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Organization environmental footprint applying a multi-regional input-output analysis: A case study of a wood parquet company in Spain

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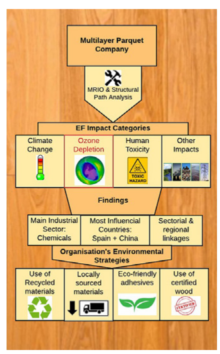
HIGHLIGHTS

- The organization environmental footprint of a parquet company was proposed.
- Environmental impacts were calculated and the sectorial and regional linkages were identified.
- Spain and China, the chemical sector and indirect impacts were the most influential in the ozone depletion category of this company's footprint.
- Viability and implications of the Environmental Footprint implementation for companies were finally discussed.

GRAPHICAL ABSTRACT



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ABSTRACT

Wood has been presented as a carbon-neutral material capable of significantly contribute to climate change mitigation and has become an appealing option for the building sector. This paper presents the quantification of the organization environmental footprint of a wood parquet company. The multi-regional input-output (MRIO) database EXIOBASE was used with a further structural path analysis decomposition. The application of the proposed method quantifies 14 environmental impacts. Highly influential sectors and regions responsible for these impacts are assessed to propose efficient measures. For the parquet company studied, the highest impact category once normalized was ozone depletion and the dominant sector responsible for this impact was the chemical industry from Spain and China. The structural path decomposition related to ozone loss revealed that the indirect impacts embedded in the supply chain are higher than the direct impacts. It can be concluded that the assessment of the organizational environmental footprint can be carried out applying this well-structured and robust method. Its implementation will enable tracking of the environmental burdens through a company's supply chain at a global scale and provide information for the adoption of environmental strategies.

1. Introduction

The raising awareness of the environmental performance involved in the building sector has led to the concept of "Green building". This type of building promotes the use of energy-efficient materials and constructive and operational techniques to reduce negative impacts on the environment (Agostino et al., 2017; Bergman and Taylor, 2011; World

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Green Building Council, n.d.). In order to reduce human pressures on the environment and its resources, the construction sector becomes of vital importance. It plays an essential role in Europe's economy, with approximately 3 million companies, 18 million workers and a share of around 9% of the Gross Domestic Product (European Commission, n.d.). Identified as one of the most resource-intensive sectors, the building sector represents 40% of the energy consumption in Europe, of which a large amount corresponds to the manufacturing of building products (Bribián et al., 2011).

In relation to building materials, wood has been presented as a better option when compared to concrete, ceramic, steel and other building materials (Bribián et al., 2011; Cobut et al., 2015; Islam et al., 2015). The fact that wood products have the capacity to store carbon during their service life and delay its return to the atmosphere, evidences their contribution to mitigating greenhouse gas emissions and climate change (Demertzi et al., 2015; Martínez-alonso and Berdasco, 2015). Because of the enormous potential of wood as a renewable, re-usable and recyclable material to contribute positively to Europe's Resource Efficient Roadmap (European Commission, 2011), it is relevant to study the environmental impacts of companies manufacturing wood products.

The Life-Cycle Assessment (LCA) provides a framework suitable for assessing the potential environmental impacts. This methodology has proved to be a well-established tool for measuring the environmental impacts produced by a product or service throughout its lifespan (ISO 14040:2006) and it has been applied in numerous wood-related studies. In relation to wood products, Garcia and Freire (2014) described a life-cycle model for wood-based panels, Min and Guangyao (2014) developed a carbon footprint assessment following an LCA approach for wood furniture, Cobut et al. (2015) analysed the environmental performance of an interior wooden door for non-residential construction and Demertzi et al. (2015) established a LCA for cork floating floors. The three most widely accepted methods proposed for LCA are the process-based method, the input-output method and the hybrid method (Su and Ang, 2014). The majority of the life-cycle assessments performed on individual products apply the process-based method. It is a bottom-up method which considers the activities and operations that may cause environmental pressures (Majeau-Bettez et al., 2011). Despite this method having a high level of detail and accuracy, it presents some disadvantages. Having to collect information for every process involved in a product's life-cycle is time-consuming. It also means having to carry out a high labor intensity work (Suh and Huppes, 2005). Not only implies spending time and effort, but also the most important limitation is the truncation effect due to the difficulty establishing the system boundaries (Alvarez and Rubio, 2015).

