A STRUCTURAL DECOMPOSITION ANALYSIS OF CO_2 MAIN DRIVERS FOR THE SPANISH ECONOMY

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CO_2'S MAIN DRIVERS FOR SPAIN'S ECONOMY. A STRUCTURAL DECOMPOSITION ANALYSIS

Abstract:

The aim of this paper is to identify the main drivers of CO_2 emissions in Spain, using an enhanced Structural Decomposition Analysis (SDA) from an extended Input-Output Model, which would allow both the direct and indirect effects of possible drivers to be captured. Six factors are considered; for two of them at wo-level decomposition is conducted. The approach used is a multisectoral one that offers a fine analysis, which is interesting for policy discussion. Data came from the World Input-Output Database (WIOD), a free database offering relevant data for the 1995-2009 period. The results are examined in light of past and current political mitigation measures at both the international level and by Spain so the historical analysis from SDA is completed with prospective documents.

KEYWORDS: CO_2 EMISSIONS, STRUCTURAL DECOMPOSITION ANALYSIS, SPAIN

1. INTRODUCTION

Not only the amount of carbon dioxide (CO_2) but also other greenhouse gases (GHG) in the atmosphere are increasing, which is leading to global climate change (IPCC, 2013). In fact, climate change is one of the main problems facing nations today. The main anthropogenic driver is emissions into the atmosphere of GHG emissions from fossil fuel combustion. Anthropogenic activities under business-as-usual scenario would lead to a 5 °C increase in global temperature but proper and timely interventions could restrict it within 2 °C (The World Bank, 2010; Das and Kumar, 2014). There is ample consensus in its mitigation from global measures which began in 1997 with the Kyoto Protocol Agreement. For European Union (EU) members states, such measures continued with Directive 2003/87/CE (European Commission, 2003) and the so-called 2020 Horizon approved in 2009 (European Parliament, 2009). This latest European agreement established three important targets to reach by 2020; a 20% reduction in GHG emissions, a 20% reduction in energy consumption and a share of 20% of Renewable Energy Sources (RES) in the energy matrix. This document also established national targets. For the case of Spain, the fixed target was to reduce its GHG emissions for 2020 up to 10% when compared to the 2005 statistics. In Spain, the main contributor to total GHG emissions is CO_2 which shares around 80% (Spanish National Inventory GHG emissions, 2013).

If we focus on CO_2 emissions, the dominant anthropogenic greenhouse gas flux from fossil fuel combustion, although a set of mitigation measures are in force, their effectiveness could be enhanced in light with results from the main drivers of CO_2 emissions. Only if mitigation measures are oriented towards the divers of emissions will it be possible to reduce them effectively. In others words, by acting from previous knowledge of the drivers would help the decoupling between economic growth and CO_2 emissions. Acting this way would make meeting economic growth without higher emissions possible. Indeed, it could be possible to meet economic growth and a decrease in CO_2 emissions.

This paper analysis the main drivers of Spain's CO_2 emissions by using an enhanced Structural Decomposition Analysis (SDA) supported on a rich database. The results are interesting, not only for researchers but also for utility companies and policy-makers. Emissions from biomass and marine and aviation bunkers are excluded from the analysis. Such results will allow us to know the connection between economic and technical factors with CO_2 emissions. They will also help us determine what the various responsive factors are in emissions for the 1995-2009 period. This period of analysis is determined by the available dataset as described below.

This paper aims to contribute to this growing body of knowledge about CO_2 emissions drivers by carrying out such an approach. Past and current political mitigation measures are also analyzed in line with such results. This paper focuses on the main drivers that explain the annual change in CO_2 emissions from 1995 to 2009 in Spain. To do this, an enhanced (SDA) was carried out with a multi-sectoral approach. To the knowledge of the authors, Spain's GHG (particular CO_2) emissions drivers have not been previously investigated from such an approach. The solution developed to solve the SDA and a two-level decomposition for two of the factors considered enhances the analysis which has been developed with the following main objectives:

1. Decomposition of changes in CO_2 emission between 1995–2009 into carbonization effect, energy intensity effect, technology effect, the structural demand effect, the consumption pattern effect and scale effect.

2. Decomposition of changes in CO_2 emission between 1995–2009 at the sectoral level and tracing the changes in emissions from each consumption category to the contributing sectors.

3. To analysis the impact of past relevant policy measures, the entire period was divided into four sub-periods: 1995-2000 (before European directive 2001/77/EC of Renewable Energy Sources -European Commission 2001-), 2001-2004 (after European directive 2001/77/EC and before Kyoto -United Nations, 1998-), 2005-2007 (after Directive 2003/87/EC –European Commission, 2003- and after Kyoto implementation), and 2008- 2009 (after Kyoto first stage).

4. To Analysis the impact of current policy measures oriented towards CO_2 emissions mitigation and provision of energy policy recommendations at the sectoral level.

This paper has been structured as follow. After the introduction, section 2 reviews the literature, section 3 provides the methodology. Section 4 shows the dataset used. The results are presented and discussed in section 5. Current political measures are examined in section 6. In the light of our results, we draw a number of conclusions, which are presented in Section 7.

2. Review of the Literature

Understanding the forces to change CO_2 emissions over time has best been analyzed by means of a decomposition analysis. A decomposition analysis looks into the effects of changing one parameter at a time, while keeping all others unchanged at the base year, along with an interaction effect (Das and Kumar, 2014). A decomposition analysis could show which effects are more crucial to reduce CO_2 emissions. Grossman and Krueger (1991) were the first to use a decomposition analysis for environmental studies. The authors decomposed emissions into three factors: a scale factor measuring the effect of growth on economic activity; the structure of the economy that quantified the variation in emissions due to a change in the sectoral composition of production; and a technological factor that measured the change in emissions caused by changes in technology. The authors applied this decomposition in member countries of the North American Free Trade Agreement and concluded that economic growth tended to decrease pollution problems. Freitas and Kaneko (2011) offered an overview of decomposition studies from the seminal paper by Grossman and Krueger (1991).

Similarly, Torvanger (1991) analyzed the change in emissions in the industrial sectors of nine OECD countries. Their results indicated that the main factor contributing to the decline of emissions was a reduction in the energy intensity of production.

In early 1990, the decomposition method began to be applied for developing countries. Some examples are the papers by Ang (1995), Shrestha and Timilsina (1996), Ang and Pandiyan (1997), Han and Chatterjee (1997), Sun (1998), Sun and Malaska (1998), Ang (1999), Ang and Zhang (1999), Luukkanen and Kaivo-oja (2002), Paul and

Bhattacharya (2004), Wu *et al*. (2005), Lee and Oh (2006) and Zhang *et al*. (2009). More recently, this methodology has been used to decompose energy intensity and emissions. Examples include Kerhof *et al*. (2009), Wu and Zeng (2013), Duarte *et al*. (2013), Fernández *et al*. (2014), Ren *et al*. (2014) and Wang *et al*. (2014). This method was also applied to studies by the International Energy Agency (IEA/OECD, 2004).

The decomposition analysis involves two main, recently developed methods; the Index Decomposition Analysis (IDA) and the Structural Decomposition Analysis (SDA). Ang & Zhang (2000), Ang (2005), Hoekstra & van der Bergh (2002) and, more recently, Su & Ang (2012) compared both of them. Policy makers use these techniques widely as an analytical tool.

IDA is a less data demanding method. However, the results show fewer details than SDA regarding economic structure. Recently, IDA has been applied to analyze energy consumption (Tunç *et al*, 2009; Oh *et al*, 2010), GHG emissions (Lu *et al*, 2007; Dong *et al*, 2010), among other topics.

SDA uses data from Input Output (IO) Tables and offers a broader range of information concerning technical aspects and the effects of final demand than does IDA. SDA is implemented by researchers using an extended input-output analysis (IOA) to study changes in energy consumption or emissions. SDA is a useful approach to study the drivers of physical movements in an economy (Hoekstra & van der Bergh, 2002), as a consequence is an appropriated approach to analyze changes in the economic structure driving environmental changes. Thus, changes in environmental variables could be matched with changes in technical coefficients in the Leontief Matrix or in final demand

and its components. One of the seminal papers (Rose & Cheng, 1991) uses SDA to analyze changes in sectoral energy consumption in the U.S. Later, Rose & Casler (1996) showed the main principles to obtain equations of structural changes. SDA could carry out two type of decomposition; additive and multiplicative (Dietzenbacher *et al,* 2000). The difference between these two types of decomposition analysis is the discussion about results. Any case, certain limits also affect SDA (Dietzenbacher and Loss, 2000).

SDA has been applied to analyze GHG drivers. These are the cases of Chang *et al* (2008), Guan *et al* (2008), Zhang (2009), Achão & Schaeffer (2009), Baiocchi & Minx (2010) who use a multi-regional IO model, as do Cellura *et al*., 2012 and Zhu *et al*., 2012. Most papers use a reduced number of decomposition factors from a range of four or five. However, literature offers a number of studies with a higher number of factors, such as the case of Lim *et al* (2009) with eight factors; Chang *et al*. (2008) with nine factors or Wood (2009) with ten factors. Although in SDA studies it is commonplace to consider demand side factors, papers with a supply side factors are available. These papers use the Goshian instead of the Leontief matrix (Zhang, 2010).

In the case of Spain, similar papers focusing on GHG include the work by Llop (2007), Roca & Serrano (2007), Tarancón and Del Río (2007 a and b), Bartoletto and Rubio (2008), Alcántara & Padilla (2009), Butnar & LLop (2011), Alcántara *et al*. (2010), Bhattacharyya and Matsumura (2010), Cansino *et al*. (2011), Zafrilla *et al*. (2012), Demisse *et al*. (2014) and Cansino *et al*. (2015) among others.

3. METHODOLOGY

3.1. Input-Output analysis (IOA).

IOA is a useful method to better understand and account for the links between consumption and production sectors (Leontief, 1986). The input-output relationship may be expressed as follows (Miller and Blair, 1985):

$$x = A \cdot x + y \quad (1)$$

Being *x* an n x 1 vector that shows the total output of each sector in an economy, A is an n x n technical coefficient matrix that indicates the inputs that each sector needs for its own production. Therefore, *A.x* is the intermediate output. Finally, y is an n x 1 vector that refers to the final demand of each sector. This equation may be reformulated as follows:

$$x = (I - A)^{-1} \cdot y \quad (2)$$

Where *I* is n x n identity matrix, $(I\text{-}A)^{-1}$ is the Leontief inverse matrix (*L*) that shows the requirements for an economy's production. Consequently, the eq. 2 may be expressed as follows:

$$x = L \cdot y \quad (3)$$

Leontief-style IOA accounting has become an increasingly active area of research for a variety of environmental indicators, including CO_2 (Kanemoto *et al*., 2014). IO embodiment analysis, which facilitates a deeper appreciation of the sectoral total emission requirements in terms of both the direct and indirect hidden emissions costs, has been popular as a main frontier method for benchmarking CO_2 emissions embodied in economic activity (Chen and Zhang, 2010).

