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A WASTE GENERATION INPUT OUTPUT ANALYSIS: THE CASE OF SPAIN

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Abstract

In last decades society has been generating more waste that must be managed. Since then, the legislation has included this problem to minimize the impact that waste exerts on environment and human health. In addition, to converge at a more sustainable economic growth, the Circular Economy Strategy, whose aim is to lengthen the product life reintegrating waste in the productive process, came into force in the European Union. Therefore, to achieve this Strategy it is necessary to quantify the waste arisings in each Member. This paper introduces a waste generation analysis based on Economic Input-Output Life Cycle Assessment (EIO-LCA)[1], a hybrid model that combines both Life Cycle Assessment and Input-Output analysis to study the waste arisings in Spain for 2010 (year for which is available the last symmetric table). This model is useful to study the waste that an industry generates not only by producing goods or services but just by providing other sectors, distinguishing between direct and indirect suppliers. Moreover, this tool reveals the type of waste that each link of the supply chain has arisen. The obtained results show that the supply chains of mining and quarrying industry and construction are the more pollutant in terms of waste generation in Spain.

Keywords

Waste, supply chain, economic input-output-life cycle assessment, circular economy, Spain.

1. Introduction

Recently, society is becoming more involved with environmental awareness. The current economic growth is based on a lineal system (extraction, manufacture, use and disposal) which has increased the pollution levels and the volume of waste, engendered serious natural resource depletion, among other environmental problems which are getting more evident.

To create a smarter, sustainable and inclusive economic growth, the European Commission applied the Circular Economy Strategy, one of the seven initiatives within Europe´s 2020 Strategy. The Circular Economy is an economic concept whose aim is to maintain the value of products, materials and resources in the economy for as long as possible, minimizing waste generation and materials use, that is, reincorporating waste as a resource in the productive processes (Geissdoerfer et al, 2017; Su et al., 2013). The Strategy implies a new economy based on the principle of "closing the loop of product lifecycles" through waste valorisation.

Up to now, a lot of resource and waste management practices have been applied throughout Europe. According to Milios (2018) "over the last 15 years the strategic resource policy direction of the European Union gradually turned towards the sustainable use of natural

[1] EIO-LCA Economic Input Output-Life Cycle Assessment

resources, increasing resource efficiency in the economy and scaling up the recycling and prevention of waste, while simultaneously aiming at sustainable levels of economic growth. […]" (Milios, 2018, p. 866). Nevertheless, Pires et al. (2011) analysed the strengths and weaknesses of the waste management practices by countries in the European Union and highlighted the need of using solider waste management strategies. Notwithstanding these policies, the European Union considered going further and in 2015 applied the Circular Economy Strategy to support a transition to a more sustainable economy. To get this aim the Circular Economy Strategy includes legislative proposals and even a detailed Action Plan (COM (2015) 614 final) to consolidate a new society model that optimizes the stocks and flows of materials, energy and waste, lengthening the product lifecycles as much as it is possible (European Commission, 2015). According to European Commission (2017), the Circular Economy package can modernize our economy towards a more sustainable one, with the environmental implications that it brings. Besides, this Strategy encourages new businesses, green local jobs, increases investment, and stimulates competitive industries. It reduces costs because of energy savings and waste reusing and recycling which have lower prices than raw materials (Lieder and Rashid, 2016).

On the other hand, there are authors who do not believe in the challenges that Circular Economy brings. After studying issues related to sustainable economics, Skene (2016) underlined that nature does not work in the same way that the basis of the Circular Economy. His conclusions are based on the fact that whilst nature uses short cycles, is sub-optimal and eco-inefficient, the Circular Economy Strategy promotes contradictory principles about nature. Murray et al. (2017) considered that the Circular Economy must be redefined as "an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human well-being" (Murray et al. 2017, p. 377). These authors justified that the current concept is associated with limitations and tensions, for instance, it describes over-simplistic goals, it does not include the social dimension, or it does not admit the negative consequences for the environment that the Strategy implies (e.g. green fuel is considered eco-friendly, but planting oil palms is destroying rainforests). Other authors considered that the current definition of Circular Economy is feasible, but it could have unintended effects and so, it is important to ensure some strategies to avoid Circular Economy rebound. According to Zink and Geyer (2017, p. 593) "the proponents of the Circular Economy tend to look at the world purely as an engineering system and have overlooked the economic part of the Circular Economy […]. When Circular Economy activities with low per-unit production impacts, obtain increased levels of production, reduce their benefit". To solve the Circular Economy rebound Zink and Geyer (2017) gave some proposals to correct it by producing products and materials that truly are perfect substitutes for primary production alternatives, not affecting the final demand, drawing consumers away from primary production, etc. Nevertheless, it is necessary to note that, although the Circular Economy package is a "recent" Strategy in the European Union, it has been installed since 1980s and 1990s in German and Japanese policy, which inspired China to apply it, obtaining important results (Su et al., 2013; Geng and Doberstein, 2008).

