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An input–output analysis of the "key" sectors in CO_2 emissions from a production perspective: an application to the Spanish economy.[*]

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Abstract

Here we present an approach that allows the identification of the "key" productive sectors responsible for CO_2 emission. For this purpose, we develop an input–output methodology from a supply perspective. We focus on the impact of an increase in the value-added of the different productive sectors on total CO_2 emissions and we identify the productive sectors responsible for the increase in CO_2 emissions when there is an increase in the income of the economy. The approach shows the contribution of the various sectors to CO_2 emission from a production perspective and allows us to identify the sectors that deserve more consideration for mitigation policies. This analysis is complementary to the input–output analysis from a demand perspective. The methodology is applied to the Spanish economy.

Keywords: CO_2 emissions, "key" productive sectors, input–output analysis.

JEL classification: C67, Q40, Q43.

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1. Introduction

By the end of 1997, the Kyoto Protocol had committed industrialized countries (Annex B of the Protocol) to limiting emissions of greenhouse gases. In response to this protocol, the European Union (EU) established a distribution of burdens for its member states, which implied a total cutback of 8% by 2010–2012 in relation to 1990 levels for the following six gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). In the case of Spain, the agreement of the Presidency of the Environmental Council in June 1998 allowed a 15% increase in emissions.

Given the economic effort that emission mitigation entails, it is essential to determine the link between economic performance, energy consumption and CO_2 emissions.[1] In this regard, the contribution of the diverse productive sectors to CO_2 emission should be established, taking into account, at least, the technological structure of the economy, the interrelations among sectors, and the sectoral capacity of generating value-added.

Here we develop a methodology that allows the identification of the "key" sectors[2]—from a production perspective—responsible for CO_2 emission, and apply it to the Spanish economy. For this purpose, we use an input–output methodology and a supply approach to show the impact of income generation on CO_2 emission. This analysis is complementary to the input–output analysis from a demand perspective.

[1] This paper does not explicitly focus on the relationship between energy consumption and emissions. Alcántara, V. and Padilla, E. (2003) address the relationship between energy consumption and productive activity.

[2] We quote the term "key" because we are not exactly referring to the same concept that input-output analysis literature refers to as key sector, as we explain below.

2. Motivation and methodology

The methodology starts from the concept of key sectors developed by Rasmusen (1956) and Hirschman (1958), which are determined by the multiplier effects of final demand. Our approach is an alternative to the diverse proposals that have derived from Rasmusen's original concept. The notion developed by Rasmusen and the interpretation by Hirschman of the concept of key sector have been widely debated in the literature. The discussion on the article by Yotopoulos and Nugent (1973) led to a deep and careful revision of the issue. There are well-known studies, such as the ones by Laumas (1976), Boucher (1976), Riedel (1976), and the article by Jones (1976), which is especially related to our paper. The same discussion took place afterwards on the article by Cella (1984). The proposal by Guccione (1986) and the reply by Cella (1986) should also be taken into account. An excellent review of the issue can be found in Lenzen (2003).

The approach by Jones (1976) opened the way for an interpretation of key sectors both from a supply and a demand perspective simultaneously. An approach of this type, with an adaptation to atmospheric pollution analysis, can be found in Alcántara (1995), who applies it to the case of Spain. However, in this paper we only approach the relationship between CO_2 emissions and income generation (understood as the value-added generated inside a country). In this sense, we talk about "key" sectors.

We focus on the effect of an increase of a certain percentage in the value-added of the different productive sectors on CO_2 emissions and we identify the productive sectors responsible for the increase in CO_2 emissions when there is an increase in the total income of the economy. The relevance of these issues is clear if we take into account the relationship between social welfare—at least from a material perspective regarding access to certain goods and services—and increased income. This concept of welfare may well be questionable; however, from an ecological perspective it is pertinent to identify how the different ways of income generation affect the environment. In this work, we consider the ability to generate income of the different sectors. Thus, the sectors with the worst performance, the "key" sectors, would be those that emit more emissions per unit of value-added generated and whose emissions increase more with economic growth. When designing the policies to reduce emissions, the ability to generate income of the different productive sectors should be taken into account, especially labor income, because constraints on carbon-generating industries might cause unemployment if attention is not paid to both pollution and labor intensity simultaneously. In the case of Spain, a substantial part of the income generated in the economy is generated by sectors with certain structural instability (construction and the industries related to it). Nevertheless, there are also other sectors with important ecological impacts which also deserve to be paid attention (such as road transport).