The Environmental Input-Output (EIO) model allows us to analysis the link among CO_2 emissions, productive sectors and the final demand. In the EIO model, the total production based CO_2 emissions are calculated as follows:

$$e = \hat{K} \cdot L \cdot y \tag{4}$$

Where *e* is an n x 1 vector representing the total supply chain of CO_2 emissions needed to meet the final demand, $\hat{K}$ is a diagonal matrix n x n that represents the emission intensities of economic sectors. In other words, every element shows the CO_2 emissions per unit of each economic output sector.

3.2. Structural decomposition analysis.

CO_2 emissions from the burning of fossil fuel and industrial processes were related to Climate Change through the IPAT equation (Impact=Population×Affluence×Technology) (York *et al.*, 2002) and the 'Kaya identity' (Commoner, 1971 and Metz, 2007). One of the main barriers of the IPAT equation is that only assesses the direct effects of CO_2 drivers on environment. Together with this, the IPAT equation implies an aggregated approach that not allows a sectoral analysis to be developed but can be bridged through IOA and SDA. The combination of IOA-IPAT and SDA strengthens the standard IPAT analysis by identifying with economic sectors driving changes (Guan *et al*, 2008).

The SDA approach is used in this paper to analyze the changes of CO_2 emissions due to six factors. These are the carbonization factor, *C*, that represents the ratio of CO_2 emissions, measured in Gg, related to the relevant energy use, measured in Terajules (TJ); the energy intensity factor is represented by *E* and is defined as the ratio of emissions due to relevant energy use per unit of output (this factor is often used as a measure of the energy efficiency of a country's economy); the technology factor, *L*, is the Leontief inverted matrix, which reflects the relationship between the final demand vector and the total output vector; the structural demand factor, *S*, where each of its elements shows the relative weight that every demand category (private consumption, gross capital, public expenditure and exports) has in every 35 economic sectors; the final demand pattern factor, *D*, represents the ratio of the final demand of each category over total final demand; and the scale factor, *f*, shows final demand of economy.

Considering equation (4), first, $\widehat{K}$ is decomposed into $\hat{C} \cdot \hat{E}$, where $\hat{C}$ is a diagonal matrix (n x n) that shows the carbonization of the economy. $\hat{E}$ is a diagonal matrix (n x n) that represents the energy intensity of an economy. The expression for the decomposition analysis identity is:

$$e = \ddot{C} \cdot \ddot{E} \cdot L \cdot y \tag{5}$$

Secondly, y is decomposed into $S \cdot \ddot{D} \cdot f$, with S being an n x d matrix (d categories of final demand allocation) and represents the final demand sectoral structure. $\widehat{D}$ is a diagonal matrix (d x d) that shows the percentage of each category for final demand by economic sectors, while f is a column vector d x 1 that shows final demand of the economy, where all of the d elements are equal and represents the total final demand.

$$y = S \cdot \bar{\ddot{D}} \cdot f \qquad (6)$$

Hence, this decomposition allows us to express total CO_2 emissions of an economy 'e' into the six effects or factors defined above (carbonization, energy intensity, technology, structural demand, consumption patterns and scale factor), as follows:

$$e = \ddot{C} \cdot \ddot{E} \cdot L \cdot S \cdot \bar{\ddot{D}} \cdot f \qquad (7)$$

The basic approach to additive structural decomposition analysis, using these six factors changes in CO_2 emissions for one country may be expressed as follows:

$$\Delta e = \Delta e_C + \Delta e_E + \Delta e_L + \Delta e_S + \Delta e_D + \Delta e_F \qquad (8)$$

Each of the six addends of the expression (8) represents a column vector (n x 1), where each element shows the contribution of each factor to the variation of CO_2 between two time periods. Similarly, the sum of the 35 elements of each vector represents the total contribution of each factor to the variation of emission.

The change in CO_2 emissions between two periods may be decomposed into changes in the component driving forces as follows:

$$\begin{aligned}
\Delta e_C &= \bar{\Delta}\bar{C} \cdot \ddot{E} \cdot L \cdot S \cdot \bar{\ddot{D}} \cdot f \\
\Delta e_E &= \ddot{C} \cdot \bar{\Delta}\bar{E} \cdot L \cdot S \cdot \bar{\ddot{D}} \cdot f \\
\Delta e_L &= \ddot{C} \cdot \ddot{E} \cdot \Delta L \cdot S \cdot \bar{\ddot{D}} \cdot f \qquad (9) \\
\Delta e_S &= \ddot{C} \cdot \ddot{E} \cdot L \cdot \Delta S \cdot \bar{\ddot{D}} \cdot f \\
\Delta e_D &= \ddot{C} \cdot \ddot{E} \cdot L \cdot S \cdot \bar{\Delta}\bar{D} \cdot f
\end{aligned}$$

$$\Delta e_F = \ddot{C} \cdot \ddot{E} \cdot L \cdot S \cdot \ddot{D} \cdot \Delta f$$

For example, the first element Δe_c shows the change in factor 'C' while the rest of the factors remain unchanged. The main problem to calculate the value of every component in (9) is due to the fact that the remaining factors may be evaluated at the start or end-point of the time period investigated. As a consequence, the number of possible decomposition is high and is determined by the expression: $2^{n \cdot (n-1)}$. In this paper, with six factors, the number of possible decompositions amounts 2^{30} = 1,073,741,824. However, not all decompositions are valid. The number of correct decompositions is determined by the expression n!; that in our case is 6! = 720 (Dietzenbacher & Los, 1998).

There are methods to accurately calculate the various effects. Miller & Blair (2009) use the average for a two-polar decomposition; Dietzenbacher & Los (1998) use weighted average in intermediate periods; De Haan (2001) uses the average of specular pairs and (Boer, 2008) uses the Montgomery's decomposition. However, the main disadvantage is the high number of calculations that are needed. It is not necessary to carry out n! decomposition forms (Seibel, 2003) in all cases. For each element, there are only 2^{n-1} different ways to appear in the decomposition. This means that each of these appear more than once. The number that appears for the decomposition or frequency is determined by the expression *(n-1-k)!·k!*, where k is the number of factors that remain unchanged, which is different for the variable value (notes by Δ) evaluated in period t+1. Moreover, due to unchanged factors that could appear in various sites within the decomposition path, the number of different ways in which the path could appears as (n-1)!/[(n-1-k)!·k!]. For example, the decomposition for the first element is shown in Table

A.1 of Appendix 1. As a solution, this paper uses the average of correct decompositions (in our case is 6! = 720). We follow the complete decomposition method proposed by Seibel (2003). However, although the average for all decompositions does not offer any residue, the problem of the high number of possible solutions persists. Nonetheless, this method is comparatively easier. It offers the advantages of being complete/perfect (no residuals, Sun, 1998), ideal (time/factor reversal, Su and Ang, 2012), symmetric (no theoretical assumptions for the factors) and mathematically simple.

4. DATABASE

The data used in this paper comes from the World Input-Output Database (WIOD), as described by Timmer *et al.* (2015) and Dietzenbacher *et al.* (2013). This is a free-access database financed by the EU and developed to analyze the effects of globalization on trade patterns, environmental pressures and the socioeconomic development of a large group of countries. The WIOD database is heavily grounded on official statistics from the national statistical institutes of the countries listed. WIOD opened to the public on 16 April 2012. The data include world input-output tables for the 27 European Union countries and 13 other major world economies. It covers the period of 1995-2013 and includes 35 industries and 59 commodities.

The WIOD environmental accounts offer information on sectoral energy consumption and CO_2 emissions, but only for the period 1995-2009. Emission relevant energy use is considered for the calculations in order to avoid double counting.

Limits in data concerning emissions have determined the period studied for this analysis as 1995-2009. More specifically, national input-output tables in national currencies and current prices provided by WIOD database have been recalculated into constant 1995 prices. The methodology applied is as follow:

Given that for each year of the 1995-2009 period the TIO to current prices are available as are the TIO prices for hte previous years, thus, it is possible to calculate the variation rate of the transactions between each of the two periods. This variation may also be expressed as an index number. Thus, for example, to say that a variable has increases 50% is similar to stating that a variable has seen a 1.5 times increase as a result of dividing its value for the moment t+1 by its value for the moment t. Having both tables mentioned (TIO for the current prices and TIO for the next year to prices of the previous year) for a couple of years, we may divide this latter among the first and obtain a new TIO, whose elements are index numbers. Each cell of the new matrix would indicate the volume variation observed between the two periods.

Given that there are 15 time periods (from 1995 to 2009), 14 tables of index numbers have been obtained between two consecutive periods. Once the corresponding tables have been obtained, it is then possible to calculate the accumulative index tables for these same time periods. These are obtained by multiplying cell by cell of the corresponding tables in such a way that each new cell would show just how much the inter-sectorial transactions have varied between any two time periods. For example, if the index tables for 1995-96 (T_{96}), for 1996-97 (T_{97}), for 1997-98 (T_{98}) and for 1998-99 (T_{99}) are taken into consideration, it is possible to calculate the table for accumulative indexes for the 1995-99 ($T_{95\text{-}99}$) period, such as

$$T_{95-99} = T_{96} \cdot T_{97} \cdot T_{98} \cdot T_{99} \quad (10)$$

Each of the cells on the resulting table shows the variation of the inter-sectorial transactions between 1995 and 1999.

As of the 14 accumulative index tables, all of the TIO to constant prices could be obtained for each year. To do this, the TIO to current prices for the year was multiplied, which becomes the base—in this case, it was 1995—for each of the periods for the accumulative index table. In the example, the table to constant prices for 1999 would result from multiplying the TIO for the year 1995 (TIO_{95}) by the corresponding accumulative index table of our example ($T_{95\text{-}99}$).

This procedure must be completed with an RAS adjustment, given that there are variations in the rows (employment) and the total columns (resources) of the TIO calculated. The origin of these variations has to be sought in the actual magnitude of the table (it is a table with 35 sectors, to which the values of the components of the final demand and added value must be added) and the complexity of the calculation; this has the prices of the previous year (previous treatment). Specifically, to create the accumulative index tables, the table is multiplied up to fourteen times.

5. RESULTS

Table 1 shows values for changes in each decomposition factor (columns 2 to 7) and the total changes in CO_2 emissions (column 8). Figures are related to the years expressed in column 1.

Table 1. Contributions of decomposition factors to CO_2 emissions changes.

	Δe_C	Δe_E	Δe_L	Δe_S	Δe_D	Δe_F	Δe
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
1995-1996	-15,473	-7,663	820	557	1,007	4,262	-16,488
1996-1997	3,662	4,173	-2,035	-5	2,212	10,043	18,049
1997-1998	-3,831	2,001	-2,654	-2,664	981	9,583	3,417
1998-1999	8,500	-8,436	3,973	4,951	835	12,228	22,051
1999-2000	-8,472	-8,124	8,173	-1,006	1,517	17,816	9,905
2000-2001	-6,550	-6,552	8,005	195	-50	6,377	1,425
2001-2002	12,503	1,159	-1,512	430	-348	4,094	16,326
2002-2003	-15,325	13,563	-1,764	-1,737	-491	5,750	-4
2003-2004	7,794	-1,069	1,957	-217	-682	9,068	16,852
2004-2005	4,875	-14,193	14,119	-1,108	-364	10,335	13,663
2005-2006	-4,254	-29,432	5,910	1,316	1,146	15,629	-9,685
2006-2007	4,606	-4,457	-3,411	-1,483	379	13,143	8,775
2007-2008	-15,199	-13,485	4,036	461	-2,115	-409	-26,711
2008-2009	-13,693	6,845	4,557	-4,182	-4,703	-19,007	-30,183

Source: Own elaboration.