Summarising, despite the different scholar positions on the concept and implications of the Circular Economy Strategy, all of them agree about the need to look for sustainable solutions to avoid the pressure exerted on environment in general, and waste impact in particular. In any case, to get a more sustainable economic growth it is required the quantification and control of waste flows as a priority in environmental policies.

Over the last years, the number of studies related to quantification of waste generation in the supply chain has considerably grown. For instance, we can highlight studies that have applied Life Cycle Assessment that offers a detailed analysis of the environmental impact of a product through its whole life cycle (from the cradle to the grave). Finnveden et al. (2009) reviewed the recent applications of Life Cycle Assessment and highlighted the importance of this method and its potential to develop other ones. Hoogmartens et al. (2014) analysed the methodological disparity between Life Cycle Assessment, Life Cycle Costing and Cost-Benefit Analysis, justifying that hybrid or mixed models are more accurate than Life Cycle Assessment. According to Suh and Huppes (2005), hybrid models associate both Life Cycle Assessment and Input-Output analysis and integrate the advantages of both methods. Whilst Life Cycle Assessment studies the environmental impact related to a product during its whole life cycle, Input-Output model analyses the production phase and the interactions between economic stakeholders (industries, public sector and households). Therefore, hybrid models are more accurate than Life Cycle Assessment models due to the first ones include all the economic interactions both direct and indirect.

Since Leontief developed his Environmental Input-Output analysis, a lot of hybrid methodologies have been used to explain environmental issues. For instance, EIO-LCA (Salemdeeb et al., 2016; Lenzen and Crawford, 2009; Hendrickson et al., 1998, 2006) or waste input-output analysis (Liao et al., 2015; Nakamura and Nansai, 2016; Nakamura and Kondo 2009; 2007).

This paper introduces an EIO-LCA model to study the forces behind the generation of waste in the Spanish economic system. The structure of this paper is as follows. The next section describes the employed data and the applied method. After that, the obtained results are presented, and the last section provides the main obtained conclusions.

2. Material and methods

2.2.1. Data sources.

This paper introduces an ongoing research which consists in developing a Spanish waste input-output analysis. For this, we have required two primary sources: the last available symmetric input-output table (for the 2010 time-period) and waste generation statistics, obtained from the Spanish Statistics Institute (INE) (INE, 2018) and Eurostat (Eurostat, 2018) respectively.

The 2010 symmetric table classifies industries into 64 categories according to the Statistical Classification of Economic Activities in the European Community (NACE, Rev. 2). On the other hand, the waste statistics offer information about waste generation by economic activities. Waste data are classified according to the European Waste Classification (EWC-Stat) which shows a great breakdown of type of waste. Because of the original input-output table in its full scale is too large to be shown here, and due to the unavailability of high-resolution waste generation data by activities, the industries from the input-output table have been aggregated into 27 categories and the 46 types of waste into 34 as follows.

[Insert Table 1 and 2 about here]

2.2.2. A waste generation input-output analysis for Spain.

The Life Cycle Assessment method identifies the opportunities to improve the environmental effects of products at different stages of their life cycle. This method requires a large quantity of data related to the energy consumption, the co-products, etc., as well as the environmental loads linked with each stage of the production process. Therefore, this tool is useful to describe each phase of the product life. However, it has some disadvantages. For instance, Life Cycle Assessment implies high costs to get the information and can be less accurate because it is necessary to define a system boundary that excludes the most of links between industries (Ruiz, 2014). To reduce some Life Cycle Assessment limitations, hybrid methods were developed combining both Life Cycle Assessment and Input-Output analysis like EIO-LCA (see Hendrickson et al., 1998; 2006; Nakamura and Nansai, 2016; Lenzen and Crawford, 2009). In this paper an EIO-LCA tool has been used to link each Spanish activity with the waste generated throughout its supply chain.