We approach the problem in a simple way. The importance of a sector in the generation of emissions would be given, firstly, by its direct and indirect impact, and secondly, by the weight of its direct emissions on total emissions. This procedure allows us to obtain a first sectoral classification that indicates the kind of environmental policies to apply according to the characterization of each sector. For example, in the case of a sector with a notable direct impact and a minor indirect impact, it seems reasonable to think that it would be appropriate to act directly on the sector —although the technological characteristics of the sector and other aspects related to its linkage with the rest of sectors should also be taken into account to decide the adequate policies. In other cases, of course, it would be more reasonable to apply policies falling upon the demand.

Our analytical approach is based on the concept of elasticity and consists of the elaboration of a sectoral impact indicator, which depends on the productive structure of the economy and the weight of the sector value-added in its corresponding production (capacity for income generation). The method proposed is an adaptation to energy analysis of the method developed by Alcántara (1995).[3]

We next define the variables and parameters that we are going to employ in our analysis:

x: *(n x 1)* vector of total productions

v: *(n x 1)* vector of value-added

A: *(n x n)* matrix of technical coefficients

s: *(n x 1)* vector of value-added coefficients. These show the relationship between the value-added of sector *i* (v_i) and the production of sector *i*; that is: v_i/x_i.

u: *(n x 1)* unitary vector.

c: *(n x 1)* vector of sectoral direct emissions.

C: scalar that shows the total level of CO_2 emissions.

^: indicates the diagonalization of a vector. Thus, it denotes a matrix whose out-of-the-diagonal elements are zeros.

(‘): indicates the transposition of a matrix or vector.

In this paper we employ an input–output table in monetary terms. Therefore, from a supply perspective, we can start from the following identity:

$$\mathbf{x} = \hat{\mathbf{x}}\mathbf{A}'\mathbf{u} + \mathbf{v} \tag{1}$$

Dividing both sides of (1) by $\hat{\mathbf{x}}^{-1}$, we obtain:

$$\mathbf{u} = \mathbf{A}'\mathbf{u} + \mathbf{s} \tag{2}$$

[3] This method is an extension of the disaggregated calculation of the production/demand elasticity proposed by Pulido and Fontela (1993, pp. 82–84).

Therefore, we can write:

$$\mathbf{u} = (\mathbf{I} - \mathbf{A}')^{-1}\ \mathbf{s} \qquad (3)$$

This expression allows us to distribute among sectors any variable related to production. This distribution is done according to the productive structure and the weight of the income generated in relation to the own production.

Let **c** be a vector of sectoral direct CO_2 emissions, as we previously defined. If we premultiply both sides of expression (3) by this vector, we obtain:

$$\mathbf{c} = \hat{\mathbf{c}}(\mathbf{I} - \mathbf{A}')^{-1}\ \mathbf{s} \qquad (4)$$

Let **g**' = (g_1, ..., g_n) be a vector of the distribution of total emissions among the *n* productive sectors, so that $\sum_{i=1}^{n} g_i = 1$. Thus, vector **c** can be expressed as follows:

$$\mathbf{c} = C\,\mathbf{g} \qquad (5)$$

Thus,

$$\mathbf{c} = C\ \hat{\mathbf{g}}\ (\mathbf{I} - \mathbf{A}')^{-1}\ \mathbf{s} \qquad (6)$$

and premultiplying both sides of (6) by **u**', we obtain:

$$C = C\ \mathbf{g}'\ (\mathbf{I} - \mathbf{A}')^{-1}\ \mathbf{s} \qquad (7)$$

A proportional increase α in the value-added would lead, *caeteris paribus,* to an increase in total emissions. That is:

$$\Delta C = C\ \mathbf{g}'\ (\mathbf{I} - \mathbf{A}')^{-1}\ \mathbf{s}\,\alpha \qquad (8)$$

Dividing both sides of this expression by total emissions C, we obtain:

$$C^{-1}\Delta C = \mathbf{g}'\ (\mathbf{I} - \mathbf{A}')^{-1}\ \mathbf{s}\,\alpha \qquad (9)$$