To overcome these negative aspects, the Input-Output Analysis method was also proposed for LCA calculations (Chang et al., 2010; Wiedmann et al., 2007). This approach is adequate for industrial sectors, households, individual businesses and average product groups. By applying this method, the direct and indirect emissions produced upstream can be quantified, tracking the impacts throughout the complete production and supply chain (Wiedmann et al., 2011). A more comprehensive approach including the international flows of goods and services can be achieved through MRIO analysis, where inter-industrial and trans-regional human activities are assessed (Budzinski et al., 2017). Given the interest in this approach, investigations have been published applying it to obtain different footprints, for instance the carbon footprint (Tártaro et al., 2017), the nitrogen footprint (Shindo and Yanagawa, 2017), the ecological footprint (Zhang et al., 2017) and the water footprint (Owusu-sekyere et al., 2017). Among all the studied footprints, the carbon footprint has been the most popular for businesses (Berners-Lee et al., 2011; Huang et al., 2009). Major international initiatives, such as the Single Market for Green Products, proposed the organization environmental footprint (OEF) as a useful indicator to quantify environmental impacts (European Commission, 2012; Finkbeiner et al., 2006). What differentiates the OEF from previous footprints is the fact that it evaluates the environmental stresses from an integrated point of view. Laurent et al. (2012) established the limitations of using a single footprint, such as the carbon footprint, to represent the full environmental impacts. In order to overcome these limitations, the OEF is a multi-criteria indicator that combines around 15 impact categories and provides a more comprehensive approach. Despite the popularity of MRIO analysis, it has not been studied as extensively for the calculation of the Environmental Footprint of organizations.

The aim of this study was to quantify the OEF of a wood parquet business by means of the input-output method. By applying a MRIO analysis and a further structural path decomposition, the total environmental impacts and the linkages between sectors and regions concerning this business were obtained. Further implications of organizations implementing this tool to evaluate their environmental performance are provided.

2. Materials and methods

2.1. Case study

A multilayer parquet company was chosen for the calculation of the OEF applying an input-output approach. Europe's production and consumption of wooden parquet increased from 1990 to 2007. However, with the financial crisis, its production decreased until 2009. From this year onwards parquet's production has experienced a slight recovery, reaching a production of 78.5 million m^2 in 2015. Among the EU member countries, Spain experienced one of the most significant production gains, increasing its production of parquet 10% in 2015 with respect to the previous year (Global Wood, n.d.).

The company manufactures parquet, which is a wood product for floor covering. The product manufactured by this business is a multilayer parquet consisting of three layers glued together. The first layer located at the top is made of hardwood with a matt lacquer protection. The middle and the final layer, called the backing balancing layer, are aimed at providing stability to the parquet board. The company is located in the Spanish province of Guadalajara and it is a family-owned business founded in 1990. In order to stay competitive in the market, they are studying new measures to improve their public environmental image. The OEF was presented as an indicator to shape their environmental action plans.

Table 1 shows the expenditure data classified according to the 163 industry sectors included in the MRIO database EXIOBASE and used as the final demand vector. It was obtained from the company's accountancy department that provided us with accounting records of the goods and services needed for the processes in Fig. 1 during 2011. Capital expenditure has been considered as direct expenses (executed in the year of study). Consequently, no amortization period has been considered. In the same way, depreciation costs and amortization expenses related to investments from previous years have not been included in the study.

2.2. Methodology

In this paper, MRIO analysis is applied as the methodological basis. This method is capable of quantifying all direct and indirect inputs needed for a specific final demand. Therefore, it is a consumption-based accounting model that shows the interdependencies between regions and sectors within the global economy (Schaffartzik et al., 2014; Turner et al., 2007). Methodological foundations and extensions of Input-Output Analysis can be found in Miller and Blair (2009).

Several MRIO databases have been developed in the past years (Moran and Wood, 2014). In our study, the EXIOBASE 2 MRIO database of 2007, was chosen driven by its highly detailed industrial and environmental information compared to other databases (Wood et al., 2015). Coming from the initiative Compiling and Refining Environmental and Economic Accounts (CREEA), EXIOBASE 2 contains tables for 27 EU