To start with, the Input-Output table shows the interindustry relations for an economy (see Figure 1). Considering an economy with n industries, the Input-Output symmetric table has three differentiated parts: intermediate demand (the inputs that an industry requires from the rest to produce), final demand (the final destiny of these goods and services: consume, exports, fix capital formation, stocks/inventories), and primary inputs (compensation of employees and operating surplus). For instance, the activity i (by rows) is provided with inputs from other industries to produce (x_{ij}). At this point we can distinguish between direct and indirect suppliers. The first ones are those who supply directly the industry *i*, and the indirect suppliers are providers to the direct suppliers of industry *i*. Therefore, an industry has suppliers of first level, second level, third level, and so on. This sequence of suppliers is called *supply chain* of an industry and its length depends on the complexity of the good or service considered.

[Insert Figure 1 about here]

In an economy with *n* industries, the total output of industry *i* is obtained by adding its requirements of inputs plus its final demand:

$$X_i = x_{i1} + x_{i2} + \ldots + x_{in} + y_i \quad (1)$$

We can define the matrix *A* as the technical coefficient matrix, a squared *nxn* matrix that shows the intermediate inputs that any activity requires from another one by unit of output. Each element of the coefficient matrix has values less than or equal to one and is obtained as follows:

$$a_{ij} = x_{ij}/X_j \Rightarrow x_{ij} = a_{ij} \cdot X_j \quad (2)$$

Therefore, we can rewrite equation (1) as follows:

$$X_i = a_{i1} \cdot X_j + a_{i2} \cdot X_j + \ldots + a_{in} \cdot X_j + y_I \quad (3.1)$$

Or in matrix form:

$$X = AX + Y \quad (3.2)$$

Solving eq. (3.2) we obtain:

$$X_{TOTAL} = (I-A)^{-1}\, Y \quad (4)$$

Equation 4 represents the Leontief´s demand model where X_{TOTAL} is the output of the whole economy to satisfy the desired final demand represented by *Y*. The element *I* is a *nxn* squared identity matrix. In addition, $(I-A)^{-1}$ is the Leontief inverse matrix that shows the total requirements by each unit (euro) of final demand. According to Miller and Blair (2009) the

Leontief's inverse matrix can be characterized as the so-called the Euler-series, and due to $a_{ij} \leq 1$, the infinite Euler-series converges to a finite limit, the Leontief inverse:

$$(I-A)^{-1}=I+A+A^2+A^3+A^4+... \quad (5)$$

Therefore, from the Leontief's demand model we can distinguish by direct and indirect suppliers (Equations 6 and 7) and estimate the waste that each link of the supply chain generates because of providing an industry. *(I+A)* shows the direct requirements by each unit (euro) of final demand and $[(I-A)^{-1} - (I+A])$ shows the indirect ones.

$$X_{DIRECT}= (I+A)\ Y \quad (6)$$

$$X_{INDIRECT}= [(I-A)^{-1} - (I+A)\ Y \quad (7)$$

Using equations (4), (6) and (7), we can estimate the total (W_{TOTAL}), direct (W_{DIRECT}) and indirect waste ($W_{INDIRECT}$) per million of euros of final demand generated by each type of provider (Hendrickson et al., 2006; 1998; Beylot et al., 2016):

$$W_{TOTAL}= R\ X_{TOTAL} \quad (8)$$

$$W_{DIRECT}= R\ X_{DIRECT} \quad (9)$$

$$W_{INDIRECT}= R\ X_{INDIRECT} \quad (10)$$

Where *R* is a diagonal matrix of the waste arisings and shows the volume of waste generated by euro of output for each activity, therefore, *R* is a *nxn* squared matrix.