The diagonalization of **s** in (9) leads to the next vector:

$$\varepsilon' = \mathbf{g}'\ (\mathbf{I} - \mathbf{A}')^{-1}\ \hat{\mathbf{s}}\ \alpha \qquad (10)$$

whose characteristic element ε_j shows the proportional change in (direct and indirect) sectoral total emissions in relation to a proportional change in income. They can be interpreted as elasticities. Notice that, in fact, the proportional increase α in income is equivalent to the ratio $\Delta v_i / v_i$ for each sector. Thus, vector ε' can be expressed as follows:

$$\varepsilon_i = \frac{\Delta C / C}{\Delta v_i / v_i} = \frac{\Delta C}{\Delta v_i} \frac{C}{v_i} \tag{11}$$

Therefore, the elements of the vector obtained in (10) express the proportional change in total emissions when there is a percentage increase in the value-added of each of the sectors. In other words, the income elasticity of total emissions, which we consider as a measure of sectoral impact. For a more accurate interpretation of this result, we diagonalize vector **g'** and assume α = 1%:

$$\mathbf{E^v} = \hat{\mathbf{g}}(\mathbf{I} - \mathbf{A'})^{-1} \hat{\mathbf{s}} \tag{12}$$

The characteristic element of matrix $\mathbf{E^v}$, E^v_{ij}, shows the percentage increase in the emissions of sector *i* (with respect to total emissions) in response to a 1% increase in the value-added generated in sector *j*, and it can be interpreted as an elasticity. The sum of the elements of the sector *j* column—$\sum_i^n E^v_{ij}$—expresses the percentage of variation in CO_2 emissions experienced by the economy in response to a 1% growth in value-added experienced by sector *j* (*total impact*).

The sum by rows of this matrix—$\sum_j^n E^v_{ij}$—shows the sectoral distribution of emissions and is an indicator of the impact that a global economic increase of 1% would have on the emissions of each sector (*direct impact*). In our approach the productive structure, the higher or lower capacity of generating value-added of the diverse sectors, and the direct emission intensity are decisive elements for determining the environmental impact of each sector.

3. Application and results

In this section we apply the method proposed to determine the “key” productive sectors responsible for CO_2 emissions in Spain.

Annex I shows sectoral emissions in 1995, published by the *Instituto Nacional de Estadística* (INE, 2002a) (Spanish National Institute for Statistics), and the coefficients of sectoral emissions. The input–output table we use is the symmetric table elaborated by the INE (2002b) for that year. Sectoral emissions include those corresponding to the transport of each sector. This implies that these emissions are not included in land transport emissions (sector 60), sector that includes only the emissions made by firms in the transport sector (transport services contracted by third parties). Private road transport of households appears in the chapter Households and is not analyzed in this study[4]. Similarly, the self-production of electricity, whose emissions are allocated to the sector that obtain it as an auxiliary activity and not to the electricity sector (sector 40) (INE, 2002a, pp. 114-115). The data provided by the INE are consistent with European guidelines for the environmental framework NAMEA (National Accounting Matrix Environmental Accounting), so they can be compared with the data for other European countries.

With this data we compute matrix $\mathbf{E}^v$, which allows us to obtain the *direct*

[4] In this paper we focus only on industrial emissions. However, it should be highlighted that Household emissions has grown faster during last decade. One of the most important problems regarding the analysis

impact, sum by rows, which would express the percentage increase in the emissions of the economy that occurs in each sector in response to a 1% increase in value-added by all the sectors. This matrix also allows us to obtain the *total* (direct and indirect) *impacts*, sum by columns, which would express the percentage increase in the emissions generated by the whole productive system in response to a 1% increase in value-added by the corresponding sector. The results are shown in Table 1.

As an example, a 1% increase in the agrarian sector value-added would lead to a 0.0352% increase in total emission, while a 1% value-added increase in all the sectors would cause a direct increase in the agrarian sector of 0.0405 % of global emissions.

TABLE 1 ABOUT HERE

With this information we can establish a sectoral taxonomy to show the relevance of the growth of each sector on CO_2 emissions.

