

**CHARACTERIZATION OF SPANISH ECONOMIC SECTORS FROM AN
ECONOMIC AND ENVIRONMENTAL PERSPECTIVE:
EVOLUTION AND FORECAST OF GREENHOUSE GAS EMISSIONS**

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Abstract

The aim of the Kyoto Protocol is to reduce the growth of greenhouse gases emissions. In this context, it is very important to characterize the economic sectors according to environmental indicators to properly design environmental policies; Moreover, it could be advisable to analyze the emissions that directly and indirectly are generated by economic sectors to carry out their production and meet their demand.

This paper conducts such environmental characterization and analysis for Spanish industries through an input-output analysis. In addition, we forecast the effects of an increase in consumption on greenhouse gases emissions by using macroeconomic forecasts from 2011 to 2014.

JEL classification codes: C67, Q40, Q50

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1.- Introduction

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (which entered into force on February 2005) aims to reduce the growth of greenhouse gases emissions (GHG). According to this protocol, European Union has committed to reduce their collective emissions in the 2008-2012 period to 8% below. Under this protocol, Spain is committed to limiting the growth of GHG emissions by at least 15% of 1990.

Moreover, under the European Climate Package and Energy (CE 2008) the European Commission has agreed to reduce the total greenhouse gas emissions by at least 20% from 1990 levels in 2020, and Spain also should decrease diffuse emissions by 10% relative to emissions in 2005.

In order to achieve these objectives, several measures has been realized as the creation of the allowance market, launched in the EU since 2005 and currently affecting sectors of Power Generation, Oil Refining, Metal Production and Processing Ferrous Metals, Cement, Lime, Glass, Ceramics, Pulp, Paper and Board and it will also include Aircraft Operators, and facilities in the Chemical and Aluminum from 2012. However, other sectors such as Agriculture, Transport Services and Other Activities which represent important greenhouse gas emissions sources are not cover by this allowance market. As we can see in Table 1, although the largest contributors to GHG emissions are Electricity Generation (29.5%) and Manufacture of Other Non-Metallic Mineral products (15.4%), other sectors such as Agriculture (mainly by methane produced by ruminants and nitrous

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oxide due to fertilizer use) or Transport (for the carbon dioxide emitted by fossil fuel combustion) represent respectively 15.4% and 10.2% of GHG emissions in Spain.

Therefore, in order to achieve the objectives of the Kyoto Protocol it is also advisable to use specific strategies in each of the sectors by assessing specific sectoral policies. In this sense, the environmental characterization of the Spanish industry and the analysis of the relationship between emissions and economic structure could be a prerequisite for the design of sectoral policies.

Table 1. Contribution by sector¹ to the total of GHG emissions. Average 1990-2008

CNAE	Economic Activity	Contribution
AB	Agriculture, Hunting, Forestry and Fishing	15,4%
CA	Extraction of energy products	0,8%
CB	Extraction of minerals except energy products	0,1%
DA	Food, Beverages and Tobacco	1,8%
DB	Textiles and Textile Products	0,6%
DC	Leather, Leather and Footwear	0,1%
DD	Wood and Products of Wood and Cork	0,2%
DE	Pulp, Paper, Paper , Printing and Publishing	1,2%
DF	Coke, Refined Petroleum and Nuclear Fuel	6,5%
DG	Chemicals and Chemical Products	3,3%
DH	Rubber and Plastics	0,2%
DI	Other Non-Metallic Mineral	15,4%
DJ	Basic Metals and Fabricated Metal	4,6%
DK	Machinery, Nec	0,2%
DL	Electrical and Optical Equipment	0,1%
DM	Transport Equipment	0,6%
DN	Manufacturing, Nec; Recycling	0,2%
E	Electricity, Gas and Water Supply	29,5%
F	Construction	1,5%
G	Sale, Maintenance and Repair of Motor Vehicles; Retail Sale of Fuel	1,8%
H	Hotels and Restaurants	0,1%
I	Transport, Post and Telecommunications	10,2%
J	Financial Intermediation	0,1%
K	Real estate and rental business services	0,1%
L	Public Admin and Defence; Compulsory Social Security	0,2%
M	Education	0,0%
N	Health and Social Work	0,4%
O	Other Community, Social and Personal Services	4,8%

Source: Satellite Atmospheric Emissions Account (INE)

In this paper, we perform that characterization of the Spanish economic sectors according to a set of physical and economic variables. This information comprises the Satellite Atmospheric Emissions Accounts (several years) for pollution emissions and the

¹ Among the National Classification of Economic Activities there is the sector "Households with employed persons" however, as this sector does not have emissions assigned in Satellite Atmospheric Emissions Accounts we do not include it in the study.

estimated symmetric input-output table from the supply and use tables for 2007 published by the Spanish Statistic Institute (INE)

To make this characterization we use an input-output methodology as allows us the construction of hybrid models with economic and physical variables and the study of the environmental impacts by integrating both economic and technical relations that take place within the production system. This technique has been applied to the study of some Spanish sectors (Alcántara and Padilla 2003 for the service sector or Sánchez and Duarte 2003 for the water sector) although there are still few studies using the input-output model to account for the GHG emissions for all sectors of the Spanish economy (Alcántara 2007 and Butnar and Llop 2007).

Moreover, we summarize all the information in a smaller number of variables or dimensions by using the Principal Component Analysis (PCA).

Another important aspect to characterize the economic sectors is to study the impact of the changes in the final demand for production activities on the evolution and composition of greenhouse emissions. We calculate the emissions multipliers to capture the impacts on pollutant emissions due by exogenous shocks in sectorial demand by using the input-output model.

This approach makes possible to analyze the impact of final demand changes on emissions and predict the evolution of emissions once the demand forecasts are known. Therefore, by using the matrix of multipliers and the demand forecasts provided by the updated Spanish Stability Program 2012-2015 adopted on April 27, 2012 (Ministry of Economy and Competitiveness) we forecast the Spanish greenhouse gases for the period 2009-2014.

The paper is structured as follows: In section 2 we characterize Spanish Economic sectors according to both physical and economic variables, using the technique of principal components. In this section, from the information provided by the input-output table, we determine the capability of economic sectors to push the overall economic activity through its demand and supply. In section 3, we forecast the GHG emissions for the 2009-2014 period. The GHG forecasts are made considering a basic scenario from the currently available data and the macroeconomic forecasts of the government. Finally, the article concludes with a compilation of the concluding remarks.

2.- Economic and environmental characterization hybrid of Spanish economic sectors

In this section we conduct an environmental and economic characterization for Spanish industries through an input-output analysis. We use economic variables (backward and forward linkages, ratios of exports and imports and employment) and physical variables (greenhouse gas emissions). Moreover, we summarize all the information in a smaller number of variables or dimensions by using the PCA. This information comprises the Satellite Atmospheric Emissions Accounts (several years) for pollution emissions and the Supply Table and Use Table corresponding to the input-output accounts for the production system published by the Spanish Statistical Institute (INE). Specifically, we have estimated the symmetric input-output table from the supply and use tables for 2007 published by the INE (December 20, 2010).