[Insert Figure 2 about here]

3. Results and discussion

Before applying the EIO-LCA model that analyses the waste generated by each supplier, we describe the distribution of the total waste generated by each industry. The Spanish economy generated 114.32 million tonnes, that is, 5,297 tonnes per million of euro of output in 2010. Figure 3 shows the quantity of waste arisen by each sector. The mining and quarrying industry has the highest waste generation rate (with 4,012 t/million €), followed by manufacturing

(867.24 t/million €). Between manufacturing activities, we must highlight the manufacture of other non-metallic mineral products (175 t/million €) and the manufacture of paper and paper products (80 t/million €). The manufactures are followed by construction (175 t/million €) and agriculture, forestry and fishing (135 t/million €). As expected, services have the minor contribution to waste arisings (106 t/million €). Although these results are high, the waste generated in Spain between 2005 and 2010 has considerably decreased mainly encouraged by the economic downtown (Rodríguez et al., 2016).

[Insert Figure 3 about here]

When analysing waste generation throughout the supply chain, the obtained results tend to be larger than the offered data from official statistics. The total waste generated by the whole supply chains (248.6 million tonnes) are by far larger than the original data from INE (114.32 million tonnes). That occurs because EIO-LCA includes the interactions between industries given by Input-Output model and so, it considers the waste generated by each industry plus the waste arisen by its suppliers both direct (121.67 million tonnes) and indirect (126.89 million tonnes). These figures indicate that there is not a significant difference between direct and indirect suppliers in terms of waste generation. Whilst the first ones are responsible of the 49% of the waste generated in the supply chains, the indirect ones generate the 51% remaining.

Due to the tables of the detailed results are too large to be shown here, the obtained data have been summarised. Table 3 shows a high concentration both in types of waste and their generators. The most generated wastes have been: other mineral wastes (120.05 million tonnes or 48.30% from total waste arisings). This category of waste is by far the most generated by direct (60.53 million tonnes) and indirect providers (59.52 million tonnes). These wastes are followed by mineral waste from construction and demolition (6.09%), sorting residues (6.09%), combustion wastes (5.58%) and animal faeces, urine and manure (4.45%). All of them accounted for more than 70% of the total waste arisen in 2010 in Spain.

[Insert Table 3 about here]

On the other hand, Table 4 shows the waste arisen by industry. In this case, the supply chains of mining and quarrying and construction concentrate almost the half of the total waste generated in Spain in 2010. Mining and quarrying industry has the highest participation in waste generation. Its whole supply chain generates 74.03 million tonnes of waste, especially, “other mineral wastes” that represents the 99% of the total waste generated by this industry. Construction concentrates 47.22 million tonnes of waste. From them, 12.67 million tonnes are “mineral waste from construction and demolition”. These industries are followed by water collection, treatment and supply sewerage; remediation activities and waste collection, treatment, disposal activities even materials recovery (36-39), with 23.58 million tonnes of waste.

[Insert Table 4 about here]

Figure 4 distinguishes the participation of waste arisings by type of supplier. Considering the more pollutant industries in terms of waste generation, construction is mainly supplied by direct providers that generate the 14.95% from the total waste generated. The most arisen waste by direct suppliers is mineral waste from construction and demolition with 9,97 million tonnes, while indirect ones represent the 4.05%. However, for mining and quarrying, the main generator of waste, the indirect suppliers generate 18.58% of the total waste arisings, and its direct providers 11.21%. Although the 99% of its direct and indirect suppliers arise other mineral waste, the 1% remaining is composed by metal wastes, ferrous (26.19% and 43.42% for direct and indirect suppliers respectively) and mixed ferrous and non-ferrous (12.55% and 20.81% respectively) and mineral waste from construction (11.14% for direct suppliers and the 18.47% for the indirect ones).

[Insert Figure 4 about here]

4. Conclusion

It is a well-known fact that waste generation is a current problem which requires efficient solutions. In this sense, policy makers must consider both the industrial problems and the environmental impact, and despite the different positions on the Circular Economy Strategy, it could be a feasible solution, which has got positive results in other countries like China (Su et al. 2013). This package pretends to lengthen the product life reintegrating waste in the productive process. Nevertheless, to get this objective it is highly important to quantify the stock and flows of waste for each Member.