With this objective, we made a classification (Table 2) in accordance with the following criterion: the distributions of direct impact and total impact were classified in quartiles, in such a way that each square shows the intersection of the corresponding subgroups of sectors. For example the paper industry (sector 21 of NAMEA's classification) is included in the third quartile of total emission with an impact of 0.0133 ($0.0078< 0.0133 \leq 0.0182$); and in the third quartile of direct impact, which is, in terms of elasticity, equal to 0.0108 ($0.0034< 0.0108 \leq 0.0140$).

The sectors placed in the third and fourth quartiles in both distributions, the square in the top right-hand corner of the table, are those that have a greater impact (both direct and total impact). These sectors are placed over the median of both

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of transport sector is the separation between public and private transport, what would require the elaboration of "ad hoc" information.

distributions. We classified the sectors in quartiles (instead of using the median) to provide a more precise evaluation of the sectors considered "key" in CO_2 emission from the perspective of value-added generation. From this point of view, the sectors that stand out are those in the top right-hand square, which corresponds to the fourth quartile in both distributions.

TABLE 2 ABOUT HERE

According to our methodology we can conclude that the "key" sectors from the point of view of value-added generation are Electricity, gas, steam and hot water supply (40), Land transport (60), Manufacture of basic metals (27), Manufacture of other non-metallic mineral products (26), Manufacture of chemicals (24), Manufacture of coke, refined petroleum products and nuclear fuel (23), Wholesale and retail trade, repair of vehicles and personal and household goods (50-52), and agriculture (1). The impact of a 1% increase in the income of the economy entails a 0.8317% direct increase in total emissions taking place in these "key" sectors while a 1% increase in the value-added of these sectors implies a 0.6825% total increase in the emissions of the economy (Table 2). Thus, these few sectors are responsible for most of the 1% increase in emissions. The stronger effect on the environment of the value-added generated in these sectors should be considered in the design of mitigation policies. Moreover, it also should be taken into account that a reduction in emissions in the sectors placed in the bottom left-hand square would have, other things equal, much higher costs in terms of the value-added loss it would involve—this is the case of recycling (sector 37), among other sectors. Nevertheless, our approach is a supply analysis, and it has to be taken into account that the production of these sectors is made, to a great extent, for other sectors. Our analysis is therefore complementary to the input–output analyses from a demand perspective.

Figure 1 shows the elasticity of the emission of the diverse “key” sectors (those in the top right-hand square of table 2) in response to a 1% increase in value-added.

FIGURE 1 ABOUT HERE

The role played by the sector Electricity, gas, steam and hot water supply is highlighted (40). The analysis shows that a 1% increase in the income of the economy implies a 0.3496% direct increase in total CO_2 emissions in sector 40, so almost 35% of the global increase in emissions would take place in this sector. Moreover, a 1% increase in the value-added of sector 40 entails a 0.2874% increase in total CO_2 emissions. Therefore, the value-added generated in this sector is clearly the one that has greatest impact on total CO_2 emissions so it deserves to be paid special attention. Notice that from a demand approach this impact would have been distributed among the several sectors acquiring gas and electricity. Nevertheless, the production perspective should be taken into consideration by the policies oriented to cut back emissions in the generation of electricity. These policies should be planned both from the final saving perspective and taking into account the effects of the different ways of generating electricity. Other sector that stands out is land transport (sector 60), which has a direct impact of 0.0441% and a total impact of 0.0637%. Although this sector includes railway transport, the largest part corresponds to road transport. Following the NAMEA’s distribution criterion, the own transport of the different sectors is included in these sectors. In this regard, road transport, which is included in land transport (60), only covers the emissions of transport firms and also excludes emissions from private cars.

Finally, we will comment briefly some of the possibilities and measures for reducing emissions in these "key" sectors in Spain.[5] The reduction in the electricity sector can be achieved through the use of gas in combined-cycles, cogeneration and increasing the use of renewable energy sources. The Spanish government has issued a plan with the objective that at least 12% of the total production of energy by the year 2010 comes from renewable sources (see MIMAM, 2002a, 2002b). This measure follows from the directives of the European Union, which also established that 22% of electricity should come from renewable sources by 2010. In February of 2004, the National Council of Climate approved the "Spanish Strategy of Fight against Climate Change", which includes measures promoting energy saving, the use of solar energy, cogeneration, biomass and biofuels[6]. However, the application of these measures does not seem very ambitious, and electricity generation emissions will probably continue to grow in next years. For a significant change in these emissions, Spain should take advantage of its higher potential of renewable sources of energy, mainly wind and sun, in a more decided way.