We have made homogeneous the sectorial aggregation from all sources following the National Classification of Economic Activities (CNAE93). The indicators we consider in our study are listed in Table 2.

Table 2. Physical and Economic Indicators

Type of Indicators		
Physical	Methane emissions (Kt. CO ₂ -eq)	CH ₄
	Carbon Dioxide emissions (Kt. CO ₂ -eq)	CO ₂
	Nitrous oxide emissions (Kt. CO ₂ -eq)	N ₂ O
Economics	Backward linkages	BL
	Forward linkages	FL
	Export ratio (exports/total production)	X*
	Import ratio (imports/total production)	M*
	Employment (thousand of persons)	EM

We begin this study by analyzing the physical indicators.

2.1. Physical indicators: Greenhouse emissions

The greenhouse emissions regulated by the Kyoto Protocol are: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF₆). In our study we consider only CO₂, CH₄ and N₂O as they constitute the 99% of the total gases

As different gases are measured in different units, to allow for comparisons and global estimations, we express all the emissions in common units, which are carbon dioxide equivalents (CO₂ eq.) This is determined by multiplying the amount of a particular gas emitted by the global warming potential of the gas assigned to a horizon of 100 years reported in the Second Assessment Report (1995, Intergovernmental Panel on Climate Change IPCC).

Under the Kyoto Protocol to the United Nations Framework Convention on Climate Change this protocol, Spain is committed to limiting the growth of GHG emissions by at least 15% of 1990 in the 2008-2012 period for the three main greenhouse gases, carbon dioxide, methane and nitrous oxide.

As we can see in Table 3, Spain is very far to accomplish its commitment as the growth of the two main gases, CH₄ and CO₂ is bigger than the 15% of 1990 in most of the years. N₂O shows a virtually identical level in the period considered with a reduction of 6% in 2008 compared to 1990.

Table 3. Emissions by type of gas. Temporal indexes (1990=1)

	19 90	19 95	19 96	19 97	19 98	19 99	20 00	20 01	20 02	20 03	20 04	20 05	20 06	20 07	20 08
Total	1	1,1	1,07	1,15	1,19	1,28	1,33	1,34	1,41	1,43	1,49	1,55	1,52	1,56	1,44
CH ₄	1	1,11	1,15	1,2	1,23	1,24	1,28	1,31	1,33	1,34	1,33	1,35	1,38	1,37	1,36
CO ₂	1	1,12	1,06	1,15	1,19	1,3	1,35	1,36	1,44	1,46	1,54	1,61	1,57	1,61	1,48
N ₂ O	1	0,94	1,04	1,03	1,07	1,11	1,15	1,08	1,05	1,1	1,05	1	1,01	1,02	0,94

Source: Own elaboration from Satellite Atmospheric Emissions Account (INE)

The evolution of emissions by type of economic activity- showed in Table 4- indicates that the most significant increases were produced in activities related to the service sector. For example education or financial intermediation activities have increased their emissions 25% and 23% respectively in 2008 compared with 1990 levels. However, the most relevant value is that corresponding to electricity activity which experienced a significant increase of 40% in 2008 compared to 1990.

Table 4. Emissions by economic activity. Temporal Indexes (1990=1)

CNAE	19 95	1996	19 97	19 98	19 99	20 00	20 01	20 02	20 03	20 04	20 05	20 06	20 07	20 08
AB	0,99	1,06	1,05	1,09	1,11	1,14	1,13	1,12	1,16	1,13	1,09	1,11	1,13	1,07
C	0,96	1,02	1,01	0,98	1,05	1,02	0,95	0,91	0,93	0,94	0,93	0,86	0,83	0,77
D	1,11	1,05	1,13	1,15	1,19	1,23	1,27	1,28	1,34	1,39	1,40	1,38	1,38	1,29
E	1,11	0,91	1,09	1,08	1,33	1,39	1,30	1,52	1,41	1,55	1,71	1,57	1,66	1,40
F	0,80	0,80	0,80	0,87	0,93	0,98	1,04	1,08	1,13	1,21	1,26	1,31	1,36	1,28
G	1,20	1,23	1,20	1,27	1,35	1,46	1,57	1,58	1,67	1,80	1,84	1,82	1,89	1,79
H	1,24	1,27	1,25	1,31	1,39	1,52	1,64	1,64	1,74	1,88	1,92	1,88	1,94	1,85
I	1,11	1,17	1,15	1,24	1,31	1,41	1,49	1,49	1,54	1,69	1,77	1,80	1,91	1,82
J	1,45	1,43	1,49	1,52	1,66	1,89	2,07	2,11	2,31	2,38	2,49	2,24	2,22	2,23
K	1,45	1,43	1,50	1,53	1,67	1,89	2,07	2,11	2,32	2,38	2,50	2,24	2,23	2,23
L	1,45	1,42	1,49	1,52	1,66	1,88	2,06	2,11	2,31	2,38	2,49	2,23	2,22	2,23
M	1,47	1,41	1,53	1,53	1,64	1,90	2,07	2,13	2,37	2,43	2,55	2,26	2,26	2,25
N	1,22	1,24	1,26	1,30	1,34	1,40	1,44	1,48	1,46	1,55	1,60	1,58	1,59	1,55
O	1,32	1,38	1,47	1,54	1,61	1,69	1,78	1,84	1,88	1,89	1,96	2,02	2,09	2,17

Source: Own elaboration from Satellite Atmospheric Emissions Account (INE).

Table 5. Emissions by type of gas and gas contributions to emissions. Averages 1990-2008.