From the figures of Table 1, Spain's CO_2 emissions increased for most of the period under consideration. This not goes against the EU commitment derived from Kyoto's Protocol. In fact, Spain was one of the EU member states that could increase its emissions level from the 1990 value. However, from 2005 onward, CO_2 emissions trend showed negative values for most years--2007 was the only exception. So, after implementing the Kyoto protocol (2005-2007) and after stage one of Kyoto (2008-2009), the European Union's mitigation commitments seems to impact on Spain's CO_2 emissions. Now, an effect by effect analysis is carried out.

Changes in the carbonization factor Δe_C fails to follow a regular path during the 1995-2009 period, although some periods are negative (1995/96, 1997/98, 1999/00, 2000/01, 2002/03, 2005/06, 2007/08, 2008/09) thus contributing positively to diminishing CO_2. The results are similar to those of Cansino et *al.* (2015) by using a

LMDI approach. Despite these unclear results, it is possible to carry out a richer analysis based of figures from Tables 2 and 3.

Table 2. Gross energy inland consumption. Thousand tonnes of oil equivalent (TOE)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Solid fuels	18,987.4	16,099.8	18,285.4	17,484.7	19,620.9	20,937.6	19,145.2	21,655.4	20,114.9	20,940.3	20,565.7	18,382.9	19,748.3	13,978.7	10,608.6
Total petroleum products	54,885.1	52,629.8	56,086.0	60,455.2	62,984.9	63,966.6	66,268.6	66,402.3	68,244.2	69,942.3	70,457.3	70,138.1	70,673.9	67,703.1	62,852.1
Gas	7,791.6	8,680.1	11,336.7	11,651.2	13,319.1	15,304.7	16,433.3	18,783.9	21,387.3	25,210.0	29,885.6	31,271.9	31,825.9	34,953.6	31,264.1
Nuclear heat	14,304.8	14,530.5	14,264.3	15,217.5	15,181.1	16,046.3	16,433.7	16,255.2	15,960.9	16,407.4	14,842.4	15,509.7	14,214.0	15,212.3	13,609.9
Renewable energies	5,507.3	6,984.7	6,643.7	6,781.9	6,028.0	6,815.1	8,156.6	6,894.1	9,195.7	8,815.6	8,397.7	9,163.9	10,007.5	10,552.3	12,437.8
Hydro power	*1,984.5*	*3,421.0*	*2,988.2*	*2,922.5*	*1,962.4*	*2,429.6*	*3,515.7*	*1,824.9*	*3,480.9*	*2,672.7*	*1,581.5*	*2,232.1*	*2,348.2*	*2,008.9*	*2,270.9*
Wind power	*23.2*	*31.3*	*63.8*	*116.3*	*235.9*	*406.4*	*581.2*	*803.3*	*1,038.3*	*1,350.0*	*1,820.8*	*2,003.2*	*2,370.4*	*2,832.8*	*3,277.5*
Solar thermal	*24.6*	*25.3*	*22.8*	*25.2*	*28.0*	*31.1*	*35.7*	*40.0*	*44.9*	*53.2*	*61.4*	*73.2*	*94.5*	*128.5*	*197.6*
Solar photovoltaic	*1.3*	*1.0*	*1.1*	*1.3*	*1.5*	*1.5*	*2.1*	*2.6*	*3.5*	*4.8*	*3.5*	*10.2*	*43.0*	*220.3*	*512.6*
Solid biofuels (excl. charcoal)	*3,300.4*	*3,319.8*	*3,388.3*	*3,537.7*	*3,605.5*	*3,623.3*	*3,671.1*	*3,811.7*	*4,061.7*	*4,137.3*	*4,176.0*	*4,206.3*	*4,231.7*	*4,207.1*	*4,579.8*
Biogas	*75.4*	*76.7*	*78.5*	*81.5*	*89.9*	*131.2*	*134.3*	*170.0*	*256.6*	*295.1*	*299.5*	*207.9*	*216.8*	*206.8*	*193.6*
Municipal waste (renewable)	*93.7*	*105.5*	*96.8*	*93.3*	*99.4*	*114.7*	*139.3*	*97.4*	*113.7*	*122.2*	*189.3*	*252.1*	*309.2*	*328.1*	*319.2*
Biogasoline	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*71.7*	*98.5*	*73.9*	*113.1*	*114.4*	*114.4*	*116.3*	*150.8*
Biodiesels	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*71.8*	*71.8*	*67.1*	*92.2*	*100.9*	*145.3*	*56.5*	*270.0*	*492.4*	*922.1*
Geothermal Energy	*4.1*	*4.1*	*4.1*	*4.1*	*5.3*	*5.4*	*5.4*	*5.4*	*5.4*	*5.4*	*7.3*	*8.0*	*9.3*	*11.0*	*13.7*
Electrical energy	385.7	91.1	-264.2	292.5	491.7	381.9	296.6	458.2	108.6	-260.4	-115.5	-282.0	-494.5	-949.2	-696.8
Waste (non-renewable)	214.1	235.6	252.5	250.2	255.6	189.5	139.3	97.4	113.7	122.2	189.3	252.1	309.2	328.1	319.2
All products	**102,076.0**	**99,251.7**	**106,604.4**	**112,133.2**	**117,881.3**	**123,641.6**	**126,873.4**	**130,546.4**	**135,125.3**	**141,177.4**	**144,222.6**	**144,436.7**	**146,284.3**	**141,778.9**	**130,394.9**

Source: Eurostat (2014)

Table 2 shows the total gross, inland energy consumption in Spain for the 1995-2009 period. During the 2006-2009 sub-period, when the carbonization factor Δe_C has negative values, Spain's energy mix was cleaner and helped reduce total CO_2 emissions. When the carbonization factor Δe_C has negative values, as shown on Table 2, there is a lesser use of coal as a primary energy source while at the same time, an increase in the use of natural gas (a low carbon emission source).The same occurs when there is a decrease in the use of total petroleum products as primary energy source. During the sub-period 2006-2009, the lesser use of coal and total petroleum products were added to the higher use of RES; this led to an important decrease in the CO_2 emissions. This is coherent with the implementation of the 2005-2007 Kyoto Protocol and the initial state of said Protocol (2008- 2009).

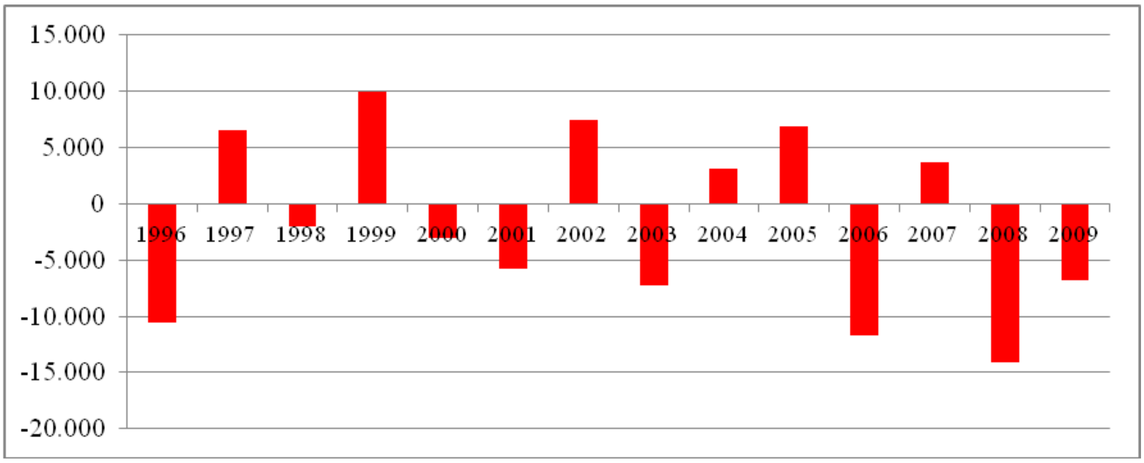
RES, as a whole, showed an increasing trend for 1995-2009 but not all clean technologies follow the same path. The contribution of hydropower to renewable energies is quite unique because it depends directly on rainfall. The main contribution of technologies to total RES is due to biomass (solid biofuels) that were used for heating but also as a fuel in combined cycled plants to generate power. At any rate, wind energy was the one technology with the greatest deployment during 1995-2009. Deployment of PV, solar thermal technology and the use of biodiesel (despite its unclear desirable effects, Sanz *et al*., 2014) must be stressed for 2007-2009. In fact, with Kyoto's first stage (2008- 2009) Spain's authorities implemented a very strong policy towards RES. In addition to the feed-in tariffs, the government also adopts direct public funding, subsidized loans and tax credits to encourage wind and solar power, biomass, biofuels and small hydro plants. The G-20 Clean Energy Fact book (2010) pointed out Spain as the 5th largest G-20 investor in renewable energies and the 1st in clean energy investment intensity (clean energy investment as a percentage of GDP).

In summary, Table 2 shows that the positive contribution of the carbonization effect that decreases CO_2 emissions in most of the periods are due to a lesser use of coal and petroleum products and an increase in RES used in 2008-2009 (Kyoto's first stage). That is, clean technologies have a main effect against CO_2 emissions from the carbonization effect point of view.

If changes in the carbonization factor are analyzed by sectors (Table A.2 of Appendix 2), the electricity, gas and water supply sectors are the most important, followed by Transportation, Other Non-metallic Mineral and Coke, and the Refined Petroleum sectors. In these sectors, the changes in the carbonization factor do not follow a defined trend but they do show the highest values.

Figure 1 shows the carbonization factor trend in the electricity, gas and water supply sector. When the carbonization factor is compared to the primary energy consumption for power generation, a similar path could be found between the coal consumption and the carbonization factor. This sector shows the most important changes in the carbonization factor during the previously mentioned 2006-2009 period. As a result, the increase in the use of RES for electricity is one of the main drivers diminishing CO_2 emissions in Spain.

Figure 1. Carbonization factor's trend in Electricity, gas and water supply sector *(kt)*



Source: Own elaboration

Other pollutant sectors include coke, refined petroleum and other non-metallic minerals. In these sectors, coal is an important energy source as seen in Table 3 and therefore coal consumption might explain an important percentage of CO_2 emission changes due to the carbonization factor. It is important to note the decrease in the use of coal as of 2005. This applies to of two Kyoto's sub-periods considered (2005-2007) and (2008-2009).