As for the transport sector, the mitigation measures cited in the Third Communication submitted by the Spanish government to the UNFCCC (MIMAM, 2002a), which are also contained in the later "Spanish Strategy of Fight against Climate Change" document, include incentive plans for vehicle renewal, improvement in the environmental quality of fuels (promotion of bioethanol and biodiesel), control of

[5] The mitigation measures of the Spanish government are shown in MIMAM (2002a, 2002b). For a comment on Spanish climate policy see Tàbara (2003).

[6] This strategy contains 440 measures to reduce CO_2 emissions. It includes 5 major areas: town and country planning; saving and efficiency in energy consumption; employment of available technological improvements in economic activity; fiscal measures to reduce pollution; and the application of management and control measures in the affected sectors.

vehicle emissions, promotion of cleaner means of transport, improvements in the design of highways, further construction of ring roads and investments in railways.

It should be noticed that most of the measures included in such communication, and the later Strategy document, consist of indirect mitigation measures which in most cases are assumed not to constrict economic growth but to stimulate it. However, a significant reduction in emissions would require relevant changes in the present transport pattern.

In other sectors, such as Manufacture of basic metals (27), Manufacture of other non-metallic mineral products (26) and Manufacture of chemicals (24), emissions can be reduced substantially in the medium- and long-run. The optimization of ethylene plants and the autothermal conversion are some examples in the chemicals case while the reduction by fusion is a possibility for the manufacture of basic metals (IDAE, 2001, p. 43). However, these changes are difficult to make in the short-run because of the life span of the equipment installed and the costs of the new technology. With respect to the agriculture sector (1), separation technologies might provide considerable energy savings (IDAE, 2001, p. 43), and from 1995 there has been an increase in the share of natural gas and a decrease in petroleum products used in this sector (IDAE, 2000, p. 29).

4. Concluding remarks

The methodology presented here provides a tool for determining the higher or lower relevance of productive sectors with respect to the emission of CO_2. The application of this methodology has allowed us to establish the “key” sectors in CO_2 emissions from a production perspective for the Spanish economy. We conclude that the productive sectors that deserve more attention are electricity and gas, land transport, manufacture of basic metals, manufacture of non-metallic mineral products, manufacture of chemicals, manufacture of coke, refined petroleum products and nuclear fuel, wholesale and retail trade, and agriculture (sectors 40, 60, 27, 26, 24, 23, 50-52 and 1, respectively). These sectors concentrate most of the emissions caused with economic growth and are also the ones whose income increase causes more grow in total emissions.

The design of energy and mitigation policies should consider the impact on CO_2 emissions from the perspective of production and take into account the effects that the different ways of generating income have on the environment. The ability to generate income—especially labor income—of the different productive sectors should be taken into account by climate policies, given the economic sacrifices that might cause the constraints imposed by these policies on carbon-generating industries. The approach developed here is complementary to the input–output studies that analyze the relation between CO_2 emissions and the economy from a demand perspective and both provide valuable information for decision-making.

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Table 1. Total and direct impact on CO_2 emissions