CNAE	Economic Activity	Kt CO ₂ eq.			Contribution		
		CH ₄	CO ₂	N ₂ O	CH ₄	CO ₂	N ₂ O
AB	Agriculture, Hunting, Forestry, Fishing	18747	10485	16162	57,7%	4,4%	77,1%
CA	Extraction of energy products	1213	1210	9	3,7%	0,5%	0,0%
CB	Extraction of minerals except energy	29	381	3	0,1%	0,2%	0,0%
DA	Food, Beverages and Tobacco	139	5098	43	0,4%	2,1%	0,2%
DB	Textiles and Textile Products	26	1709	14	0,1%	0,7%	0,1%
DC	Leather, Leather and Footwear	2	193	2	0,0%	0,1%	0,0%
DD	Wood and Products of Wood and Cork	5	618	5	0,0%	0,3%	0,0%
DE	Pulp, Paper, Paper, Printing, Publishing	168	3247	27	0,5%	1,4%	0,1%
DF	Coke, Refined Petroleum, Nuclear Fuel	112	18814	133	0,3%	7,8%	0,6%
DG	Chemicals and Chemical Products	316	7632	1825	1,0%	3,2%	8,7%
DH	Rubber and Plastics	11	561	5	0,0%	0,2%	0,0%
DI	Other Non-Metallic Mineral	96	44766	248	0,3%	18,6%	1,2%
DJ	Basic Metals and Fabricated Metal	119	13212	81	0,4%	5,5%	0,4%
DK	Machinery, Nec	8	600	5	0,0%	0,2%	0,0%
DL	Electrical and Optical Equipment	4	244	2	0,0%	0,1%	0,0%
DM	Transport Equipment	24	1740	14	0,1%	0,7%	0,1%
DN	Manufacturing, Nec; Recycling	19	502	3	0,1%	0,2%	0,0%
E	Electricity, Gas and Water Supply	434	85761	477	1,3%	35,7%	2,3%
F	Construction	5	4458	34	0,0%	1,9%	0,2%
G	Sale, Repair of Motor Vehicles	14	5284	36	0,0%	2,2%	0,2%
H	Hotels and Restaurants	1	411	3	0,0%	0,2%	0,0%
I	Transport, Post, Telecommunications	352	29256	232	1,1%	12,2%	1,1%
J	Financial Intermediation	2	338	2	0,0%	0,1%	0,0%
K	Real Estate and rental business services	1	264	1	0,0%	0,1%	0,0%
L	Public Admin, Defence, Social Security	3	490	3	0,0%	0,2%	0,0%
M	Education	0	33	0	0,0%	0,0%	0,0%
N	Health and Social Work	3	897	417	0,0%	0,4%	2,0%
O	Other Community, Social, Personal Ser,	10616	2228	1184	32,7%	0,9%	5,6%

Source: Own elaboration from Satellite Atmospheric Emissions Account (INE)

Regarding the contribution of each economic activity to the total of GHG emissions- showed in Table 5- agriculture and other social activities and community services (which includes water sanitation) are the most CH₄ emitters as this gas is produced by livestock digestion and waste (dumping). The carbon dioxide emissions are mainly produced by the use of energy and fossil fuel production, so it is mainly produced by the manufacturing of other non-metallic mineral products, refined petroleum products and Fuels, Metallurgy, Production Electricity, Gas and Water, and Transport. Finally N₂O is an industrial gas generated by the production of nitric acid and adipic acid and the use of fertilizers in agriculture, so it is mainly emitted by the agricultural sector and the chemical industry.

2.2. Economic variables. Input-Output Methodology

By using the Spanish estimated symmetric input-output table for 2007 we calculate backward and forward linkages, export and import ratios and employment for all economic sectors. The first two variables are derived from the application of input-output analysis and allow us to determine capability of economic sectors to push the overall economic activity through its demand and supply.

An input-output table presents the intersectorial transactions that exist in an integrated economy, allowing to analyze the effects that changes in certain variables generate over others. The so-called demand model can be expressed as

$$\mathbf{x} = \mathbf{Xi} + \mathbf{y},$$

where $\mathbf{x}$ represents the vector of total output, $\mathbf{i}$ is a vector of ones, $\mathbf{X}$ is the matrix of intermediate production and $\mathbf{y}$ is the vector of final demand. Let a_{ij} be the technical coefficients, which are assumed constant, defined as $a_{ij} = x_{ij}/x_j$, which can be interpreted as the proportion of inputs purchased from industry i by industry j with respect the total output of sector j

The above model can be reformulated as follows,

$$\mathbf{x} = \mathbf{Ax} + \mathbf{y},$$

where the matrix $\mathbf{A}$ is the matrix of technical coefficients. By operating we can get: $\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{y}$, where $(\mathbf{I} - \mathbf{A})^{-1}$ is the Leontief inverse matrix. A generic element (i, j) of this matrix represents the direct and indirect requirements of i per unit of final demand for the output of sector j .

In the same way, from the supply side, we have the Ghosh model:

$$\mathbf{x}' = \mathbf{x}'\mathbf{B} + \mathbf{v}',$$

where $\mathbf{x}'$ represents the transposed vector of total output, $\mathbf{B}$ is the matrix of distribution coefficients and $\mathbf{v}'$ is the transposed vector of values added. In order to calculate the direct and indirect measures it is proposed to be constructed from the elements of the inverse matrix $(\mathbf{I} - \mathbf{B})^{-1}$. Let b_{ij} be the distribution coefficients, which are assumed constant, defined as $b_{ij} = x_{ij}/x_i$, which can be interpreted as the proportion that the production of sector i used by industry j with respect the total production of i .

From previous models, it is possible to determine backward linkages (BL) which measure the importance of productive sectors from the demand side and forward linkages (FL) which measure the importance of productive sectors from the supply side. By using the methodology of Rasmussen (1956), it is possible to obtain the expression that determines the BL as:

$$\mathbf{BL}^R = \frac{\mathbf{ni}'(\mathbf{I} - \mathbf{A})^{-1}}{\mathbf{i}'(\mathbf{I} - \mathbf{A})^{-1}\mathbf{i}}$$

where n is the number of sectors and $\mathbf{i}$ is a vector of "ones". BL reflects the effects of an increase in final demand of sector j on overall output; in other words, it measures the extent to which a unit change in the demand for the product of sector j causes production increases in all sectors. Values of BL greater than the unit are associated with sector that required of the other above of the average (and viceversa). Similarly, the expression that determines the FL is:

$$FL^R = \frac{\mathbf{n}\mathbf{i}'(\mathbf{I}-\mathbf{B})^{-1}}{\mathbf{i}'(\mathbf{I}-\mathbf{B})^{-1}\mathbf{i}}$$

FL measures the magnitude of output increase in sector i , if the final demand in each sector were to increase by one unit; in other words, it measures the extent to which sector i is affected by an expansion of one unit in all sectors. Values of FL greater than one represent a sector that sell its production to the rest sector above the average.

The measures of linkages discussed above have been calculated for Spain as it showed in Table 6.

Table 6. Classification of economic activities according to BL and FL above to the average

Code	BL	Code	FL
F	1,24	CA	1,74
DB	1,23	CB	1,50
DA	1,22	DD	1,45
DJ	1,17	E	1,33
DD	1,16	DJ	1,31
DE	1,16	DI	1,31
DI	1,15	DE	1,26
DL	1,13	DH	1,22
DH	1,12	I	1,16
DC	1,12	DF	1,11
DN	1,11	DK	1,09
DM	1,09	J	1,09
DK	1,06	DG	1,06
DG	1,06	DL	1,06
CB	1,04	DN	1,01
I	1,02		
CA	1,01		

Source: Own elaboration from Spanish estimated Symmetric Input-Output Table for 2007, INE

The sectors that have higher backward linkages are Construction (F), Textiles and Clothing (DB) and Food, Beverages and Tobacco industries (DA). From the supply side sectors with higher values of FL are Extraction of Energy Products (CA) and Electricity Industry (CB). Besides BL and FL indicators, we have considered other economic indicators such as those related to employment and the international trade, which results are showed in Table 7.