In this sense, the aim of this paper was to introduce a first approach to the Spanish waste generation input output analysis. Thus, in this paper an EIO-LCA model was applied to explain the waste arisings in the Spanish supply chains in the 2010 time-period. In Spain this type of studies is almost unexplored, and this paper can be considered as an ongoing research to show the waste arising because of the interactions between industries. This tool describes the waste generated by direct and indirect suppliers throughout the supply chain of each industry, determining the links that arise more waste. The distinction between direct and indirect suppliers for each activity shows the role that each industry plays in the economy. Thus, industries with a longer supply chain will have more indirect providers than industries with a shorter one and will contribute to the economy with a higher value added. Unfortunately, the longest supply chains tend to arise more waste because of the economic activities that are involve in the productive process.

When analysing the whole Spanish economy, direct and indirect suppliers were almost balanced in terms of waste generation because of satisfying the Spanish final demand. However, we must underline several considerations. On the one hand, the estimation of the waste arisings by type of supplier for each activity confirms that, although the impact of the whole indirect suppliers surpassed the obtained by the direct ones, the indirect suppliers did not generate individually a big quantity of waste. As mentioned, due to the high number of indirect suppliers involve in the supply chains, they are significant and so, their waste arisings. On the other hand, these results underline the need to consider the origin of intermediate inputs requirements to estimate waste generation. Furthermore, the final demand is decisive for analysis based on Input-Output models. A change in some of its components (household and public consume, exports, fix capital formation, stocks/inventories), will alter both the final output and the volume of waste.

Moreover, the results showed that there was a concentration both in terms of waste categories and in sectoral terms. In this study, mineral wastes were by far, the most generated waste in Spain. In sectoral terms, mining and quarrying industry and construction were the leading sectors in waste generation, two industries with and important role in the Spanish economy.

In brief, the hybrid models like EIO-LCA offers a description of the waste arisings related to the obtained output to satisfy the desired final demand of a country or region. However, it has some disadvantages. First, it does not consider the destiny of the waste arisings: valorisation (recycling, incineration, etc.) or disposal (landfilling). Other methods like waste input output tables developed by Nakamura and Kondo (2009) include this handicap but it requires a detailed data which are not available for Spain. Second, the Input-Output symmetric tables are not published frequently, and it is not possible to obtain updated results. Third, because of the dimensions of the full input output tables we aggregated the activities, and a more detailed disaggregation of it would be desirable.

Notwithstanding these disadvantages, the EIO-LCA tool is useful to estimate the flows of waste between the economic stakeholders. This research is expected to be followed up by disaggregating the economic activities to identify the major industries responsible for waste generation and serve as a starting point in the orientation of policies on waste prevention to get the circular economy.

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Table 1. Classification of industries.

Number	NACE Rev. 2	Sector
1	01-03	Agriculture, forestry and fishing
2	05-09	Mining and quarrying
3	10-12	Manufacture of food products: beverages and tobacco products
4	13-15	Manufacture of textiles and related products
5	16	Manufacture of wood and related products
6	17-18	Manufacture of paper and paper products
7	19	Manufacture of coke and refined petroleum
8	20-22	Manufacture of chemical, pharmaceutical, rubber and plastic products
9	23	Manufacture of other non-metallic mineral products
10	24-25	Manufacture of basic metals and fabricated metal products, excl. machinery and equipment
11	26-30	Manufacture of computer, electronic and optical products, electrical equipment, motor vehicles, and other transport equipment
12	31-33	Manufacture of furniture; jewellery, musical instruments, toys; repair and installation of machinery and equipment
13	35	Electricity, gas, steam, and air conditioning supply
14	36-39	Water collection, treatment, and supply sewerage; remediation activities and waste collection, treatment, disposal activities even materials recovery
15	41-43	Construction
16	45-47	Retail and wholesale
17	49-52	Transport
18	53	Post services
19	55-56	Hotels and catering
20	58-63	Edition and communication services
21	64-66	Financial intermediation and insurance services
22	68	Real estate activities
23	69-75	Other business activities
24	77-82	Administrative and auxiliary services
25	84, 86-88	Public administration and social work
26	85	Education
27	87-96	Other community, social and personal services

Table 2. Classification of waste.