Table 3. Coal consumption in cement factories in Spain (*miles tn*)

	Coal consumption	**Cement factories**
2000	3,580	310
2001	3,794	299
2002	3,593	245
2003	3,611	221
2004	4,555	163
2005	4,316	175
2006	3,662	210
2007	3,740	387
2008	3,491	280
2009	2,363	35

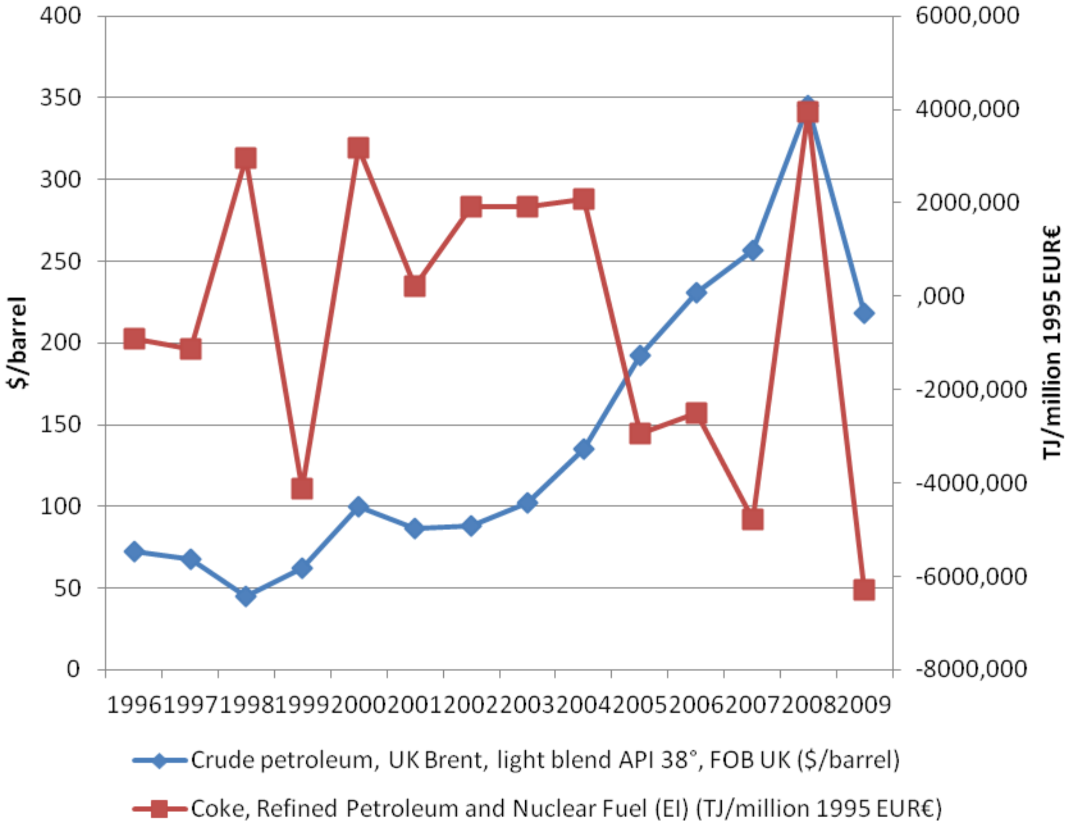
Source: Ministerio de Industria, Energía y Comercio (2001-2010)

The changes in the energy intensity effect (Δe_E) follow an irregular path. Sometimes, this effect contributes negatively to the CO_2 emissions' cut down (1996-1998, 2001-2003 and 2008-2009), while in others, it contributes positively. However, the longest period when the energy intensity factor contributes positively corresponds to the years 2003-2008, prior to implementing Kyoto. 2008-2009 was characterized by a negative contribution of the energy intensity factor to decrease CO_2 emission; the explanation for this situation was the commencement of Spain's economic recession. That is due to lower use of the productive capacities and maintaining the same consumption pattern, explained, to a large extend, by the increase in the consumption per production unit; that is, energy intensity.

Our attention is drawn to the positive contribution of the energy intensity factor to decreasing CO_2 emissions during 2003-2008. Relevant sectors for those years include Other Non-metallic, Oil and Electricity sectors. Although the European Energy Efficiency Directive was not approved until 2012 (European Commission (2012), the government of Spain applied a number of political measures in 2003 to enhance energy efficiency. That year, Spain's Strategy for Energy Saving and Efficiency (Ministerio de Economía, 2003) was approved. This was the first and most important policy measure aimed at promoting efficiency and energy saving. The first energy efficiency plan was implemented in 2004-2008, followed by the Action Plan 2008-2012 (Ministerio de Industria, Turismo y Comercio, 2008).

After 2004, the international oil prices began to rise significantly as shown in Figure 2. As a consequence of the price spike in 2004, the industrial and the residential sectors responded to that market trend with a decrease in the consumption of oil-derived products.

Figure 2. Oil price per barrel and the contribution of the EI factor for the Coke, Refined Petroleum and Nuclear Fuel sector.



Source: UNCTAD (2014)

In summary, since 2004, the changes in energy intensity factor in Spain's economy might be affected by the upward trend in oil prices, and the implementation of policy aimed at promoting energy efficiency.

The analysis of energy intensity factor by sectors is displayed in Table A.3 in Appendix II. The Table A.3 shows that the most important sectors that contribute to the changes in energy intensity factor are Coke and Electricity sectors. Special attention must be paid to 2004-2009; two Kyoto sub-periods (2005-2007) and (2008-2009) and in the EU Emissions Trading System—EU ETS— (European Commission, 2003). This is the longest period in which the Coke sector shows a positive contribution to Spain's decarbonizing trend. In 2005, the first national plan of GHG emissions allowances (Ministry of the Presidency, 2004) was applied, which extended up to 2007. After this plan, another two were approved for 2008-2012 and 2013-2020. Those two productive sectors received most of the emission allowances free of charge but only for this first period. As it well known, ETS is one of the available tools for pricing carbon; thus the behavior of these two relevant sectors oriented towards enhancing their energy intensity is coherent with such a tool.

Together with the Coke and Electricity sectors, other industrial sectors show a great influence on changes in the energy intensity factor. That is the case for the sectors "Other non-metallic materials," "Air transport," "Inland transport," "Agriculture" and "Basic metals." Neither of them shows a regular trend in their sign, so for some years, they act as a driver of CO_2 emissions while others do not. Efficiency measures seem unsuccessful in these sectors, although in the case of inland transport, major efforts were made in the energy efficiency policies implemented. In fact, during the 2005-2008 period, the inland transport sector contributed positively to decreasing CO_2 emissions through the energy intensity factor. This implies that there is room for policy measures oriented towards promoting the use of Flexible Fuel Vehicles and Electrical Vehicles (Sánchez-Braza et at, 2014). The work of Cansino et *al.* (2015) also analyzes this effect, to show similar results to those appearing in this work, not only regarding total data, but also when analyzing the data by sectors.

The technology effect (Δe_L) is affected by the change in Leontief inverse matrix and provides information about changes in CO_2 emissions due to alterations in productive structure of the economy. A detailed consideration by sectors based on Table A.5 in Appendix II shows that the Electricity sector is the main driving force, as it contributes to increasing CO_2 emissions during most periods, except in 1996/1997, 1997/1998, 2001/2002 and 2006/2007. Other relevant sectors are “Other non-metallic materials” and “Coke, Refined Petroleum and Nuclear Fuel”. Cansino *et al.* (2015) does not consider the technology effect due to limits of the LMDI approach. In this sense, SDA carried out in this paper offers richer results. From a sectoral perspective, major findings point to the Electricity sector driving CO_2 emissions. A previous paper by Alcántara *et al.* (2010) offers similar findings.

The structural demand effect (Δe_S) is the fourth factor under analysis. It can be observed that the weight of “Refined sector” and “Electricity sector” on final values are very high. There are two, well-differentiated sub-periods from the sign point of view. For most of the years between 1995 and 2001, the demand effect drives CO_2 emissions in Spain. The exception is 1998. However, for the sub-period 2002-2009, the demand effect shows a negative sign, meaning that it contributes negatively to CO_2 emissions and only for 2006, does it act as a driver.

A richer analysis of e_S effect could be derived from a two level analysis, as inspired by Xu and Ang (2014). To do that, e_S effect is decomposed into components of final demand. Table 4 shows results.

Table 4. Broken down of e_S into final demand categories

	Comsumption	Gross Capital	Public Expenditure	Exports	Total e_S
1995-96	1,290.6	-686.0	135.2	-182.7	557.1
1996-97	-580.5	303.0	-135.5	408.0	-5.0
1997-98	-578.9	-401.7	130.6	-1,813.8	-2,663.9
1998-99	3,403.6	323.5	47.4	1,176.3	4,950.8
1999-00	406.2	-1,503.5	453.0	-362.0	-1,006.3
2000-01	416.5	969.7	-43.2	-1,148.4	194.7
2001-02	-183.2	400.6	-87.4	300.4	430.4
2002-03	-756.6	-323.6	57.7	-714.2	-1,736.8
2003-04	-1,537.2	584.8	67.0	668.5	-216.9
2004-05	-1,178.9	-277.6	77.8	270.9	-1,107.8
2005-06	1,348.8	-416.1	44.2	339.7	1,316.6
2006-07	-1,638.6	-756.6	-18.2	929.9	-1,483.5
2007-08	-308.2	-159.3	-139.5	1,068.2	461.1
2008-09	-2,384.2	249.7	-252.4	-1,795.5	-4,182.4

Source: Own elaboration

For most of the years from 2002 onwards, private consumption has contributed to reduce CO_2 emissions, so consumption patterns focus on sectors with less embodied CO_2 emissions. The same could be said of gross capital. However, for most of the years, public expenditure had driven CO_2 emissions; only when the budget constraints were applied due to recession did the sign move to negative. No clear pattern appears when looking into export figures.

A sectoral analysis from Table A.5 in Appendix II helps find some keys to understanding what happened. If we focus on sectors oriented towards final demand consumption, they show a negative sign for sub-period 2007-2009 (Kyoto's first stage). Indeed, for the "Coke sector" which shows a positive value for 2007, this is lower in 2006 and turns negative in 2009. This is coherent with what happened in the cases of the Food, Leather, Wood and Pulp sectors. Another sector oriented towards the final demand as is the case of Manufacturing that shows a similar trend. Displacement from domestic sectors to imports might explain this fact. This change might displace CO_2

emissions from Spain to import countries. By using a multiregional analysis that is also based on WIOD database, it could be feasible to find information for the carbon footprint. Available results offered by Arto *et al.* (2012) and Mundaca *et al.* (2015) for the Swedish case seems to support our hypothesis. Any case, this interesting issue exceeds the aim of this paper.

The discussion factor Δe_D (final demand pattern) is similar to that made for factor Δe_S. For most of the years as of 2001, the final demand has contributed to reducing CO_2 emissions for the sub-period (2005-07), which is an exception. Two relevant sub-periods must be stressed in the analysis of e_D effect; during 1995-2000 (before European Directive 2001/77/EC), it drives CO_2 emissions. With the implementation of the Kyoto Protocol, it acted against them. The four main sectors that contribute to this effect are Other Non-metallic Minerals, Metallurgy, Refined Petroleum and the Electricity sectors. Their contribution for most of the period considered (1995-2007) is to reduce emissions uninterruptedly. In the last two years (2007-09), although its contribution was positive, and limited, it had no effect on global values.

As in the previous case, a richer analysis of e_D effect may be derived from a two-level analysis by decomposing it into components of final demand as Table 5 shows.