In relation to employment, it is showed that services sectors are those with the greatest weight on employment in the economy, emphasizing Hotels and Restaurants and Real Estate and Rental Business Services.

Regarding the international trade or external sector, we can say that most exporting sectors in relation to their production are industries of Food, Beverages and Tobacco, Electrical and Optical Equipment and Transport Equipment.. Moreover, the sectors with

high import activity are Coke, Refined Petroleum and Nuclear Fuel (which shows the high energy dependence of the Spanish economy) and Transport Equipment (also with large volume of exports).

Table 7. Employment and external sector indicators of economic activities.

CNAE	Economic Activity	EM	X*	M*
AB	Agriculture, Hunting, Forestry and Fishing	958,1	0,19	0,04
CA	Extraction of energy products	9,2	0,04	0,08
CB	Extraction of minerals except energy products	35,8	0,16	0,09
DA	Food, Beverages and Tobacco	98,8	0,76	0,04
DB	Textiles and Textile Products	441,5	0,09	0,18
DC	Leather, Leather and Footwear	167,8	0,18	0,21
DD	Wood and Products of Wood and Cork	112,5	0,11	0,23
DE	Pulp, Paper, Paper , Printing and Publishing	57,6	0,34	0,25
DF	Coke, Refined Petroleum and Nuclear Fuel	9,2	0,38	0,73
DG	Chemicals and Chemical Products	371,2	0,33	0,31
DH	Rubber and Plastics	129,8	0,31	0,30
DI	Other Non-Metallic Mineral	232,2	0,13	0,10
DJ	Basic Metals and Fabricated Metal	124,6	0,49	0,19
DK	Machinery, Nec	608	0,14	0,23
DL	Electrical and Optical Equipment	106,5	0,59	0,30
DM	Transport Equipment	295,8	0,61	0,49
DN	Manufacturing, Nec; Recycling	332,2	0,08	0,20
E	Electricity, Gas and Water Supply	92,8	0,01	0,21
F	Construction	2720	0,00	0,03
G	Sale, Maintenance, Repair of Motor Vehicles; Retail Sale of Fuel	1208,3	0,14	0,07
H	Hotels and Restaurants	3491,8	0,00	0,02
I	Transport, Post and Telecommunications	1198,5	0,13	0,10
J	Financial Intermediation	277,8	0,11	0,05
K	Real estates agent and rental business services	2244,6	0,08	0,03
L	Public Admin and Defence; Compulsory Social Security	1386,5	0,00	0,02
M	Education	1089,8	0,00	0,01
N	Health and Social Work	1450,5	0,00	0,06
O	Other Community, Social and Personal Services	953,4	0,03	0,07
P	Private Households with Employed Persons	1380,3	0,00	0,00

Source: Own elaboration from Spanish estimated Symmetric Input-Output Table for 2007, INE

2.3. Characterization of sectors. Principal component analysis

Since available information related to each sector is relatively large (4 economic variables and 3 physical variables) it could be useful to summarize the information in a smaller number of variables or dimensions that allow the characterization of the sectors.

Principal component analysis (PCA) allows reducing the number of dimensions, without much loss of information. Therefore, we apply the PCA to the above variables.

The first step is to run the Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) test to assess the appropriateness of using PCA on data. The measurement of sample adequacy KMO provides values of 0.607 indicating that there is correlation between the considered variables. Moreover, the result of the Bartlett's test of sphericity indicates that the null hypothesis (there is no correlation between variables) should be rejected.

Therefore, we can conclude that Principal component analysis is appropriate for the available data.

Principal Components Analysis is a method of factor extraction where linear combinations of the observed variables are formed. The first 'principal component' is the combination of variables that accounts for the largest amount of variance in the sample. The second 'principal component' accounts for the next largest amount of variance and is not correlated with the first component, and so on. The obtained results indicate that the initial variables are adequately represented by three components retained that accumulate the 71.25% of the total amount of variance in the sample.

The communalities indicate how the initial variables are explained from the retained factors. Communalities range from 0 to 1. Zero means that the common factors don not explain any variance; one means that the common factors explain all the variance. As it is showed in Table 8, all variables are relatively well explained with rates that are between 60% -83%, except the backward linkage (BL) whose value is approximately 37%.

Table 8. Communalities

	Initial	Extraction
BL	1,000	0,367
FL	1,000	0,780
Employment	1,000	0,717
X*	1,000	0,829
M*	1,000	0,585
CH ₄	1,000	0,790
CO ₂	1,000	0,681
N ₂ O	1,000	0,826

Source: Own elaboration

The calculated rotated factorial matrix (Table 9) gives you a clear indication how each variable correlates with each factor or component.

Tabla 9. Rotated Component Matrix

	Components		
	1	2	3
M*	0,807	-0,119	0,170
FL	0,772	0,001	0,445
Employment	-0,755	-0,006	-0,180
X*	0,636	-0,004	-0,455
BL	0,633	-0,069	-0,164
N ₂ O	-0,040	0,965	0,033
CH ₄	-0,074	0,962	-0,007
CO ₂	0,126	0,020	0,827

Source: Own elaboration. Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 7 iterations.

As it is showed, the first component represents the economic variables, all of which have a high positive correlation, except for employment, which seems to show that the activities with greater pull capacity and more weight in the foreign sector are less intensive in job.

The second factor is related with N_2O and CH_4 gases, both showing a positive correlation, thus sectors with high emissions of N_2O also have high emissions of CH_4 such as agriculture and other community services, as it has been noticed in Table 5.

Finally the third factor is only related with CO_2 emissions, as we have seen is the predominant gas of GHG (with an average contribution of 90% of the total of GHG).

The graphical representation of the economic activities and factors allows the characterization of the economic sectors. In Figure 1, the horizontal axis represents the factor 1 related to economic variables and the vertical factor 2 related to N_2O and CH_4 emissions. As we can see, the most important economic activities (according to the considered variables) are those that less methane and nitrous oxide emit. By contrast, Agriculture, Hunting, Forestry and Fishing (AB) and Other Community, Social and Personal Services (O) are the activities with highest levels of both gases emission. The specific activities of agricultural sector include 4% of global CO_2 emissions, 58% of global methane emissions (basically due to enteric fermentation and manure) and 77% of global emissions of nitrous oxide, mainly due to the use of fertilizer (as it is noted in Table 5). The activity of services to the community is responsible for 37% of methane emissions because among its activities include the treatment of wastewater.