Number	EWC-Stat	Waste	Number	EWC-Stat	Waste
1	W011	Spent solvents	18	W08 Excl. (W081, W0841)	Discarded equipment (excl. discarded vehicles and batteries and accumulators waste) (W08 excl. W081, W0841)
2	W012	Acid, alkaline or saline wastes	19	W081	Discarded vehicles
3	W013	Used oils	20	W0841	Batteries and accumulators wastes
4	(W014, W02, W031)	Chemical wastes (W014+W02+W031)	21	W091	Animal and mixed food waste
5	W032	Industrial effluent sludges	22	W092	Vegetal wastes
6	W033	Sludges and liquid wastes from waste treatment	23	W093	Animal faeces, urine and manure
7	W05	Health care and biological wastes	24	W101	Household and similar wastes
8	W061	Metal wastes, ferrous	25	W102	Mixed and undifferentiated materials
9	W062	Metal wastes, non-ferrous	26	W103	Sorting residues
10	W063	Metal wastes, mixed ferrous and non-ferrous	27	W11	Common sludges
11	W071	Glass wastes	28	W121	Mineral waste from construction and demolition
12	W072	Paper and cardboard wastes	29	(W122, W123,W125)	Other mineral wastes (W122+W123+W125)
13	W073	Rubber wastes	30	W124	Combustion wastes
14	W074	Plastic wastes	31	W126	Soils
15	W075	Wood wastes	32	W127	Dredging spoils
16	W076	Textile wastes	33	W128	Mineral wastes from waste treatment
17	W077	Waste containing PCB	34		

Table 3. Waste arisings related to the 2010 output in Spain.

	Million tonnes			%		
Type of waste	W_{TOTAL}	W_{DIRECT}	$W_{INDIRECT}$	W_{TOTAL}	W_{DIRECT}	$W_{INDIRECT}$
Spent solvents	0.64	0.28	0.36	0.26	0.11	0.14
Acid,alkaline or saline wastes	1.95	0.95	1.00	0.78	0.38	0.40
Used oils	0.94	0.40	0.54	0.38	0.16	0.22
Chemical wastes	3.31	1.48	1.83	1.33	0.60	0.73
Industrial effluent sludges	2.26	1.12	1.15	0.91	0.45	0.46
Sludges and liquid wastes from waste treatment	1.48	0.64	0.84	0.60	0.26	0.34
Health care and biological wastes	1.50	0.63	0.86	0.60	0.26	0.35
Metal wastes, ferrous	9.20	3.46	5.74	3.70	1.39	2.31
Metal wastes, non-ferrous	0.85	0.35	0.50	0.34	0.14	0.20
Metal wastes, mixed ferrous and non-ferrous	2.06	0.95	1.12	0.83	0.38	0.45
Glass wastes	1.55	0.70	0.85	0.63	0.28	0.34
Paper and cardboard wastes	8.34	3.71	4.62	3.35	1.49	1.86
Rubber wastes	1.08	0.47	0.62	0.44	0.19	0.25
Plastic wastes	3.90	1.71	2.19	1.57	0.69	0.88
Wood wastes	4.13	1.89	2.24	1.66	0.76	0.90
Textile wastes	0.34	0.18	0.16	0.14	0.07	0.06
Waste containing PCB	0.02	0.01	0.01	0,01	0,00	0,00
Discarded equipment (exc. discarded vehicles, batteries and accumulators waste)	0.39	0.17	0.23	0.16	0.07	0.09
Discarded vehicles	1.94	0.82	1.12	0.78	0.33	0.45
Batteries and accumulators wastes	0.36	0.15	0.22	0.15	0.06	0.09
Animal and mixed food waste	4.91	2.62	2.29	1.97	1.05	0.92
Vegetal wastes	6.18	2.74	3.44	2.49	1.10	1.38
Animal faeces, urine and manure	11.06	4.23	6.83	4.45	1.70	2.75
Household and similar wastes	5.55	2.46	3.09	2.23	0.99	1.24
Mixed and undifferentiated materials	4.14	1.90	2.24	1.66	0.76	0.90
Sorting residues	15.15	6.52	8.63	6.09	2.62	3.47
Common sludges	3.71	1.67	2.03	1.49	0.67	0.82
Mineral waste from construction and demolition	15.12	11.04	4.08	6.09	4.44	1.64
Other mineral wastes	120.05	60.53	59.52	48.30	24.35	23.95
Combustion wastes	13.87	6.76	7.12	5.58	2.72	2.86
Soils	0.52	0.26	0.26	0.21	0.11	0.10
Dredging spoils	0.01	0.00	0.00	0.00	0.00	0.00
Mineral wastes from waste treatment	2.03	0.88	1.16	0.82	0.35	0.47
Total	**248.6**	**121.7**	**126.9**	**100**	**49**	**51**

Table 4. Waste arisings by industry related to the 2010 output in Spain.