	<u>**Sectors**</u>	**Total Impact (%):** $\sum_{i}^{n} E_{ij}^{v}$	**Direct Impact (%):** $\sum_{j}^{n} E_{ij}^{v}$
01	Agriculture, hunting and related service activities	0.0352	0.0405
02	Forestry, logging and related service activities	0.0022	0.0008
05	Fishing	0.0140	0.0216
10	Mining of coal and lignite; extraction of peat	0.0257	0.0012
11-12	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying. –Mining of uranium and thorium ores	0.0024	0.0013
13	Mining of metal ores	0.0012	0.0007
14	Other mining and quarrying	0.0075	0.0009
15-16	Manufacture of food products and beverages – Manufacture of tobacco products	0.0139	0.0215
17	Manufacture of textiles	0.0061	0.0053
18	Manufactures of wearing apparel; dressing and dyeing of fur	0.0015	0.0019
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	0.0011	0.0017
20	Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	0.0058	0.0040
21	Manufacture of pulp, paper and paper products	0.0133	0.0108
22	Publishing, printing and reproduction of recorded media	0.0035	0.0017
23	Manufacture of coke, refined petroleum products and nuclear fuel	0.0790	0.0738
24	Manufacture of chemicals and chemical products	0.0418	0.0533
25	Manufacture of rubber and plastic products	0.0086	0.0028
26	Manufacture of other non-metallic mineral products	0.0861	0.1666
27	Manufacture of basic metals	0.0467	0.0848
28	Manufacture of fabricated metal products, except machinery and equipment	0.0200	0.0032
29	Manufacture of machinery and equipment	0.0130	0.0038
30	Manufacture of office machinery and computers	0.0002	0.0003
31	Manufacture of electrical machinery and apparatus	0.0048	0.0026
32	Manufacture of radio, television and communication equipment and apparatus	0.0001	0.0000
33	Manufacture of medical, precision and optical instruments, watches and clocks	0.0002	0.0002
34	Manufacture of motor vehicles, trailers and semi-trailers	0.0057	0.0035
35	Manufacture of other transport equipment	0.0031	0.0014
36	Manufacture of furniture	0.0022	0.0039
37	Recycling	0.0010	0.0014
40	Electricity, gas, steam and hot water supply	0.2874	0.3496
41	Collection, purification and distribution of water	0.0032	0.0022
45	Construction	0.0160	0.0140
50-52	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	0.0427	0.0189
55	Hotels and restaurants	0.0078	0.0052
60	Land transport; transport via pipelines	0.0637	0.0441
61	Water transport	0.0085	0.0128
62	Air transport	0.0122	0.0159
63	Supporting and auxiliary transport activities; activities of travel agencies	0.0182	0.0039
64	Post and telecommunications	0.0096	0.0005
65-67	Financial intermediation	0.0104	0.0013
70-74	Real estate, renting and business activities	0.0587	0.0020
75	Public administration and defense; compulsory social security	0.0022	0.0028
80	Education	0.0032	0.0024
85	Health and social work	0.0046	0.0034
90-93	Other community, social and personal service activities	0.0057	0.0056
Total		1	1

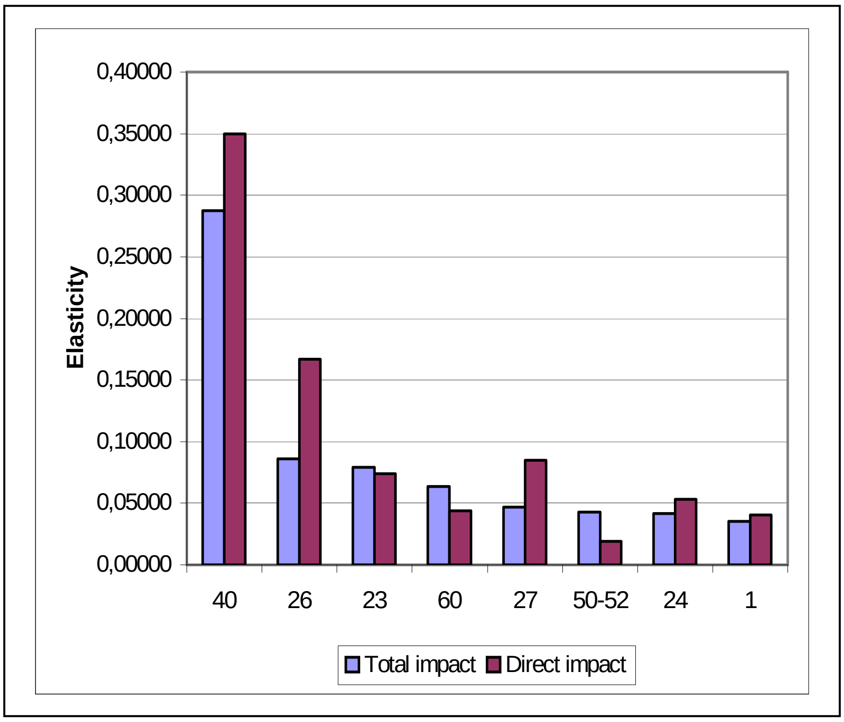
Source: own elaboration with INE (2002a, 2002b) data (see text)