Figure 1. Graphical representation of factor 1 and factor 2

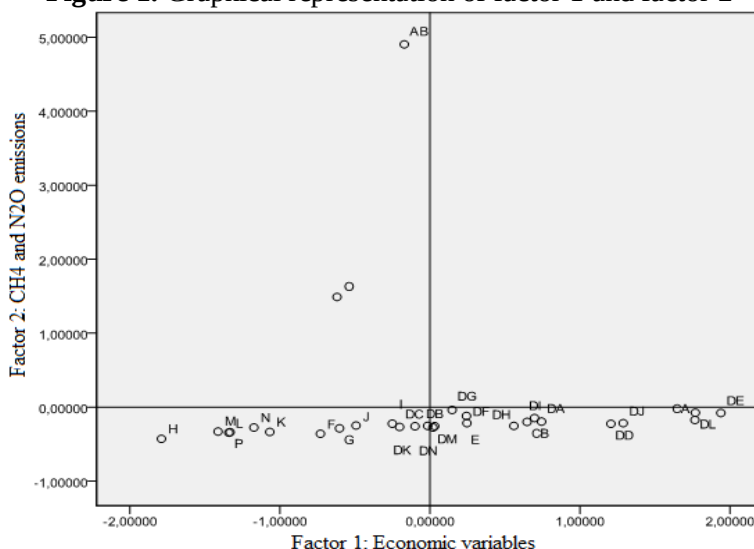
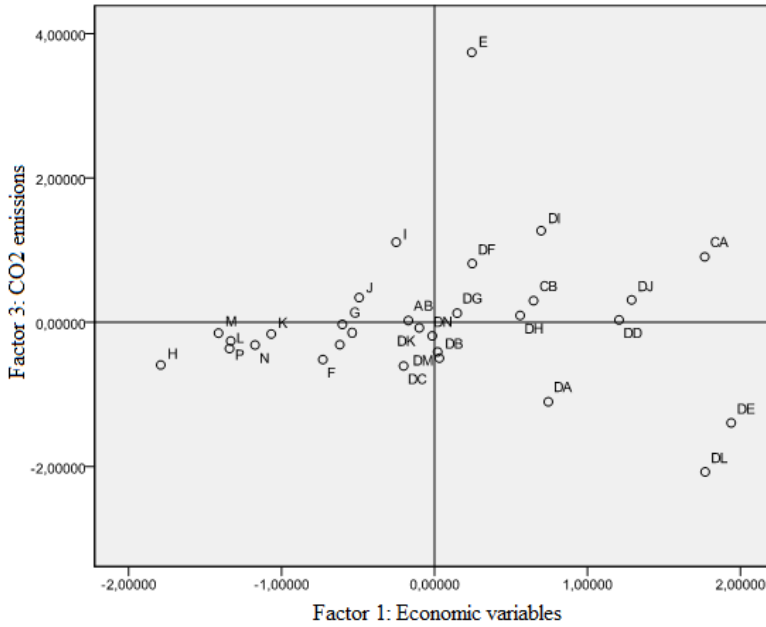


Figure 2 represents the factors 1 and 3, which includes CO_2 emissions.

Some of the economically important industries such as electricity production (E), extractive industries (CA and CB) or some activities of manufacturing industry as oil refining and nuclear fuel, chemicals, Other Non-Metallic Mineral and Basic Metals and Fabricated Metal (DF, DG, DI and DJ respectively) have high CO_2 emissions.

However, there are other economic activities with high weight on the economy but with low level of gas emissions: Food, Beverages and Tobacco, Textiles and Textile Products, Pulp, Paper, Paper, Printing and Publishing and Electrical and Optical Equipment (DA, DB, DE and DL respectively). Moreover, Transport, Post and Telecommunications (I) and financial intermediation (J) are less relevant from the viewpoint of economic variables that we considered, but emit large amounts of CO_2 .

Figure 2. Graphical representation of factor 1 and factor 3



3.- Quantifying greenhouse gas emissions caused by changes in the final demand.

Another important aspect to characterize the economic sectors is to study the impact of the changes in the final demand for production activities on the evolution and composition of greenhouse emissions.

The analytical framework that accounts this impact is based on the input-output approach. Let e_i be a vector of direct emissions representing the sectorial greenhouse gas emissions

per unit of output called direct emission: $e_i = \frac{g_i^p}{x_i}$ where g_i^p ($i=1,2, n$, and $p=1,2,..., j$) is

the emissions of gas p (CH_4 , CO_2 y N_2O) in each considered sector i and x_i is the sectorial output.

As it is noted above, we are proposing a hybrid model of analysis as we have into account magnitudes quantified in physical units such as emissions, which are measured in CO_2 -eq Kt. and magnitudes quantified in monetary units, as the sectorial production.

Let e be a $1 \times n$ vector which verifies $e'x = E$, where e' is the transposed vector e , and E is a scalar containing the total emissions. By substituting the above expression in the Leontief demand model we obtain $s = \hat{e}(I - A)^{-1}y = Hy$, where s being a $n \times 1$ vector of sectorial consumption, $\hat{e}$ being a diagonal matrix, whose diagonal elements are e_i , constituted by a_{ij} multipliers vector and y is a $n \times 1$ vector of final demand.

We define H as $\hat{e}(I - A)^{-1}$ which captures the impacts on pollutant emissions due by exogenous shocks in sectorial demand. Therefore, the elements in matrix H are the emissions multipliers that measure the amount of type p emissions caused by exogenous and unitary inflows to the final demand of sector i .

Table 10 contains the emission multipliers effects obtained from the Spanish Symmetric Input-Output Table for 2007.

The sum of the rows in Table 10 shows the increase in the levels of emissions when the activity corresponding to the row receives a unitary injection in demand. As we can see the greatest row sum correspond to Electricity, Gas and Water Supply activity which generates produces 2,57 kilotonnes of CO₂ eq. per exogenous and unitary inflow received. Other Non-Metallic Mineral, extraction of energy products and agricultural sectors show a considerable ability to generate GHG emissions as jointly amount to about 46% of the total emissions reflected in Table 10. On the other hand, new demand in financial intermediation and education causes the smallest increases in emissions (0,05 and 0,06 Kt. CO₂ equivalents respectively). In general, changes in demand in the service sector, with the exception of transport and other social activities, produce the least impact on emissions.

Table 10. Emission multipliers (Kt.CO₂ eq.)

