and 2 must be introduced into monetary units in "$Y^{p\rightarrow io}$" and finally, all data concerning scope 3 must be entered in economic units in “Y^{io}”.

Matrix coefficient correspond to the area that expresses the intercorrelations. In this proposal, C^p is an identity matrix unlike other proposals (Wiedmann et al., 2011a). Thus, the matrix does not influence the conventional process analysis where the emissions factors are multiplied by activity data, without any interrelations. The central area related to $C^{p\rightarrow io}$ matrix responds to the need to include the emissions that are not considered in the conventional process analysis. This matrix is built from the Leontief matrix, including the columns (economics sectors) that are related to the processes described in the y^p vector. In order to avoid double counting the direct emissions (previously included by means of process analysis) the diagonal is transformed to “0”. Finally, the $(I-A)^{-1}$ matrix corresponds to the standard Leontief matrix and is designated to include all other indirect emissions.

Finally, the emissions factors correspond to the direct emissions for each activity data. Therefore, no indirect emissions shall be included in these factors due to the fact that these emissions are considered by means of the coefficient matrices.

Therefore, the proposed Tiered Hybrid Analysis generates results for corporate CF that according to ISO/TR 14069 can be summarized as shown in equation 2.

Equation 2.

$$E = \begin{bmatrix} Scope\ 1\ and\ 2\ (categories\ 1\ to\ 7) & 0 & 0 \\ 0 & Scope\ 3\ (category\ 8) & 0 \\ 0 & 0 & Scope\ 3\ (categories\ 9\ to\ 23) \end{bmatrix}$$

Method implementation

In this case study we have included factors and coefficients from country-related well-known databases described below. The corporate inventories were divided in fossil fuel consumptions (physical data), electricity consumption (energy data) and economics consumptions (monetary data).

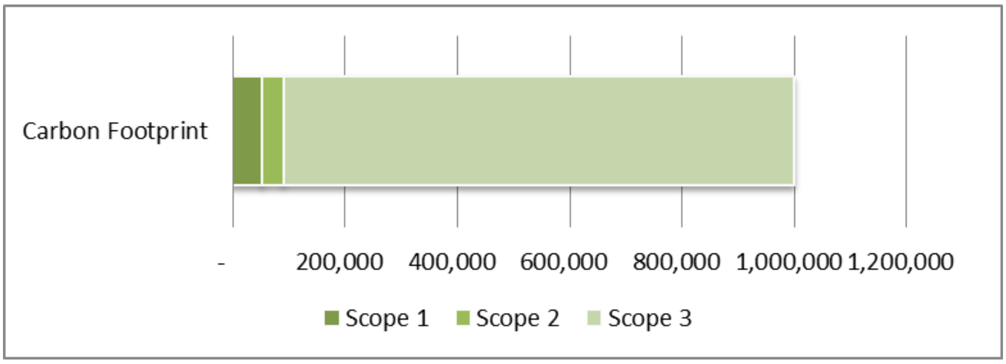
Matrix coefficient are built using as main source the multiregional "World Input-Output Database" or WIOD (Timmer, 2012). Specifically we aggregate into 6 regions plus a "Rest of World" region. The economic sectors have been aggregated to 33 to facilitate calculations. In this sense, this allows the monitoring of flows by sector and region where demand is generated. In relation to $C^{p\rightarrow io}$ matrix, the same source is used. In this case, we consider the following sectors: (1) "Internal transport" for mobile combustion, (2) "Machinery, not another classified site" for stationary combustion and (3) "Electricity, gas and water" for electricity combustion. To prevent double counting, the columns are transformed substituting with zero the coefficient associated with domestic demand and intrinsic sector demand.

Finally, considering the national framework of the case study, emissions factors are obtained from the Spanish Office of Climate Change. These are the same factors published for the National Register of Carbon Footprint (OECC, 2014).

3. PRELIMINATY RESULTS:

Our results for the timber company show the importance of scope 3 emissions on total emissions (figure 1). Out of the 998,746 kgCO2 total emissions for the company in 2011, 50,578 are due to scope 1, 39,276 are scope 2 emissions, and the remaining 91% (908,892 kgCO2) are indirect emissions included in scope 3. Not including this type of scope 3 emissions greatly underestimates emissions for the company. This emphasizes the importance of using a hybrid analysis that helps to understand not only domestic emissions for which the company is directly responsible but also emissions embodied in the products and services bought by the firm, wherever they are generated.

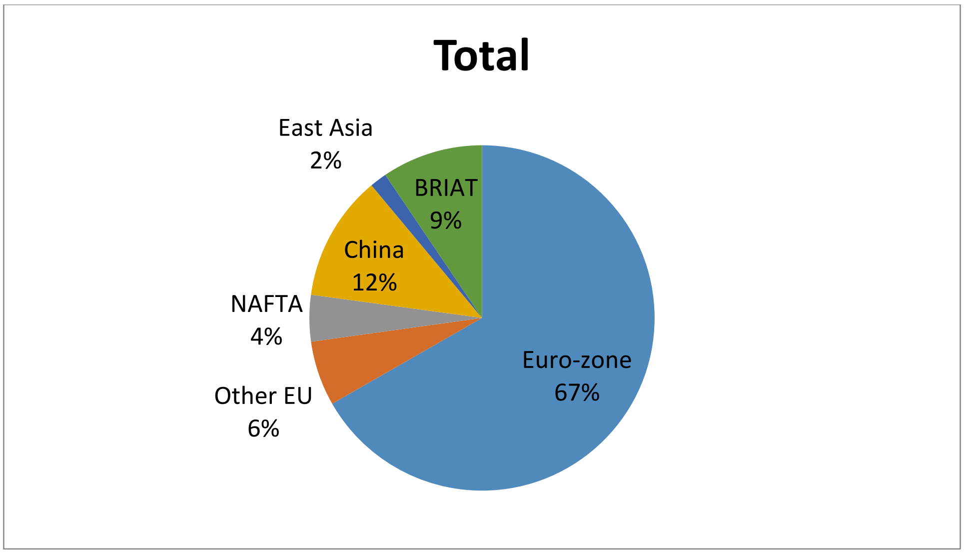
Figure 1: Carbon Footprint for our case study, timber company, scopes 1, 2 and 3, kgCO2, 2011