Table 5. Broken down of e_S into final demand categories

	Comsumption	Gross Capital	Public Expenditure	Exports	Total e_D
1995-96	-1,592.4	-100.5	-162.3	2,862.6	1,007.4
1996-97	-2,771.5	-466.6	-467.4	5,917.4	2,211.8
1997-98	-1,916.1	1,986.5	-247.2	1,158.0	981.1
1998-99	-1,094.2	1,651.6	-325.7	603.1	834.7
1999-00	-2,978.8	-118.7	-439.5	5,053.9	1,516.8
2000-01	-388.4	200.9	79.4	58.3	-49.7
2001-02	-911.7	1,412.1	295.4	-1,144.1	-348.4
2002-03	-765.6	948.7	371.9	-1,046.3	-491.2
2003-04	-198.1	-802.8	457.8	-138.6	-681.7
2004-05	-605.3	-83.5	324.0	0.5	-364.3
2005-06	-2,819.3	1,863.3	-227.1	2,329.0	1,145.9
2006-07	-1,319.5	-467.4	26.6	2,138.7	378.4
2007-08	899.4	-1,463.3	1,096.2	-2,647.1	-2,114.8
2008-09	3,446.1	-4,053.1	1,935.0	-6,031.5	-4,703.5

Source: Own elaboration

The discussion on factor e_D is similar to that for factor e_S. For most of the years as of 2002, private consumption has contributed to reducing CO_2 emissions until the recession started. The same could be said about gross capital but also in a period of recession. However, for most of the years, public expenditure drove CO_2 emissions; only when the budget constraints were applied due to recession did the sign turn negative. No clear pattern appears when we look into exports figures.

The last effect is the scale effect (Δe_F). It explains the changes in CO_2 emissions due to changes in the size of the final demand. An increase in the final demand implies a higher production and therefore, greater CO_2 emissions. The scale effect has contributed to increasing CO_2 emissions due to the final demand increase taking place in the decade before 2008. From then, the scale effect started to be negative, and therefore, a lower final demand implied lower emissions. The role of scale effect as a driver of CO_2 has been widely considered by the literature. Economic activity is the major determinant of change in emissions. Our results are in line with those found for other countries by

Freitas and Kaneko (2011), Jeong and Kim (2013), Wang *et al*. (2014), Wu and Zeng (2013) and Ren *et al*. (2014). In any case, thinking in a post crisis scenario, it might be taken into account that Mundaca *et al.* (2013) found a rebound effect in CO_2 emissions for various developed regions.

An analysis of scale effect by sectors leads us to the same previous results. The "Coke, Refined Petroleum," "Electricity, Gas and Water Supply," "Inland Transport" and "Other Non-metallic Minerals" are the most important sectors that explain changes of CO_2 emissions due to this effect. It is noteworthy that all of the sector have a similar behavior for the period studied.

6. Historical results vs current mitigation measures

The results obtained for SDA are useful when analyzing the policy measures established by Spain authorities, mainly those applied after 2009. This comparison allows us to know how well oriented these measures were for the most sensitive sectors and in the behavior when each factor was analyzed.

The measures developed by Spain's authorities focused on mitigating CO_2 emissions and are included in the outline of the document titled 'Strategy for energy efficiency and savings 2004-2012 in Spain –E4- (in Spanish, Estrategia de ahorro y eficiencia energética para España 2004-2012, E4; Ministerio de Economía, 2003). This document has no specific policy measures but only general lines that were necessary in later documents. These later documents could be grouped together in two main groups: a) plans focusing on the development of RES and b) plans oriented towards improving energy efficiency and reducing energy consumption.

The first group of documents includes the document named Renewable Energy Plan (2005-2010) (in Spanish Plan de energías renovables 2005-2010; Ministerio de Industria, Turismo y Comercio, 2005) and the National Action Plan for RES in Spain (PANER) (in Spanish, Plan de acción nacional de energías renovables en España, 2011-2020; Ministerio de Industria, Turismo y Comercio, 2010). Both documents are in line with the past deployment of RES in Spain and are coherent with values of the e_C factor in the last years of the period considered in the SDA.

The second group of documents includes the Action Plan (2008-2012) (Ministerio de Industria, Turismo y Comercio, 2008) and the Action Plan (2011-2020) (Ministerio de Industria, Turismo y Comercio, 2011 a). Both documents include measures oriented to the economic sectors that appear in Table 6.

As can be derived from Table 6, there are a number of differences among the sectors that have previously received attention from the Authorities of Spain and others that should receive attention when taking into consideration the SDA results. This might be due to the fact that SDA reports a finer analysis of the key sectors, while the political documents do not discriminate between a single category titled ‘Industry’. In fact, the multisectoral approach developed by SDA offers useful information that allows the focus to be put on more detailed key sectors. Additionally, in the case of the Agriculture, Hunting, Forestry and Fishing sector, although it receives a lot of attention in political documents, it only plays a significant role for the e_E factor in SDA.

As expected, there are also coincidences between the results from the historical analysis and the measures included in political documents; that is the case of Electricity, Gas and Water Supply Coke, Refined Petroleum and Nuclear Fuel and Other Non-Metallic Mineral sectors; all of them are well-known drivers of CO_2 emissions. Also, in the case of the last five sectors listed in Column 1 of Table 6, they only appear in political documents related to a single measure that is used to develop energy audits but it is not mandatory. Regarding the Public Administration sector, it receives lot of attention in political documents but not its components (Health, Education…) and it appears as a key sector from SDA. However, this could be explained if its role is observed when e_S and e_D are broken down into final demand categories as shown on Tables 4 and 5.

Table 6. Key sectors from SDA and from political documents

Relevant from Spanish political measures	Factors implied
Electricity, Gas and Water Supply	e_C, e_E, e_L, e_S, e_D, e_F
Coke, Refined Petroleum and Nuclear Fuel	e_C, e_E, e_L, e_S, e_D, e_F
Other Non-Metallic Mineral	e_C, e_E, e_L, e_D, e_F
Inland Transport	e_E, e_F
Basic Metals and Fabricated Metal	e_E, e_D
Air Transport	e_E
Agriculture, Hunting, Forestry and Fishing	e_E
Public Administration	Not relevant from SDA
Construction	Not relevant from SDA
Chemicals and Chemical Products	Not relevant from SDA
Textiles and Textile Products	Not relevant from SDA
Pulp, Paper, Paper , Printing and Publishing	Not relevant from SDA
Wood and Products of Wood and Cork	Not relevant from SDA
Retail Trade; Repair of Household Goods	Not relevant from SDA

Source: Own elaboration

For discussion, it could be said that the historical SDA analysis supports most of the measures put into force by Spain's Authorities after the period under consideration. However, these authors consider that other measures oriented towards mitigating CO_2 should be included in future political documents considering the SDA results.

Our recommendation is that it might be useful to insert tax benefits into programs for energy efficiency improvements in Spain for those companies that show reductions in their energy intensity ratios. We recommend including such tax benefits in the areas of Corporation Tax and Personal Income Tax. These measures include energy-use auditing and analysis and investment in profitable efficiency improvements, etc. Undertaking energy audits (as those actually included in the applicable political documents) enables the fundamental energy parameters of the process and its equipment to be determined, as well as an awareness of the deviations with regard to the energy standard of the sector.

Measures to be considered might not be significantly affected by the company productivity. The Swedish Program for Improving Energy Efficiency (Swedish Energy Agency, 2005) could be an example for such measures.

7. Conclusions and policy implications

The historic analysis carried out for the 1995-2009 period concludes the following for each of the factors analyzed:

Carbonization effect: For the two periods linked to the Kyoto Protocol (2005-2007) and (2008-2009), a change in Spain's energy mix contributed to reducing CO_2 emissions. Mainly, this change implied a lesser use of coal as a primary energy source and a higher share of RES in the energy matrix. However, it must be pointed out that the contribution of high hydro power to RES depends on rainfall.

From a sectoral perspective, the Electricity sector shows to have the greatest impact on total value of the carbonization effect. By substituting coal as primary energy source, RES appears as a main factor in the mitigation of CO_2. Coke, Refined Petroleum and Other Non-metallic Mineral sectors might remain in the core of political measures oriented towards mitigation due to their weight in the carbonization effect trend.

Energy intensity effect: Looking at the intensity effect, an initial view of the findings let us to conclude that neither European directive 2001/77/EC nor the Kyoto Protocol seem to explain its positive contribution to CO_2 mitigation as of 2003 (with the only exception being 2009). However, if we review these findings, it can be concluded that measures implemented by the government of Spain oriented towards energy efficiency and the upward trend in oil prices could explain the behavior of this effect, as it works in the same way as the carbonization effect in reducing CO_2 emissions.

When the energy intensity effect is analyzed from a sectoral perspective, EU ETS seems to have driven Coke and Electricity sectors in Spain to enhance their energy intensity. Although after economic crisis began, the EU ETS probably fell, for the period 2004-2009, as it acted as the driving force behind the mitigation of CO_2 for these relevant sectors in Spain. Together with these findings, the results allow us to conclude that there is room for policy measures to promote the use of Flexible Fuels Vehicles and Electrical Vehicles.

Technology effect: If two previous effects acted together against CO_2 emissions after the implementation of the Kyoto Protocol, the effect of technology reveals the Electricity sector as the driving force behind CO_2 emissions in Spain. This effect is derived from changes in the inter-sectoral relationship and is a broad analysis based on an LMDI approach. The weight of the Electricity sector as a driver of CO_2 emissions means that Electricity is still a crucial input for most of the sectors in Spain's economy. The lesson learned is clear: less intensive technologies in electricity consumption are need.

Structural demand effect: The structural demand effect captures the weight of 35 productive sectors in the four categories of the final demand (private consumption, gross capital, public expenditure and exports). A major finding is that prior to the European directive 2001/77/EC, this factor drove CO_2 emissions although with no significant values as a hole. The exception was 1998.

Since 2001, and during the two Kyoto Protocol periods (2005-2007) and (2008-2009), structural demand effect contributed negatively to CO_2 emissions with the only exception being 2006. It might be stressed that for most of the negative value years, this effect is not significant. The picture changed after Kyoto first stage (2008-2009); then, the effect acted strongly against CO_2 emissions. From a sectoral perspective, the results recommend further analysis to verify whether there is a displacement of CO_2 emissions from Spain to imports countries. Further analysis might incorporate not only a multi-sectoral approach but also a multi-regional one for this paper.

Final demand effect: The impact of final demand effect on CO_2 emissions seems to also be affected by measures considered in this paper to break down the entire 1995-2009 period into relevant sub-periods. After the implementation of the Kyoto Protocol, this effect acted against CO_2 emissions. From a sectoral point of view, four sectors might receive special attention from authorities: these are Other Non-metallic Minerals, Steel, Oil and Crude Refined and Electricity sector.

Both the final and structural demand effects offer interesting findings when a two-level decomposition is carried out. The attention that Public Administration sector receives in current political document against CO_2 emissions could be explained after this decomposition.