CNAE	Economic Activity	CH ₄	CO ₂	N ₂ O	Total
AB	Agriculture, Hunting, Forestry and Fishing	0,45	0,39	0,37	1,21
CA	Extraction of energy products	0,66	1,16	0,01	1,83
CB	Extraction of minerals except energy products	0,01	0,43	0,00	0,44
DA	Food, Beverages and Tobacco	0,19	0,62	0,15	0,95
DB	Textiles and Textile Products	0,10	0,29	0,08	0,48
DC	Leather, Leather and Footwear	0,03	0,19	0,02	0,24
DD	Wood and Products of Wood and Cork	0,04	0,30	0,03	0,37
DE	Pulp, Paper, Paper , Printing and Publishing	0,05	0,69	0,03	0,76
DF	Coke, Refined Petroleum and Nuclear Fuel	0,01	0,71	0,01	0,73
DG	Chemicals and Chemical Products	0,02	0,39	0,02	0,43
DH	Rubber and Plastics	0,02	0,30	0,01	0,32
DI	Other Non-Metallic Mineral	0,01	1,83	0,01	1,86
DJ	Basic Metals and Fabricated Metal	0,01	0,67	0,01	0,69
DK	Machinery, Nec	0,01	0,25	0,00	0,26
DL	Electrical and Optical Equipment	0,01	0,25	0,00	0,26
DM	Transport Equipment	0,01	0,21	0,00	0,22
DN	Manufacturing, Nec; Recycling	0,01	0,20	0,01	0,22
E	Electricity, Gas and Water Supply	0,03	2,53	0,01	2,57
F	Construction	0,00	0,31	0,00	0,32
G	Sale, Repair of Motor Vehicles; Retail Sale of Fuel	0,01	0,21	0,01	0,23
H	Hotels and Restaurants	0,02	0,13	0,01	0,16
I	Transport, Post and Telecommunications	0,01	0,47	0,00	0,48
J	Financial Intermediation	0,00	0,05	0,00	0,05
K	Real estate and rental business services	0,01	0,08	0,00	0,10
L	Public Admin and Defence; Social Security	0,00	0,12	0,00	0,13
M	Education	0,00	0,06	0,00	0,06
N	Health and Social Work	0,00	0,11	0,01	0,12
O	Other Community, Social and Personal Services	0,31	0,17	0,04	0,52
	TOTAL	2,02	13,20	0,87	16,09

Source: Own elaboration

The sum of columns in Table 10 shows the increase in the emissions of the gas is the column when there is one unitary injection in the final demand of all the activities simultaneously. As it is showed, the greatest effect is on CO₂ emissions (82% of the

total). This is followed by the effect on CH₄ emissions, which represents 13% of the total. The analysis of the emission multipliers indicates that the total emissions are highly concentrated in small group activities, which must be taken into account in the development of strategies to reduce GHGs. For example, Electricity, Gas and Water Supply sector generates 2,53 Kt of CO₂ equivalents, which accounts for 19% of total CO₂ emissions increase, and Other non-metallic Mineral products generates 1.83 Kt of CO₂ equivalent (14% of the total effects). Additionally, Agriculture and Extraction of Energy products represent respectively 22% and 32% of total emissions multipliers for methane.

These findings confirm the results obtained in Butnar and Llop (2007).

Following the expression $\mathbf{s} = \mathbf{H}\mathbf{y}$ and by assuming that the emissions multipliers are constant, the changes in the amount of emissions ($\Delta\mathbf{s}$) caused by exogenous changes in the final demand of activities ($\Delta\mathbf{y}$) can be calculated as: $\Delta\mathbf{s} = \mathbf{H}\Delta\mathbf{y}$.

This approach makes possible to analyze the impact of final demand changes on emissions and predict the evolution of emissions once the demand forecasts are known.

In this sense, as the last Satellite Atmospheric Emissions Account (INE) provides information on pollutant emissions related to 2008, it may be desirable to predict future emissions from 2008.

Therefore, by using the $\mathbf{H}$ matrix of multipliers and the demand forecasts provided by the updated Spanish Stability Program 2012-2015 adopted on April 27, 2012 (Ministry of Economy and Competitiveness) we forecast the Spanish greenhouse gases for the period 2009-2014.

A common assumption in input-output analysis is that the economic structure remains constant over a relatively short period (about 5 or 6 years); thus, since the study period is 7 years, we have to be cautious with the forecast made for the last two years.

We would like to point out that although there are forecasts of GHG emissions for Spain, those are made on unrealistic scenarios of changes in GDP, so it is appropriate to revise the forecasts according to the latest estimates and forecasts of GDP.

For example the the Saving and Energy Efficiency Plan 2011-2020 considers a GDP growth of 2,3% annually between 2010 and 2020 and the National Renewable Energy Action Plan 2011-2020 considers positive variations of this variable from 2011.

In order to make our forecast emissions we contemplate the macroeconomic scenario provided by the Ministry of Economy and Competitiveness in the updated stability program 2012-2015 adopted on April 27, 2012 and showed in Table 11.

Table 11. Spanish Macroeconomic forecasts: the updated Spanish Stability Program 2012-2015 adopted on April 27, 2012 (Ministry of Economy and Competitiveness)

Annual change % Chained volume indices Year 2008=100	2011	2012	2013	2014	2015
Real GDP	0,7	-1,7	0,2	1,4	1,8
Nominal GDP	2,1	-0,7	1,9	3	3,5
Household's final consumption expenditure (*)	-0,1	-1,4	-1,1	0,6	1,1
Public Administrations' final consumption expenditure	-2,2	-8	-4,6	-1,9	-2,8
Gross fixed capital formation	-5,1	-9	-0,5	2,4	3
Variación existencias (% PIB)	0	0	0	0	0
Exports of goods and services	9	3,5	6,9	7,5	8
Imports of goods and services	-0,1	-5,1	1,3	5,4	6,2

(*)Includes households and non-profit institutions serving households. Source: Own elaboration

By using the previous information it is possible to forecast the economic agents' demand for the period 2009-2014 which is showed in Table 12.

Table 12. Registered demand and forecasted demand by economic agent. Period 2009-2014.

(Millions of Euros)	Macroeconomic forecasts					
	2009	2010	2011	2012	2013	2014
Final consumption expenditure	816007	832616	847387	831676	830231	842525
Household's final consumption expenditure (*)	592404	608105	626937	628050	634807	649472
Public Administrations' final consumption expenditure	223603	224511	220450	203625	195424	193053
Gross fixed capital formation	251575	239266	231789	211240	211030	219320
Gross fixed capital formation	247396	233515	226038	205489	205279	213569
Changes in inventories	4179	5751	5751	5751	5751	5751
Exports of goods and services	250667	285110	324755	344860	378240	418807
Imports of goods and services	270189	308109	331809	323389	335455	363823

(*)Includes households and non-profit institutions serving households. Source: Own elaboration from INE data and the updated Spanish Stability Program 2012-2015 adopted on April 27, 2012 (Ministry of Economy and Competitiveness)

Annexes I and II show the obtained forecasted total emissions by economic agent and by economic activity which are summarized in following tables below.

As we can see Table 13 an increase in demand means an increase in emissions compared to 1990. In general, the predictions show a growing trend of GHG emissions.

Table 13. Forecasted total emissions

Years	Emissions Kt-CO ₂ eq.	Index (1990=1)
2009	305141	1,33
2010	297823	1,30
2011	309774	1,35
2012	303595	1,32
2013	331812	1,44
2014	351327	1,53

Source: Own elaboration

By type of gas, the results showed in Table 14 show that the most significant increases are forecasted for carbon dioxide. By the other hand, nitrous oxide is the gas that less will increase during 2009-2014. The obtained forecasts have been calculated on a baseline scenario that reflects current economic trends, without considering energy efficiency improvements during the years analyzed. Therefore, the forecasts show the evolution of emissions due solely to changes in GDP.