	Million tonnes			%		
Industry	**Total suppliers**	**Direct suppliers**	**Indirect suppliers**	**Total suppliers**	**Direct suppliers**	**Indirect suppliers**
01-03	14.39	5.46	8.93	5.79	2.20	3.59
05-09	74.03	27.85	46.18	29.78	11.21	18.58
10-12	4.39	3.15	1.24	1.77	1.27	0.50
13-15	0.27	0.21	0.06	0.11	0.09	0.02
16	0.66	0.36	0.31	0.27	0.14	0.12
17-18	6.16	2.99	3.17	2.48	1.20	1.27
19	0.18	0.14	0.03	0.07	0.06	0.01
20-22	7.98	3.61	4.37	3.21	1.45	1.76
23	5.44	3.10	2.33	2.19	1.25	0.94
24-25	16.51	8.77	7.74	6.64	3.53	3.11
26-30	8.75	2.22	6.53	3.52	0.89	2.63
31-33	0.53	0.29	0.24	0.21	0.12	0.10
35	5.45	2.29	3.16	2.19	0.92	1.27
36-39	23.58	10.10	13.48	9.49	4.06	5.42
41-43	47.22	37.15	10.07	19.00	14.95	4.05
45-47	5.23	2.18	3.05	2.10	0.88	1.23
49-52	3.29	1.28	2.02	1.33	0.51	0.81
53	0.10	0.04	0.06	0.04	0.02	0.02
55-56	1.07	1.02	0.05	0.43	0.41	0.02
58-63	2.79	1.06	1.72	1.12	0.43	0.69
64-66	4.63	0.84	3.79	1.86	0.34	1.52
68	2.87	2.41	0.47	1.16	0.97	0.19
69-75	3.61	1.38	2.23	1.45	0.56	0.90
77-82	1.99	0.93	1.06	0.80	0.37	0.43
84,86-88	4.45	1.58	2.88	1.79	0.64	1.16
85	0.62	0.56	0.05	0.25	0.23	0.02
87-96	2.36	0.67	1.68	0.95	0.27	0.68
Total	**248.6**	**121.7**	**126.9**	**100.00**	**49**	**51**

Figure

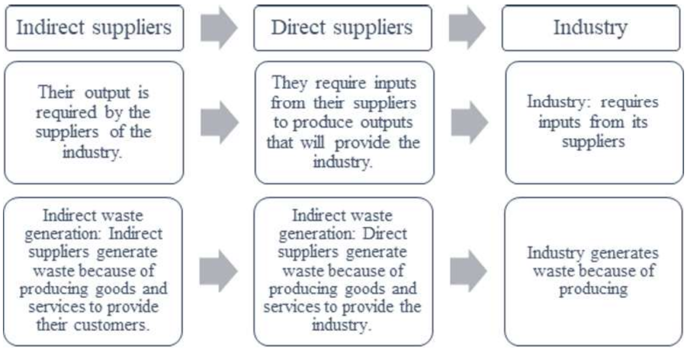
Figure 1. Basic structure of an input-output table.

		Intermediate Consumption				Intermediate demand	Final demand	Total output
		1	2	3	n			
Intermediate Demand	1	x_{11}	x_{12}	x_{13}	x_{1n}	$\sum_{j=1}^{n} x_{1j}$	Y_1	X_1
	2	x_{21}	x_{22}	x_{23}	x_{2n}	$\sum_{j=1}^{n} x_{2j}$	Y_2	X_2
	3	x_{31}	x_{32}	x_{33}	x_{3n}	$\sum_{j=1}^{n} x_{3j}$	Y_3	X_3
	n	x_{n1}	x_{n2}	x_{n3}	x_{nn}	$\sum_{j=1}^{n} x_{nj}$	Y_n	X_n
Intermediate inputs		$\sum_{i=1}^{n} x_{i1}$	$\sum_{i=1}^{n} x_{i2}$	$\sum_{i=1}^{n} x_{i3}$	$\sum_{i=1}^{n} x_{in}$			
Value added		V_1	V_2	V_3	V_n		GDP*	
Total input		X_1	X_2	X_3	X_n			

*GDP: Gross Domestic Product is obtained by rows or by columns. By rows, adding the final demand and by columns, aggregating the value added for each activity.