Source: Own elaboration from company data, WIOD and Spanish Office for Climate Change.

We provide detailed information on the origin of those embodied emissions in figure 2. While the company acquires all of its inputs from Spanish or Euro-zone sources, not all scope 3 emissions are generated within the Euro-zone borders. By using the multiregional input-output analysis we can describe the ultimate origin of the emissions required indirectly to produce all the goods and services used by the company. From the approximately 900 tnCO2, 600 are generated in the Euro-zone, around 100 in China, 85 in BRIIAT (Brazil, Russia, India, Indonesia and Australia), 54 in other EU countries, 39 in NAFTA countries and 14 in other East Asian countries. This illustrates the important fragmentation of production stages in global value chains in today's economy: while 100% of purchases come from Euro-zone countries, only 67% of emissions are generated within their borders. China accounts for 12% of total scope 3 emissions and BRIIAT countries for 9%.

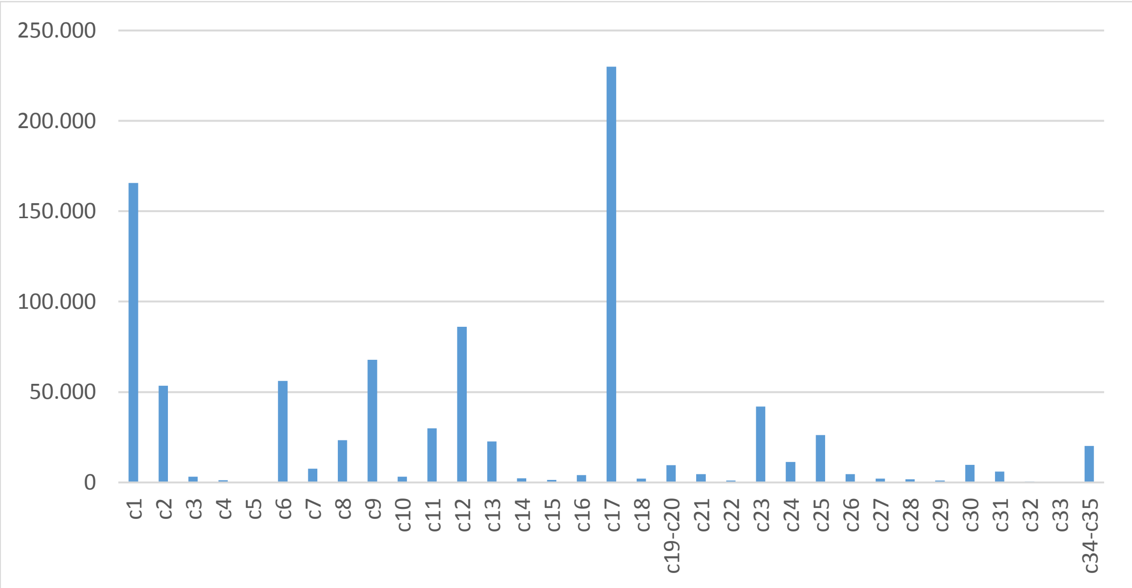
Figure 2: Origin of scope 3 emissions for our case study, timber company, %, 2011



Source: Own elaboration from company data, WIOD and Spanish Office for Climate Change.

By sectors (figure 3), electricity, gas and water is by far the biggest pollutant (around 230 tnCO2 or around 25% of total emissions). Second is the primary sector (agriculture, hunting, forestry and fishing) with 165 tnCO2 (18%). Basic and fabricated metals (86 tn), chemicals (68 tn), wood products (56 tn) and mining and quarrying (53) are also particularly relevant in this case, what can be explained by the company's type of activity.

Figure 3: Scope 3 emissions by sector for our case study, timber company, kgCO2, 2011



Source: Own elaboration from company data, WIOD and Spanish Office for Climate Change.

4. DISCUSSION AND CONCLUSIONS

As illustrated by the proposed methodology and application to a case study, hybrid models allow for a complete calculation of emissions required for the company's activity. Therefore, the weakness of process analysis techniques establishing the system boundaries is solved.

In our case, 91% of total emissions are scope 3 emissions. Furthermore, the multiregional input-output data used in this paper allows us to identify where emissions embodied in all products used direct or indirectly by the firm are generated. This means that even though all purchases come from Euro-zone countries, only 67% of the emissions required for those products are generated within Euro-zone borders. In our case study, 12% of total scope 3 emissions take place in China.

This method also has some potential drawbacks. Traditionally, the methods that describe hybrid analysis levels have the option to enter data activity through its description of processes or their aggregate by economic sectors description. This double standard may lead to the strategy of introducing the activity data from information that generates less environmental impact.

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