The last effect under consideration is the scale effect. This is a usual factor in decomposition analysis (either LMDI or SDA) and the results were as expected as a driver of CO_2 emissions until the crisis started. An interesting finding appears for 2006–prior to the onset of the crisis. For this year, the carbonization factor, energy intensity factor, and structural demand factor over compensated the role of the technology effect and scale effect as CO_2 drivers, in which case, total emissions decreased. In any case, a risk of a rebound effect in a post-crisis scenario does exist.

These results allow us to conclude that that the implementation of the Kyoto Protocol seems to have an impact on CO_2 emissions trends in Spain, together with European Directives related to the promotion of RES. Specifically, the EU ETS as a pricing carbon tool seems to be effective in decisions for certain crucial sector despite its fall at the beginning of the economic crisis. This allows us to recommend other pricing carbon tools.

By comparing a historical analysis with Spain's political measures currently in force, it could be said that they focus properly on the key sector that could act as CO_2 emission drivers.

In light of major finding and after reviewing the current mitigation measures in Spain, a number of policy recommendations are given to avoid the rebound effect and to enhance the fight against Climate Change. We recommend the insertion of tax benefits into Spain's programs for energy efficiency improvements for those companies that prove reductions in their energy intensity ratios. In a more accurately way, we recommend including such tax benefits in the areas of Corporation Tax and Personal Income Tax.

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APPENDIX 1

Table A.1 Structural decomposition for the first sum component

Total different decomposition forms: $2^{n-1} = 2^{6-1} = 32$	
Decomposition pattern 1. Ningún factor valorado en t+1	
Number of different decomposition forms: $\frac{(n-1)!}{(n-1-k)!\cdot k!} = \frac{(6-1)!}{(6-1-0)!\cdot 0!} = 1$ Frequency of every component: $(n-1-k)!\cdot k! = (6-1-0)!\cdot 0! = 120$	
Forms of decomposition	Frequency
1. $\widehat{\Delta C}\cdot\widehat{E_0}\cdot L_0\cdot S_0.\widehat{D_0}\cdot f_0$	120
Decomposition pattern 2. Un factor valorado en t+1	
Number of different decomposition forms: $\frac{(n-1)!}{(n-1-k)!\cdot k!} = \frac{(6-1)!}{(6-1-1)!\cdot 1!} = 5$ Frequency of every component: $(n-1-k)!\cdot k! = (6-1-1)!\cdot 1! = 24$	
Forms of decomposition	Frequency
2. $\widehat{\Delta C}\cdot\widehat{E_1}\cdot L_0\cdot S_0.\widehat{D_0}\cdot f_0$	24
3. $\widehat{\Delta C}\cdot\widehat{E_0}\cdot L_1\cdot S_0.\widehat{D_0}\cdot f_0$	24
4. $\widehat{\Delta C}\cdot\widehat{E_0}\cdot L_0\cdot S_1.\widehat{D_0}\cdot f_0$	24
5. $\widehat{\Delta C}\cdot\widehat{E_0}\cdot L_0\cdot S_0.\widehat{D_1}\cdot f_0$	24
6. $\widehat{\Delta C}\cdot\widehat{E_0}\cdot L_0\cdot S_0.\widehat{D_0}\cdot f_1$	24
Decomposition pattern 3. Dos factores valorados en t+1	
Number of different decomposition forms:	

$$\frac{(n-1)!}{(n-1-k)!\cdot k!}=\frac{(6-1)!}{(6-1-2)!\cdot 2!}=10$$

Frequency of every component:

$$(n-1-k)!\cdot k!=(6-1-2)!\cdot 2!=12$$

Forms of decomposition	Frequency
7. $\widehat{\Delta C}\cdot \widehat{E_1}\cdot L_1\cdot S_0.\widehat{D_0}\cdot f_0$	12
8. $\widehat{\Delta C}\cdot \widehat{E_1}\cdot L_0\cdot S_1.\widehat{D_0}\cdot f_0$	12
9. $\widehat{\Delta C}\cdot \widehat{E_1}\cdot L_0\cdot S_0.\widehat{D_1}\cdot f_0$	12
10. $\widehat{\Delta C}\cdot \widehat{E_1}\cdot L_0\cdot S_0.\widehat{D_0}\cdot f_1$	12
11. $\widehat{\Delta C}\cdot \widehat{E_0}\cdot L_1\cdot S_1.\widehat{D_0}\cdot f_0$	12
12. $\widehat{\Delta C}\cdot \widehat{E_0}\cdot L_1\cdot S_0.\widehat{D_1}\cdot f_0$	12
13. $\widehat{\Delta C}\cdot \widehat{E_0}\cdot L_1\cdot S_0.\widehat{D_0}\cdot f_1$	12
14. $\widehat{\Delta C}\cdot \widehat{E_0}\cdot L_0\cdot S_1.\widehat{D_1}\cdot f_0$	12
15. $\widehat{\Delta C}\cdot \widehat{E_0}\cdot L_0\cdot S_1.\widehat{D_0}\cdot f_1$	12
16. $\widehat{\Delta C}\cdot \widehat{E_0}\cdot L_0\cdot S_0.\widehat{D_1}\cdot f_1$	12

Decomposition pattern 4. Tres factores valorados en t+1

Number of different decomposition forms:

$$\frac{(n-1)!}{(n-1-k)!\,k!}=\frac{(6-1)!}{(6-1-3)!\cdot 3!}=10$$

Frequency of every component:

$$(n-1-k)!\,k!=(6-1-3)!:3!=12$$

Forms of decomposition	Frequency
17. $\widehat{\Delta C}\cdot \widehat{E_1}\cdot L_1\cdot S_1.\widehat{D_0}\cdot f_0$	12
18. $\widehat{\Delta C}\cdot \widehat{E_1}\cdot L_1\cdot S_0.\widehat{D_1}\cdot f_0$	12
19. $\widehat{\Delta C}\cdot \widehat{E_1}\cdot L_1\cdot S_0.\widehat{D_0}\cdot f_1$	12

20. $\widehat{\Delta C} \cdot \widehat{E_1} \cdot L_0 \cdot S_1 . \widehat{D_1} \cdot f_0$	12
21. $\widehat{\Delta C} \cdot \widehat{E_1} \cdot L_0 \cdot S_1 . \widehat{D_0} \cdot f_1$	12
22. $\widehat{\Delta C} \cdot \widehat{E_1} \cdot L_0 \cdot S_0 . \widehat{D_1} \cdot f_1$	12
23. $\widehat{\Delta C} \cdot \widehat{E_0} \cdot L_1 \cdot S_1 . \widehat{D_1} \cdot f_0$	12
24. $\widehat{\Delta C} \cdot \widehat{E_0} \cdot L_1 \cdot S_1 . \widehat{D_0} \cdot f_1$	12
25. $\widehat{\Delta C} \cdot \widehat{E_0} \cdot L_1 \cdot S_0 . \widehat{D_1} \cdot f_1$	12
26. $\widehat{\Delta C} \cdot \widehat{E_0} \cdot L_0 \cdot S_1 . \widehat{D_1} \cdot f_1$	12
Decomposition pattern 5. Cuatro factores valorados en t+1	
Number of different decomposition forms: $\frac{(n-1)!}{(n-1-k)! \cdot k!} = \frac{(6-1)!}{(6-1-4)! \cdot 4!} = 5$ Frequency of every component: $(n-1-k)! \cdot k! = (6-1-4)! \cdot 4! = 24$	
Forms of decomposition	Frequency
27. $\widehat{\Delta C} \cdot \widehat{E_1} \cdot L_1 \cdot S_1 . \widehat{D_1} \cdot f_0$	24
28. $\widehat{\Delta C} \cdot \widehat{E_1} \cdot L_1 \cdot S_1 . \widehat{D_0} \cdot f_1$	24
29. $\widehat{\Delta C} \cdot \widehat{E_1} \cdot L_1 \cdot S_0 . \widehat{D_1} \cdot f_1$	24
30. $\widehat{\Delta C} \cdot \widehat{E_1} \cdot L_0 \cdot S_1 . \widehat{D_1} \cdot f_1$	24
31. $\widehat{\Delta C} \cdot \widehat{E_0} \cdot L_1 \cdot S_1 . \widehat{D_1} \cdot f_1$	24
Decomposition pattern 6. Cinco factores valorados en t+1	
Number of different decomposition forms: $\frac{(n-1)!}{(n-1-k)! \cdot k!} = \frac{(6-1)!}{(6-1-5)! \cdot 5!} = 1$ Frequency of every component: $(n-1-k)! \cdot k! = (6-1-5)! \cdot 5! = 120$	
Forms of decomposition	Frequency

32. $\widehat{\Delta C} \cdot \widehat{E_1} \cdot L_1 \cdot S_1 . \widehat{D_1} \cdot f_1$	120
Total different decomposition forms: n! = 6! = 720	**720**

Source: Own elaboration

APPENDIX 2

Table A.2. Carbonization effect by economic sectors.

	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Agriculture, Hunting, Forestry and Fishing	-33	478	544	-987	-1,294	623	286	-1,979	-1,176	715	1,119	-385	1,044	-128
Mining and Quarrying	428	35	56	259	-343	304	-200	244	121	-323	-7	-46	136	-273
Food, Beverages and Tobacco	-473	199	-405	500	292	280	-565	666	218	324	484	26	-114	-61
Textiles and Textile Products	-180	6	-81	-43	75	433	-41	244	131	69	497	229	97	-1
Leather, Leather and Footwear	-8	5	-15	1	-45	27	-7	39	-11	8	58	28	14	-6
Wood and Products of Wood and Cork	-15	-46	-120	-429	68	29	-10	21	-103	77	85	-45	44	-119
Pulp, Paper, Paper , Printing and Publishing	-308	34	-299	-640	77	484	-240	-316	626	-225	46	-246	349	-179
Coke, Refined Petroleum and Nuclear Fuel	-1,232	365	-327	189	-157	639	1,399	-1,499	775	-974	-890	927	-507	246
Chemicals and Chemical Products	102	210	-318	-191	-650	965	-639	707	-575	-233	-321	307	46	-64
Rubber and Plastics	19	-69	-37	33	-189	-3	-65	127	-225	-247	491	-520	85	-8
Other Non-Metallic Mineral	-2,264	-2,607	681	-2,491	-3,523	-2,277	5,748	-5,734	3,436	-2,939	5,621	-1,258	-4,199	-3,381
Basic Metals and Fabricated Metal	-811	-180	-1,052	392	-248	-1,854	452	-301	-272	2,182	1,391	-588	192	-2,011
Machinery, Nec	-101	-12	-70	14	-75	-86	31	14	59	56	34	4	6	-21
Electrical and Optical Equipment	-37	-8	-26	23	-50	-39	25	27	-19	-26	117	-76	30	-10
Transport Equipment	-258	19	-268	-11	-118	130	80	2	65	364	199	-188	42	-54
Manufacturing, Nec; Recycling	46	-71	-30	78	-56	14	-51	72	-154	-159	498	-331	59	-19
Electricity, Gas and Water Supply	-10,599	6,584	-2,016	10,018	-3,063	-5,744	7,454	-7,194	3,148	6,876	-11,677	3,694	-14,039	-6,783
Construction	-113	220	-519	-149	4	-275	-124	-62	-414	-64	145	-9	176	-93
Sale, Mainten and Repair of Motor Vehicles ...	29	-165	-118	84	28	-109	-1	81	26	-268	-101	273	-272	-143