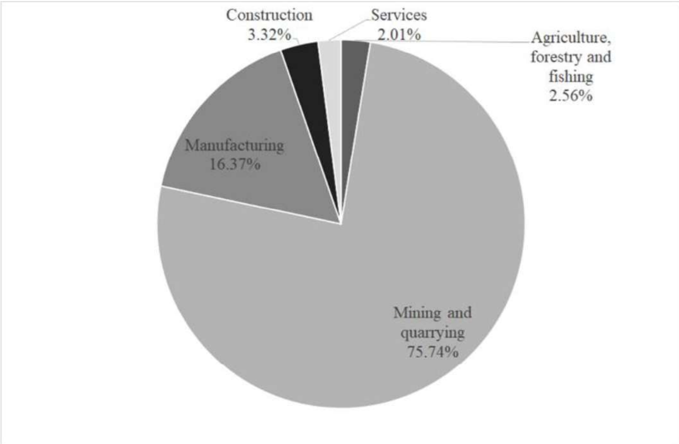
Figure

Figure 2. Methodological scheme.



Figure

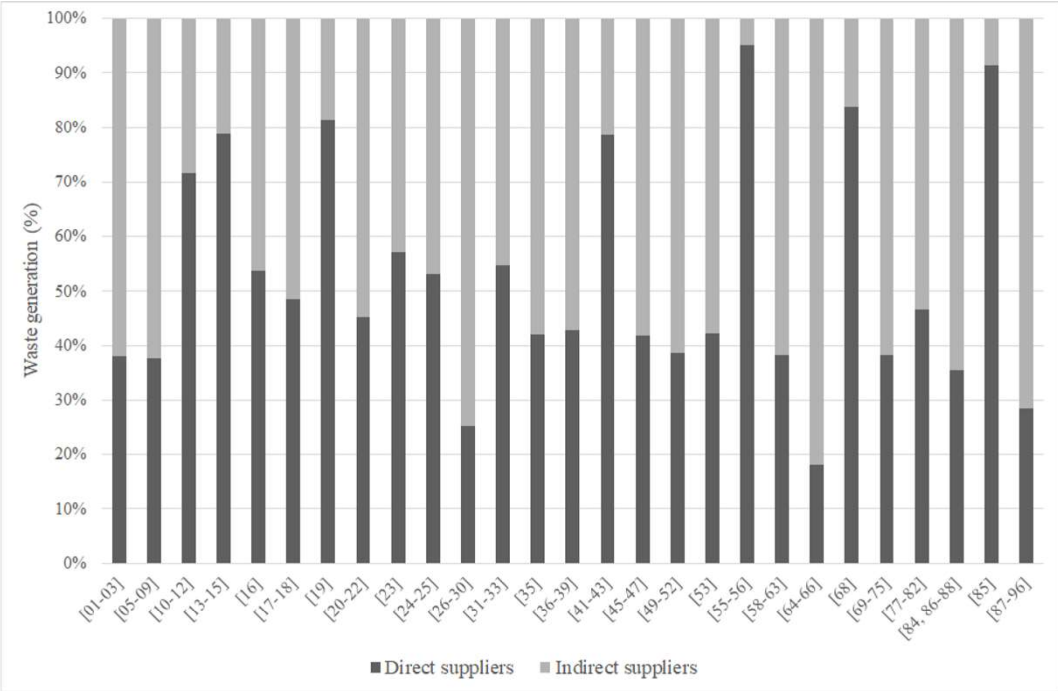
Figure 3. Waste generated per million of euro.



Source: Own elaboration from INE (2018).

Figure

Figure 4. Waste generated by type of supplier (direct or indirect one).



Source: Own elaboration.