Table 14. Forecasted emissions by type of polluter gas

Years	Emissions Kt-CO ₂ eq.			Index (1990=1)		
	CH ₄	CO ₂	N ₂ O	CH ₄	CO ₂	N ₂ O
2009	34321	251653	19168	1,36	1,37	0,93
2010	36091	269960	20608	1,43	1,47	1,00
2011	38604	287809	22345	1,53	1,56	1,09
2012	38905	288204	22788	1,54	1,57	1,11
2013	40457	301733	23974	1,60	1,64	1,17
2014	42959	323194	25704	1,70	1,76	1,25

Source: Own elaboration

The analysis of the emissions by sectorial activities -summarized in Table 15 and shown in detail in Annex II- confirms the importance of Agriculture, Refined Petroleum and Nuclear Fuel, Other non-Metallic Mineral Products, Production and Distribution of electricity, Gas and Water, Transport and Communication and Other Social and Community Services in the emission of greenhouse gases, which on average are jointly responsible for 80% of emissions in the 2009-2014 period.

The annual rates of growth of total emissions indicate that the lower growth in emissions will occur in 2012, as result of the decrease of the general economic activity (the annual rate of growth of GDP for that year is -0.7%).

Table 15. Forecasted emissions by sectorial activity (Kt-CO₂ eq.)

	Sectorial activity	2009	2010	2011	2012	2013	2014
AB	Agriculture, Hunting, Forestry, Fishing	43156	46897	51206	52568	55546	59743
CA	Extraction of energy products	1755	1893	2044	2066	2180	2350
CB	Extraction of minerals except energy	407	450	480	475	504	549
DA	Food, Beverages and Tobacco	4988	6308	7839	8309	9297	10726
DB	Textiles and Textile Products	2008	2075	2157	2180	2235	2314
DC	Leather, Leather and Footwear	225	235	247	251	259	271
DD	Wood and Products of Wood and Cork	625	680	721	718	754	811
DE	Pulp, Paper, Paper, Printing, Publishing	3584	3987	4468	4611	4977	5483
DF	Coke, Refined Petroleum, Nuclear Fuel	18063	19931	22124	22857	24532	26803
DG	Chemicals and Chemical Products	9387	9992	10872	11031	11693	12657
DH	Rubber and Plastics	554	630	704	725	787	872
DI	Other Non-Metallic Mineral	38948	42246	43391	41906	43394	46285
DJ	Basic Metals and Fabricated Metal	10673	13057	15138	15631	17487	20044
DK	Machinery, Nec	563	618	651	642	675	728
DL	Electrical and Optical Equipment	141	196	230	224	258	311
DM	Transport Equipment	1531	1827	2098	2168	2401	2722
DN	Manufacturing, Nec; Recycling	536	575	608	609	636	678
E	Electricity, Gas and Water Supply	100654	105053	110295	110023	113465	119394
F	Construction	4120	4396	4313	3979	3997	4170
G	Sale, Repair of Motor Vehicles	5920	6355	6813	6803	7089	7589
H	Hotels and Restaurants	506	515	526	526	531	541
I	Transport, Post, Telecommunications	35884	38023	40505	40806	42566	45282
J	Financial Intermediation	363	387	413	415	432	460
K	Real estate and rental business services	279	293	306	303	312	328
L	Public Admin., Defence; Social Security	731	661	650	606	585	579
M	Education	47	43	43	41	39	39
N	Health and Social Work	1755	1642	1641	1562	1531	1535
O	Other Community, Social, Personal Ser.	17740	17692	18273	17861	18001	18592
	TOTAL	305141	297823	309774	303595	331812	351327
	Annual growth rate of emissions (%)	-3,2	7,1	6,8	0,3	4,6	7,0

Source: Own elaboration

The analysis of the variations of the emissions produced (Kt-CO₂ eq.) by type of demand's economic agent is showed in Table 16. The largest contribution to the emission corresponds to household's private final consumption as final consumption of households is most responsible for the growth of greenhouse gases in the period 2010-2014. In

addition, the weakness in the coming years in government spending has a positive effect on the emission of greenhouse gases, as these are reduced by the decrease in administration activity.

Table 16. Variations in emissions compared to 2007 by type of demand's economic agent

	Source of variation in demand	
	Household's final consumption expenditure	Public Administrations' final consumption expenditure
2009	-4448,772138	8199
2010	1253,282665	4125
2011	8092,333094	3427
2012	8496,695521	625,8
2013	10950,44373	-653
2014	16276,3709	-948

Source: Own elaboration

4.- Conclusions

In this work, by using physical variables (GHG emissions) and economic variables (backward and forward linkages, ratios of exports and imports and employment) we have characterized Spanish Economics sectors.

This information is obtained from the Satellite Atmospheric Emissions Accounts (several years) and the Supply Table and Use Table corresponding to the input-output accounts for the production system published by the Spanish Statistical Institute (INE). Specifically, we have estimated the symmetric input-output table from the supply and use tables for 2007 published by the INE (December 20, 2010).

In addition, we have study the impact of the changes in the final demand for production activities on the evolution and composition of greenhouse emissions and we have made forecast the Spanish greenhouse gases for the period 2009-2014.

The analysis of the gases emissions by sectors has shown that the agricultural industry and other social and community services (including water sanitation) are the most CH₄ emitters. The CO₂ emissions come mainly from other non-metallic mineral products manufacture, refined petroleum products and fuels, metallurgy, electricity, gas and water supply, and transportation. Finally N₂O is basically emitted by the agricultural activity, livestock and the chemical industry.

We have calculated the backward and forward linkages, export and import ratios and employment. All variables are being summarized in a smaller number of variables or dimensions by using the Principal component analysis. It allows us to group the initial variable on three factors: economic factor, CO₂ emission factor and N₂O-CH₄ emission factor.

From this analysis we found that economic activities that seem to be innocuous from a contaminant point of view because their production do not involve a lot level of direct emissions, they could produce a lot level of indirect emissions to cover their demand. For example, although the emission produced by construction sector represent 1.5% of the total, this sector use as inputs the production of sectors very polluters. This information is very important to identify the responsibility of sectors on other sectors' emissions but also to design environmental policies for reducing greenhouse gases.

Regarding the characterization of the sectors from the point of view of demand, the obtained emission multiplier matrix indicates that the total emissions are highly concentrated in a very specific group of activities: electricity, gas and water, manufacture of other minerals nonmetallic extraction of energy products and agriculture. In general, service sector shows little impact on emissions when its final demand changes- with the exception of transport activity.

Finally, the GHG emissions forecasts for the 2009-2014 period show an increase in emissions compared to 1990, which takes us away from the commitments made in the Kyoto Protocol and the objectives of the European package of Climate and Energy of the European Union. In particular, household's private final consumption is largely responsible for the growth of greenhouse gases for those years.