Table 2. Sectoral classification according to direct and total impact

	Direct impact			
Total impact	First quartile (up to 0.0031)	Second quartile (up to 0.0078)	Third quartile (up to 0.0182)	Fourth quartile (up to 0.2874)
Fourth quartile (up to 0.3496)			**5, 15-16, 62**	**1, 23, 24, 26, 27, 40, 50-52, 60** *Total: 0.6825* *Direct: 0.8317*
Third quartile (up to 0.0140)	**36**	**17, 20, 34, 55, 90-93**	**21, 29, 45, 61, 63**	
Second quartile (up to 0.0034)	**18, 19, 75**	**22, 31, 41, 80, 85**	**25**	**28, 70-74**
First quartile (up to 0.0014)	**2, 11-12, 13, 30, 32, 33, 35, 37** *Total: 0.0104* *Direct: 0.0060*	**14**	**64, 65-67**	**10**

Source: own elaboration with INE (2002a, 2002b) data (see text)

Figure 1. Impact of the "key" sectors in CO_2 emission



Annex I

Variables of significance for the analysis

		Ktn CO_2	tn CO_2 per pts 10^6	Actual Product pts10^6	value-added pts10^6
01	Agriculture, hunting and related service activities	8187	1,69	4836989	2879781
02	Forestry, logging and related service activities	162	0,98	165330	147559
05	Fishing	4361	15,12	288504	181599
10	Mining of coal and lignite; extraction of peat	248	0,85	291141	209843
11-12	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying. –Mining of uranium and thorium ores	258	9,39	27489	18649
13	Mining of metal ores	135	3,90	34621	26587
14	Other mining and quarrying	181	0,58	309722	153007
15-16	Manufacture of food products and beverages – Manufacture of tobacco products	4333	0,44	9799496	3136329
17	Manufacture of textiles	1062	0,83	1273599	742417
18	Manufactures of wearing apparel; dressing and dyeing of fur	389	0,38	1037169	461593
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	342	0,32	1054095	340590
20	Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	798	0,86	930708	443334
21	Manufacture of pulp, paper and paper products	2174	1,57	1381154	827939
22	Publishing, printing and reproduction of recorded media	348	0,24	1449648	558388
23	Manufacture of coke, refined petroleum products and nuclear fuel	14907	10,52	1416972	1132678
24	Manufacture of chemicals and chemical products	10769	3,00	3594603	1868668
25	Manufacture of rubber and plastic products	573	0,36	1577362	1003240
26	Manufacture of other non-metallic mineral products	33634	14,54	2313076	1062558
27	Manufacture of basic metals	17114	7,39	2315137	1028899
28	Manufacture of fabricated metal products, except machinery and equipment	638	0,23	2768134	1388118
29	Manufacture of machinery and equipment	774	0,36	2167751	1151378
30	Manufacture of office machinery and computers	60	0,19	323060	199227
31	Manufacture of electrical machinery and apparatus	535	0,45	1181974	630931
32	Manufacture of radio, television and communication equipment and apparatus	0	0,00	586847	342332
33	Manufacture of medical, precision and optical instruments, watches and clocks	43	0,12	345668	218815
34	Manufacture of motor vehicles, trailers and semi-trailers	701	0,15	4747343	2743256
35	Manufacture of other transport equipment	285	0,44	649499	397697
36	Manufacture of furniture	782	0,56	1392901	658515
37	Recycling	273	3,88	70343	17330
40	Electricity, gas, steam and hot water supply	70599	24,21	2915585	2026277
41	Collection, purification and distribution of water	439	1,03	427193	267243
45	Construction	2821	0,22	12981559	5808041
50-52	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	3824	0,32	12103911	8469916
55	Hotels and restaurants	1050	0,12	8761970	5266672
60	Land transport; transport via pipelines	8899	2,52	3533072	2527590
61	Water transport	2580	9,92	260178	158650
62	Air transport	3217	5,44	591537	386655
63	Supporting and auxiliary transport activities; activities of travel agencies	783	0,44	1794896	1096345
64	Post and telecommunications	111	0,06	1863965	1626658
65-67	Financial intermediation	263	0,05	5252176	3860431
70-74	Real estate, renting and business activities	399	0,03	13925039	10444554
75	Public administration and defense; compulsory social security	566	0,11	5341075	4192157
80	Education	480	0,13	3829092	3379595
85	Health and social work	696	0,14	5123540	4097091
90-93	Other community, social and personal service activities	1123	0,33	3453258	2274864

Source: INE (2002a, 2002b) and own elaboration

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