Wholesale Trade and Commission Trade ...	-69	-83	-48	-24	84	33	-33	113	-62	-122	-374	159	-76	4
Retail Trade; Repair of Household Goods	-69	-15	-87	-7	-22	-13	-32	60	-76	-3	-355	85	-67	-8
Hotels and Restaurants	-6	-24	-16	-7	82	12	-12	-4	-3	2	-44	32	-20	-6
Inland Transport	336	-1,611	729	426	-552	431	18	-1,455	2,484	-1,229	141	828	-500	-531
Water Transport	-38	-159	-66	435	262	219	241	-106	-39	78	145	845	257	-1
Air Transport	254	134	437	1,002	405	-1,052	-935	608	304	849	-337	692	2,111	0
Other Supporting and Aux. Transport Activities	-24	38	13	26	97	44	-69	115	-18	7	-44	185	-27	-3
Post and Telecommunications	-15	28	-4	-16	-83	26	-9	29	-14	-12	-92	23	4	-4
Financial Intermediation	-18	-1	-15	36	80	32	1	35	-5	32	-104	7	2	-11
Real Estate Activities	-7	-3	-9	3	-44	7	-4	3	-5	-3	-31	4	1	0
Renting of M&Eq and Other Business Activities	-8	1	-17	-6	27	7	-4	17	-20	-9	-57	-2	-4	-2
Public Adm and Defence; Comp Social Security	-23	-2	-40	21	25	14	-14	38	-39	41	-157	9	-18	2
Education	-1	1	-3	-1	0	1	-2	4	-3	3	-7	1	0	-1
Health and Social Work	-8	-38	-40	-23	120	27	-41	20	-61	-18	-100	20	-66	-11
Other Community, Social and Personal Services	33	398	-245	-15	315	119	-135	38	-306	44	-629	-76	14	-14
Private Households with Employed Persons	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**-15,473**	**3,662**	**-3,831**	**8,500**	**-8,472**	**-6,550**	**12,503**	**-15,325**	**7,794**	**4,875**	**-4,254**	**4,606**	**-15,199**	**-13,693**

Source: Own elaboration.

Table A.3. Energy Intensity effect by economic sectors.

	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Agriculture, Hunting, Forestry and Fishing	-1,369	-780	-432	1,330	738	-318	-235	1,988	1,351	348	-2,079	-365	-732	-765
Mining and Quarrying	-244	-143	189	-20	394	-519	92	-279	-54	387	-251	12	-82	215
Food, Beverages and Tobacco	-124	124	163	-412	-180	-130	717	-24	-197	-397	-644	-40	226	-201
Textiles and Textile Products	-52	59	35	31	-54	-257	117	14	109	-27	-573	-82	-20	288
Leather, Leather and Footwear	-16	-7	10	22	64	-11	24	-2	39	10	-60	-15	-17	27
Wood and Products of Wood and Cork	-50	65	77	406	-108	11	21	41	143	-75	-125	77	-11	138
Pulp, Paper, Paper , Printing and Publishing	-137	294	45	633	-280	-195	222	786	-529	112	-356	281	-115	-2
Coke, Refined Petroleum and Nuclear Fuel	-1,505	-447	3,805	-7,689	1,121	1,830	436	4,584	203	-3,882	-5,136	-5,031	-202	202
Chemicals and Chemical Products	-1,030	444	-571	129	343	-532	891	-207	774	127	-370	-709	-11	-757
Rubber and Plastics	-100	99	-28	-40	168	11	55	-65	248	211	-500	508	-115	48
Other Non-Metallic Mineral	2,707	1,720	-1,903	34	800	-2,879	-5,260	7,226	-4,906	-164	-8,035	-370	503	7,178
Basic Metals and Fabricated Metal	-276	812	383	-1,157	-117	1,923	-621	322	103	-2,132	-3,112	183	177	1,049
Machinery, Nec	-15	50	-4	-27	81	86	-25	64	-61	-37	-137	-14	-10	81
Electrical and Optical Equipment	0	21	4	-28	39	42	2	8	27	18	-147	72	-26	35
Transport Equipment	-1	23	99	-59	1	36	-60	156	-20	-334	-433	79	122	316
Manufacturing, Nec; Recycling	-87	78	8	-89	48	9	49	-34	149	162	-528	328	-73	54
Electricity, Gas and Water Supply	-5,527	2,280	-962	323	-10,269	-8,627	3,734	-3,015	706	-8,254	-7,950	2,866	-10,209	-5,012
Construction	211	-262	577	158	9	201	-482	17	727	-139	-329	383	-441	-425
Sale, Mainten and Repair of Motor Vehicles ...	-5	4	105	-65	42	105	-88	-75	65	194	160	-312	183	-159

Wholesale Trade and Commission Trade ...	51	3	62	41	28	91	0	-79	90	155	218	-240	61	-108
Retail Trade; Repair of Household Goods	59	-23	87	33	93	64	-16	13	93	-29	206	-127	-56	-117
Hotels and Restaurants	16	13	29	19	-50	22	9	11	24	3	17	-25	-8	-13
Inland Transport	-165	514	1	-1,006	333	1,182	104	2,490	-1,545	620	-748	-583	-1,618	-681
Water Transport	109	-238	-2	-113	-275	-77	93	80	-99	-108	195	-254	-162	-153
Air Transport	-106	-178	-45	-979	-735	1,450	1,268	-417	1,126	-735	753	-683	-745	5,632
Other Supporting and Aux. Transport Activities	0	-43	-14	-37	-68	-61	62	-117	56	-44	-25	-182	-10	-20
Post and Telecommunications	-24	-44	-12	7	74	-23	-8	-16	8	-9	53	-40	-13	-19
Financial Intermediation	19	-1	12	3	-68	-14	-19	-20	-33	-70	-4	-38	-2	17
Real Estate Activities	4	5	7	2	53	-2	0	4	6	6	15	-7	0	-15
Renting of M&Eq and Other Business Activities	1	-2	10	1	-18	5	6	-1	17	1	8	-15	-2	-12
Public Adm and Defence; Comp Social Security	18	2	41	9	10	12	5	-13	25	-38	64	-41	-9	-26
Education	0	-1	3	2	3	1	1	-1	3	-2	1	-3	-1	-1
Health and Social Work	16	8	63	25	-94	26	8	-5	63	-29	33	-47	-47	-23
Other Community, Social and Personal Services	-44	-276	161	79	-249	-13	58	130	221	-41	385	-19	-19	71
Private Households with Employed Persons	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**-7,663**	**4,173**	**2,001**	**-8,436**	**-8,124**	**-6,552**	**1,159**	**13,563**	**-1,069**	**-14,193**	**-29,432**	**-4,457**	**-13,485**	**6,845**

Source: Own elaboration.

Table A.4. Leontief inverse matrix.

	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Agriculture, Hunting, Forestry and Fishing	815	-232	-130	-462	129	-270	-275	-102	-76	-960	340	346	-201	488
Mining and Quarrying	-170	9	-125	-119	-274	114	-20	122	-87	-79	-64	-27	-31	-197
Food, Beverages and Tobacco	-90	-5	40	3	-81	90	-119	2	79	25	-92	-87	-39	194
Textiles and Textile Products	-5	-3	-34	-13	18	-24	12	47	14	20	-59	-139	36	-91
Leather, Leather and Footwear	1	4	-3	-17	-13	-4	-6	-1	-3	-2	-3	-7	5	-2
Wood and Products of Wood and Cork	-1	0	10	5	41	-5	-4	0	-19	-4	-16	-32	-10	-85
Pulp, Paper, Paper , Printing and Publishing	37	-134	-34	-57	4	-63	36	-60	-1	8	-82	-117	-72	81
Coke, Refined Petroleum and Nuclear Fuel	911	-536	-2,322	2,496	-472	-834	-841	-1,588	-210	2,167	790	478	-827	1,777
Chemicals and Chemical Products	-114	-310	218	-466	387	-92	-245	12	-271	-349	-149	-68	269	824
Rubber and Plastics	-9	-14	8	-6	0	21	26	3	-14	34	-65	-21	57	-1
Other Non-Metallic Mineral	-1,433	852	926	1,446	1,043	3,910	-499	-513	832	2,340	418	-732	-859	-5,729
Basic Metals and Fabricated Metal	-12	-630	128	605	-510	456	555	-102	505	-150	-150	-68	-383	-64
Machinery, Nec	6	-19	3	23	-128	127	4	1	31	-33	-18	-21	-13	-2
Electrical and Optical Equipment	4	-8	-2	7	-14	7	-3	-6	6	0	0	-4	5	-10
Transport Equipment	11	-24	-11	8	-10	-16	72	-7	-2	-2	-5	-3	-18	-134
Manufacturing, Nec; Recycling	2	0	4	2	64	9	21	9	36	8	-11	16	4	-4
Electricity, Gas and Water Supply	1,069	-519	-1,126	396	10,129	4,348	-339	154	1,370	10,844	5,671	-3,169	5,704	3,947
Construction	-63	-60	-10	-58	28	68	508	98	-116	221	122	-303	108	276
Sale, Mainten and Repair of Motor Vehicles ...	23	-18	53	-58	-174	50	30	13	43	-30	-83	29	-46	225

Table A.5. Structural demand effect by economic sectors.

	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Agriculture, Hunting, Forestry and Fishing	307	-40	-173	-317	-508	-224	305	-58	-323	-487	155	-76	52	547
Mining and Quarrying	97	6	-137	72	-57	-26	12	-27	27	0	-10	-48	14	-28
Food, Beverages and Tobacco	-72	15	-93	-171	-157	126	48	-57	-11	-97	-324	-117	4	204
Textiles and Textile Products	-27	12	-26	-6	-111	-32	-57	-109	-222	-113	-93	-107	-59	-74
Leather, Leather and Footwear	-3	-3	-1	-10	-15	1	-10	-17	-18	-22	-18	-14	0	-18
Wood and Products of Wood and Cork	-11	-3	-1	2	-23	4	0	-7	-4	-10	-11	-21	-19	-19
Pulp, Paper, Paper , Printing and Publishing	-109	-3	70	-7	71	-8	16	-33	-40	0	-29	-82	-92	-38
Coke, Refined Petroleum and Nuclear Fuel	877	260	-2,269	4,217	-1,866	-1,995	-1,262	-1,612	-130	1,573	3,768	2,732	1,231	-802
Chemicals and Chemical Products	13	-121	109	167	-685	248	92	96	-48	293	-243	12	-236	79
Rubber and Plastics	-5	-7	14	-3	-16	9	-9	-1	3	-17	-11	-3	-8	-4
Other Non-Metallic Mineral	-1,171	-67	-222	-114	-1,076	1,657	181	-668	41	66	-1,284	-673	-928	-324
Basic Metals and Fabricated Metal	-394	118	-152	-148	246	-408	-276	34	176	-39	178	-2	75	-1,135

