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Direct and indirect generation of waste in the Spanish paper industry

Soraya María Ruiz Peñalver [b], Mercedes Rodríguez Molina [a,b], José Antonio Camacho Ballesta [a,b,*]

[a] Department of International and Spanish Economics, Faculty of Economics and Business, University of Granada, Granada 18071, Spain
[b] Institute for Regional Development, University of Granada, Granada 18071, Spain

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ABSTRACT

The paper industry has a relatively high degree of reliance on suppliers when compared to other industries. Exploring the role of the paper industry in terms of consumption of intermediate inputs from other industries may help to understand how the production of paper does not only generate waste by itself but also affects the amount of waste generated by other industries. The product Life Cycle Assessment (LCA) is a useful analytical tool to examine and assess environmental impacts over the entire life cycle of a product "from cradle to grave" but it is costly and time intensive. In contrast, Economic Input Output Life Cycle Assessment Models (IO-LCA) that combine LCA with Input–Output analysis (IO) are more accurate and less expensive, as they employ publicly available data. This paper represents one of the first Spanish studies aimed at estimating the waste generated in the production of paper by applying IO-LCA. One of the major benefits is the derivation of the contribution of direct and indirect suppliers to the paper industry. The results obtained show that there was no direct relationship between the impact on output and the impact on waste generation exerted by the paper industry. The major contributors to waste generation were the mining industry and the forestry industry.

1. Introduction

Spain is the sixth leading paper producing industry in Europe. In 2010 its total output was 7.4 million tonnes, with a monetary value of 3.4 billion euro (CEPI, 2012). The output of this industry does not only satisfy the final demand from individual consumers (households, public sector, etc.) but it is also distributed among the industries of the economy (intermediate demand). From an economic perspective the final demand shows the consumption patterns of an economy (consumption, investment, government expenditures and exports) while the intermediate demand consists of the purchases from other industries.

The intermediate demand reflects the fact that all industries are interdependent: each industry employs the output of other industries as inputs (or intermediate consumptions) in its production process while other industries are users of its output in their production processes.

According to the Spanish National Statistics Institute (INE, 2009a) the intermediate demand for the paper industry in Spain was superior to 11 billion euro while the final demand was less than 3 billion euro. This reveals that most of the demand for the paper industry comes from other industries that employ its products as inputs.

Table 1 shows the production structure of the Spanish paper industry and the average for the total of Spanish industries in 2005. The first three rows show the amount of total, domestic and imported intermediate consumptions, that is, the amount outputs from other industries employed as intermediate inputs by the paper industry, distinguishing between those produced domestically and those imported.

The proportion of intermediate consumptions in total output considerably exceeds the national average (72% in comparison to 54%) thereby confirming that one the main characteristics of the Spanish paper industry is its high share of intermediate inputs (Del Río González, 2005). In addition, the paper industry relies more intensively of imported intermediate consumptions than the average (35% of the intermediate consumptions were imported in comparison with a national average less than 19%). The comparison of the importance of imports and exports in total supply reveals that the paper industry is more opened than the average (the shares of exports and imports in total supply more than twice exceed the national average).

As noted before, the production of paper requires intermediate inputs from a wide range of industries. Any change in the demand for the paper industry will exert an impact on other industries directly and indirectly. Thus, when the output of the paper industry increases, the use of direct inputs from other industries grows, which in turn increase their output. The increase in the output of these industries will expand their needs of inputs from other industries and so forth, resulting in a multiplier effect in the output of all industries.

* Corresponding author at: Institute for Regional Development, University of Granada, Granada 18071, Spain. Tel.: +34 958248359; fax: +34 958248967.
E-mail addresses: Soraya_rp@ugr.es (S.M. Ruiz Peñalver), m_rodrig@ugr.es (M. Rodríguez Molina), jcamacho@ugr.es (J.A. Camacho Ballesta).

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Table 1
Production structure of the Spanish paper industry, 2005 (millions of euro).