Machinery, Nec	15	-12	27	-27	85	-85	-4	-14	-17	-7	37	0	36	-22
Electrical and Optical Equipment	4	-4	5	-10	9	7	-21	-5	-9	-1	-5	-3	-1	-13
Transport Equipment	-53	-3	37	6	1	-38	-63	58	-27	-97	-26	-2	-82	-76
Manufacturing, Nec; Recycling	4	-4	7	2	-68	-13	-23	-12	-18	-23	-15	-39	-5	-25
Electricity, Gas and Water Supply	827	214	383	1,116	1,474	2,053	2,037	1,012	531	-3,157	-7	-2,093	1,603	-1,701
Construction	-93	-25	-55	6	-102	137	86	12	29	-5	-149	-64	-81	92
Sale, Mainten and Repair of Motor Vehicles ...	0	27	24	16	82	25	37	7	28	42	-50	45	-92	98
Wholesale Trade and Commission Trade ...	0	12	-7	-2	-85	4	-6	26	25	-11	-28	21	-23	-40
Retail Trade; Repair of Household Goods	0	0	2	-7	-25	22	10	0	9	15	-3	16	39	16
Hotels and Restaurants	-2	-3	-5	-4	-10	-9	0	11	2	-7	-1	-8	-1	16
Inland Transport	232	-42	-63	169	1,001	-1,007	-107	-436	82	382	-168	-614	65	-568
Water Transport	-164	-130	-15	-28	-49	44	-103	30	117	-32	-141	-281	68	-73
Air Transport	252	-185	-167	4	713	-365	-482	34	-482	537	-268	-64	-1,126	-339
Other Supporting and Aux. Transport Activities	4	-4	3	5	11	3	1	3	-1	30	-2	0	-8	-7

Post and Telecommunications	9	2	7	6	12	14	6	-2	7	10	3	8	3	2
Financial Intermediation	4	5	5	-4	86	0	-4	4	23	24	23	14	-1	-8
Real Estate Activities	0	0	0	-1	-3	0	1	1	-1	-1	-2	0	1	1
Renting of M&Eq and Other Business Activities	1	1	4	5	7	2	0	-1	0	5	5	1	-1	1
Public Adm and Defence; Comp Social Security	-5	9	-4	-7	-2	6	-4	3	-3	-6	-3	-2	1	0
Education	0	0	0	0	-1	0	0	0	-1	-1	0	0	0	1
Health and Social Work	2	3	-4	8	-17	-6	11	0	26	35	6	-4	20	36
Other Community, Social and Personal Services	16	-35	35	17	73	49	16	-11	10	13	33	-13	11	42
Private Households with Employed Persons	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**557**	**-5**	**-2,664**	**4,951**	**-1,006**	**195**	**430**	**-1,737**	**-217**	**-1,108**	**1,316**	**-1,483**	**461**	**-4,182**

Source: Own elaboration.

Table A.6. Consumption pattern effect by economic sectors.

	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Agriculture, Hunting, Forestry and Fishing	27	92	-56	-29	55	-17	-89	-80	-20	-30	-34	22	-70	-108
Mining and Quarrying	10	21	20	15	28	2	6	3	-9	-2	26	5	-27	-63
Food, Beverages and Tobacco	-18	-17	-48	-26	-23	-11	-46	-42	-9	-21	-61	-12	-11	27
Textiles and Textile Products	10	26	-4	-2	22	-2	-18	-17	-3	-3	19	25	-36	-101
Leather, Leather and Footwear	3	6	0	0	4	0	-2	-2	0	-1	1	2	-3	-8
Wood and Products of Wood and Cork	3	7	7	6	6	0	1	0	-4	-1	8	1	-11	-25
Pulp, Paper, Paper , Printing and Publishing	17	35	0	0	26	-1	-13	-12	-4	-4	4	7	-17	-32
Coke, Refined Petroleum and Nuclear Fuel	113	293	-17	-14	257	-19	-149	-129	-23	-33	76	161	-266	-567
Chemicals and Chemical Products	116	238	23	1	187	3	-56	-51	8	9	106	114	-109	-269
Rubber and Plastics	12	24	6	4	19	0	-4	-4	-2	-1	11	9	-13	-30
Other Non-Metallic Mineral	394	734	1,017	801	635	79	413	233	-392	-67	968	-13	-876	-2,181
Basic Metals and Fabricated Metal	247	505	219	154	380	13	-14	-33	-71	-16	269	132	-311	-696

Machinery, Nec	13	26	6	4	19	0	-4	-4	-2	-1	10	6	-12	-31
Electrical and Optical Equipment	5	10	4	2	9	0	-1	-1	-1	0	6	3	-6	-15
Transport Equipment	53	103	22	12	77	0	-21	-20	-4	-2	38	33	-46	-108
Manufacturing, Nec; Recycling	1	2	2	2	3	0	-1	-1	-2	-1	5	1	-7	-15
Electricity, Gas and Water Supply	-171	-263	-329	-195	-491	-84	-244	-219	-65	-140	-459	-215	29	286
Construction	-13	-43	122	102	-20	12	93	61	-57	-8	120	-40	-107	-302
Sale, Mainten and Repair of Motor Vehicles ...	-11	-19	-11	-4	-23	-4	-8	-8	-7	-8	-21	-16	-2	9
Wholesale Trade and Commission Trade ...	-3	-3	-2	1	-5	-1	-3	-4	-5	-4	-5	-6	-6	-10
Retail Trade; Repair of Household Goods	-4	-6	-3	0	-7	-1	-2	-2	-3	-3	-6	-5	-3	-3
Hotels and Restaurants	-5	-9	-6	-3	-9	-1	-3	-3	-1	-2	-11	-5	4	15
Inland Transport	76	187	-1	11	170	-15	-114	-101	-25	-31	29	66	-136	-249
Water Transport	63	106	15	9	76	0	-23	-21	-4	-2	34	36	-54	-118
Air Transport	99	223	37	20	192	-1	-55	-47	-6	-5	73	86	-112	-318
Other Supporting and Aux. Transport Activities	4	9	0	0	6	-1	-3	-3	-1	-1	0	1	-4	-7

Post and Telecommunications	-1	-1	-1	0	-2	0	-1	-1	0	0	-2	-1	1	3
Financial Intermediation	-1	-1	-1	0	-2	-1	-2	-2	-1	-1	-3	-1	0	2
Real Estate Activities	-1	-1	0	0	-1	0	0	0	0	0	-1	-1	0	1
Renting of M&Eq and Other Business Activities	1	1	2	1	2	0	1	0	-1	0	2	0	-2	-6
Public Adm and Defence; Comp Social Security	-4	-13	-7	-9	-12	2	8	11	13	9	-6	1	26	47
Education	0	-1	0	-1	-1	0	0	1	1	0	-1	0	2	3
Health and Social Work	-9	-23	-13	-14	-22	2	8	10	15	9	-16	-3	41	80
Other Community, Social and Personal Services	-18	-36	-22	-15	-38	-3	-4	-2	5	-2	-36	-15	32	86
Private Households with Employed Persons	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**1,007**	**2,212**	**981**	**835**	**1,517**	**-50**	**-348**	**-491**	**-682**	**-364**	**1,146**	**379**	**-2,115**	**-4,703**

Source: Own elaboration.

Table A.7. Scale effect by economic sectors.

	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Agriculture, Hunting, Forestry and Fishing	221	519	475	581	790	275	173	238	364	394	594	503	-16	-817
Mining and Quarrying	31	77	71	96	139	46	27	37	59	66	93	73	-2	-104
Food, Beverages and Tobacco	93	214	203	244	343	129	85	124	206	228	336	277	-9	-457
Textiles and Textile Products	31	72	68	81	115	43	28	42	69	76	114	93	-3	-153
Leather, Leather and Footwear	4	8	8	9	13	5	3	5	8	9	13	11	0	-17
Wood and Products of Wood and Cork	11	25	24	32	42	16	10	15	25	27	41	35	-1	-51
Pulp, Paper, Paper , Printing and Publishing	59	136	130	157	219	82	54	79	132	146	214	176	-6	-281
Coke, Refined Petroleum and Nuclear Fuel	393	931	863	1,052	1,419	502	311	426	671	743	1,099	923	-29	-1,465
Chemicals and Chemical Products	145	340	321	380	522	194	128	184	297	327	481	396	-13	-627
Rubber and Plastics	10	24	22	27	39	14	9	14	23	26	40	33	-1	-50
Other Non-Metallic Mineral	810	1,944	1,869	2,368	3,343	1,207	774	1,086	1,697	1,860	2,840	2,387	-71	-3,171
Basic Metals and Fabricated Metal	240	569	544	669	955	350	223	309	492	557	830	692	-22	-992

Machinery, Nec	11	25	24	29	41	15	10	15	24	27	40	33	-1	-53
Electrical and Optical Equipment	4	10	10	12	17	6	4	6	10	11	17	13	0	-21
Transport Equipment	32	74	71	84	119	44	29	43	70	78	114	93	-3	-150
Manufacturing, Nec; Recycling	9	21	20	25	35	13	8	12	20	22	36	29	-1	-42
Electricity, Gas and Water Supply	1,416	3,284	3,223	4,278	6,610	2,290	1,484	2,097	3,233	3,834	5,790	4,815	-147	-6,326
Construction	74	173	163	210	305	113	73	104	169	191	298	261	-8	-384
Sale, Mainten and Repair of Motor Vehicles ...	47	111	102	130	186	69	44	61	98	111	170	149	-5	-229
Wholesale Trade and Commission Trade ...	27	63	58	73	108	42	27	39	64	72	108	90	-3	-136
Retail Trade; Repair of Household Goods	19	44	40	51	76	29	19	27	45	51	76	62	-2	-97
Hotels and Restaurants	7	17	16	20	29	11	7	10	16	18	27	23	-1	-37
Inland Transport	367	874	809	1,028	1,466	545	350	488	793	896	1,369	1,192	-38	-1,831
Water Transport	37	77	61	84	136	53	36	53	85	96	152	147	-5	-252
Air Transport	80	205	200	268	396	146	87	115	194	241	396	353	-12	-790
Other Supporting and Aux. Transport Activities	11	25	23	29	42	16	10	14	22	25	38	33	-1	-51

Post and Telecommunications	4	9	8	10	16	6	4	6	9	11	16	12	0	-20
Financial Intermediation	6	13	12	16	24	9	6	9	14	16	23	18	-1	-30
Real Estate Activities	1	3	2	3	5	2	1	2	3	3	5	4	0	-6
Renting of M&Eq and Other Business Activities	3	8	7	9	14	5	3	5	8	9	13	11	0	-17
Public Adm and Defence; Comp Social Security	8	19	18	23	35	13	9	13	21	23	34	27	-1	-44
Education	1	1	1	2	2	1	1	1	1	2	2	2	0	-3
Health and Social Work	16	37	34	43	63	24	15	22	35	40	60	51	-2	-83
Other Community, Social and Personal Services	36	89	84	105	155	59	39	56	90	100	152	126	-4	-220
Private Households with Employed Persons	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**4,262**	**10,043**	**9,583**	**12,228**	**17,816**	**6,377**	**4,094**	**5,750**	**9,068**	**10,335**	**15,629**	**13,143**	**-409**	**-19,007**

Source: Own elaboration.