	Paper industry	National average
Intermediate consumption at purchaser's prices	8081.3	955,261
Intermediate consumption from domestic production (basic prices)	5177.1	760,404
Intermediate consumption from imports (basic prices)	2855.1	177,313
Compensation of employees	1850.5	430,832
Wages and salaries	1427.0	334,418
Social contributions	423.5	96,414
Other net taxes on production	5.7	3961
Operating surplus/mixed income, gross	1250.8	378,983
Gross Value Added at basic prices	3107.0	813,776
Output at basic prices	11,188.3	1,769,037
Imports (cif)	4084.1	274,404
Imports intra European Union	3577.2	172,347
Imports extra European Union	506.9	102,057
Exports (fob)	2798.7	197,811
Exports intra European Union	2181.9	140,890
Exports extra European Union	616.8	56,921
Total supply at basic prices	15,272.4	2,043,441

The basic price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any tax payable, and plus any subsidy receivable, by the producer as a consequence of its production or sale. It excludes any transport charges invoiced separately by the producer. The purchaser's price is the amount paid by the purchaser, excluding any VAT or similar tax deductible by the purchaser, in order to take delivery of a unit of a good or service at the time and place required by the purchaser. The purchaser's price of goods includes any transport charges paid separately by the purchaser to take delivery at the required time and place.

But is the environmental impact associated with this multiplier desirable? It is clear that a higher use of intermediate inputs will imply increases in output to satisfy a growing intermediate demand, but the volume of waste generated throughout the production processes will grow (Berglund et al., 2002). We have to note, however, that the Spanish paper industry is the second larger paper recycling industry in Europe, second only to Germany (ASPAPEL, 2009; CEPI, 2012). Process models, such as the product Life Cycle Assessment (LCA), have been employed to analyse this issue (for a systematic review of existing LCAs on paper and cardboard waste see Villanueva and Wenzel, 2007). But these models are expensive, require much time and introduce many uncertainties. An alternative are Economic Input Output Life Cycle Assessment Models (IO-LCA) that combine LCA with Input–Output analysis (IO), as they are more accurate and less expensive (Nakamura and Kondo, 2002). In this study we apply an IO-LCA model to estimate the amount of waste directly and indirectly generated by the suppliers of the Spanish paper industry in 2005.

2. Methodology

The product Life Cycle Assessment (LCA) is a useful analytical tool to examine and assess environmental impacts over the entire life cycle of a product "from cradle to grave". It involves tracing the main stages over the life cycle of a product, including raw materials extraction, manufacturing, product use, recycling and final disposal (Joshi, 2000). It requires a rigorous examination of the energy consumption and of the materials used, co-products, by-products, etc., as well as an analysis of the environmental burdens associated with each stage in the life cycle of the product. Several methodological frameworks have been introduced to implement LCA, such as those by the *Society of Environmental Toxicology and Chemistry* (SETAC), the *US Environmental Protection Agency* (EPA) or the *International Organization for Standardization* (ISO).

One of the major advantages of these models is their simplicity. They consider the entire life cycle of the products, examine in detail each stage and identify weaknesses, threats, strengths and opportunities which allows for both environmental improvements and economic benefits (Huijbregts et al., 2008; Karmperis et al., 2013). But, in spite of being a powerful tool, the LCA models have some disadvantages like problems of truncation (Hawkins, 2007), problems of comparability caused by the use of different simplifying assumptions by different analysts (Karmperis et al., 2013) or the fact that "require a large investment of time and resources due to the volume of data required, as they are not readily available and might even be confidential" (De la Rúa Lope, 2009). Moreover, it can be argued that LCA has traditionally not been subjected to public involvement (Morrissey and Browne, 2004).

Based on the environmental input–output analysis (IO) developed by Leontief in the 1970s (Leontief, 1970), hybrid models

Table 2
Advantages and disadvantages of LCA models and IO-LCA models.

	LCA	IO-LCA
Advantages	Results are detailed, process specific	Results are economy-wide
	Allows for specific product comparisons	Allows for system-level comparisons
	Identifies weaknesses, threats, strengths and opportunities	Uses publicly available data and results are reproducible
		Provides information on every industry in the economy
Disadvantages	Setting system boundaries is subjective	Product assessments contain aggregate data
	It tends to be time intensive and costly	Process assessments are difficult
	It is difficult to apply to new process design	Monetary values have to be transformed into physical units
	There are truncation problems	Imports are treated as products created within economic boundaries
	It cannot be replicated when confidential data are used	Environmental burdens associated with product use and end-of-life options are not included
	There are comparability problems	It is difficult to apply to an open economy (with substantial non-comparable imports)
	It has traditionally not been subjected to public involvement	

Modified from Hendrickson et al. (2006, p. 25).