In order to forecast GHG emissions we have considered a baseline scenario reflecting the current economic trends without considering energy efficiency measures or policy actions. To extend the forecast exercise considering different scenarios under different energy policy actions will be subject of further research.

5.- References

- Alcántara, V (2007): "Análisis input-output y emisiones de CO₂ en España: un primer análisis para la determinación de sectores clave en la emisión". *Documento de trabajo* 2-2007, Universidad Autónoma de Barcelona.
- Alcántara, V y Padilla, E (2007): "Subsistemas input-output y contaminación: una aplicación al sector servicios y las emisiones de CO₂ en España". II Jornadas Españolas de Análisis Input-Output, Zaragoza.
- Butnar I. y Llop, M. (2007): "A composition of greenhouse emissions in Spain: An input-output analysis", *Ecological Economics*, 61, pp. 388-395.
- Haan, M y Keuning, S.J.(1997): "Taking the environment into account. The NAMEA approach". *Review of Income and Wealth*, pp. 131-148.
- INE (2007): Cuentas satélite de emisiones a la atmósfera,
- INE (2007): Encuesta de consumos energéticos
- INE (2007): Marco Input-Output. Tablas Input-Output.
- Sánchez Chóliz J. y Duarte, R. (2003): "Analysing pollution by vertically integrated coefficients, with an application to the water sector in Aragon". *Cambridge Journal of Economics*, 27, pp. 433-448.
- Rasmusen, P. (1956): *Studies in Intersectorial relations*. North Holland Publishing Company, Amsterdam,

ANNEX I

Table 1. Forecasts of total emissions

Year	Emissions (Kt-CO ₂ eq.)	Temporal Index (1990=1)
1990	229721	1,00
1995	250519	1,09
1996	237581	1,03
1997	255902	1,11
1998	261096	1,14
1999	284262	1,24

2000	295836	1,29
2001	297335	1,29
2002	313483	1,36
2003	314822	1,37
2004	330643	1,44
2005	343269	1,49
2006	334164	1,45
2007	344125	1,50
2008	315288	1,37
2009	305141	1,33
2010	297823	1,30
2011	309774	1,35
2012	303595	1,32
2013	331812	1,44
2014	351327	1,53

Table 2. Composition of forecast emissions by type of gas

Year	Emissions (Kt-CO ₂ eq.)			Temporal Index (1990=100)		
	CH ₄	CO ₂	N ₂ O	CH ₄	CO ₂	N ₂ O
1990	25243	183952	20526	1,00	1,00	1,00
1995	28110	203339	19070	1,11	1,11	0,93
1996	29566	186848	21166	1,17	1,02	1,03
1997	30404	204898	20601	1,20	1,11	1,00
1998	31357	208315	21425	1,24	1,13	1,04
1999	31755	230368	22139	1,26	1,25	1,08
2000	32751	240270	22814	1,30	1,31	1,11
2001	33701	241694	21940	1,34	1,31	1,07
2002	34217	258019	21246	1,36	1,40	1,04
2003	34586	258016	22220	1,37	1,40	1,08
2004	34464	274869	21310	1,37	1,49	1,04
2005	34613	288531	20125	1,37	1,57	0,98
2006	35112	278845	20207	1,39	1,52	0,98
2007	35833	287623	20669	1,42	1,56	1,01
2008	35330	260912	19046	1,40	1,42	0,93
2009	34321	251653	19168	1,36	1,37	0,93
2010	36091	269960	20608	1,43	1,47	1,00
2011	38604	287809	22345	1,53	1,56	1,09
2012	38905	288204	22788	1,54	1,57	1,11
2013	40457	301733	23974	1,60	1,64	1,17
2014	42959	323194	25704	1,70	1,76	1,25

ANNEX II**Table A1.** Sectorial emissions in Spain (Kt. CO₂ eq.), 1990-2004

	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
AB	41537	41135	44197	43691	45387	46154	47181	46970	46461	48097	47112
CA	2685	2553	2730	2714	2612	2807	2684	2448	2327	2373	2344
CB	327	329	338	329	351	368	389	415	421	439	478
DA	3538	4730	4041	4587	4455	4601	4804	5297	5426	6115	6411
DB	1183	1560	1337	1512	1471	1522	1590	1754	1797	2024	2124
DC	130	173	154	169	167	173	182	199	202	224	238
DD	467	540	476	524	522	545	572	626	644	716	755
DE	2295	3077	2630	3006	2926	3020	3143	3449	3533	3993	4183
DF	16116	18381	17938	18819	18550	18798	19119	19244	19140	19333	20638
DG	8963	9446	8735	9473	9121	9333	9378	9983	9977	10637	10651
DH	377	519	445	504	489	504	526	581	593	668	702
DI	35542	37790	36832	39441	41821	43888	45130	46851	48222	49876	50597
DJ	11437	11651	10637	11844	11921	12452	13171	13661	13986	14239	15186
DK	395	546	474	534	520	535	560	618	631	711	746
DL	156	215	196	217	214	220	230	254	260	290	305
DM	1166	1593	1374	1568	1520	1564	1635	1796	1836	2075	2160
DN	368	444	417	445	457	478	504	537	542	590	621
E	64829	72252	59185	70791	69919	85921	90294	84559	98738	91569	100563
F	4254	3400	3401	3403	3682	3954	4179	4436	4591	4823	5161
G	3529	4241	4352	4250	4492	4750	5138	5539	5565	5885	6356
H	265	330	338	331	348	370	402	434	436	462	498
I	20419	22729	23970	23576	25414	26847	28740	30473	30362	31530	34435
J	180	262	256	269	274	299	341	372	380	416	429
K	140	204	201	210	214	234	266	291	296	325	334
L	261	378	372	389	396	433	492	539	550	602	621
M	17	25	24	26	26	28	32	35	36	41	42
N	939	1146	1168	1186	1224	1255	1317	1349	1393	1368	1459
O	8205	10871	11363	12095	12604	13207	13836	14624	15137	15401	15495

Table A2. Sectorial emissions in Spain (Kt. CO₂ eq.), 2005-2014

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
AB	45375	46031	47002	44578	43156	46897	51206	52568	55546	59743
CA	2321	2077	1973	1824	1755	1893	2044	2066	2180	2350
CB	488	503	528	495	407	450	480	475	504	549
DA	6483	6182	6226	6283	4988	6308	7839	8309	9297	10726
DB	2150	2055	2073	2087	2008	2075	2157	2180	2235	2314
DC	240	232	236	234	225	235	247	251	259	271
DD	769	751	765	758	625	680	721	718	754	811
DE	4226	4024	4042	4087	3584	3987	4468	4611	4977	5483
DF	20234	19940	20121	19517	18063	19931	22124	22857	24532	26803
DG	10886	10107	9986	9914	9387	9992	10872	11031	11693	12657
DH	709	675	680	685	554	630	704	725	787	872
DI	51713	52248	51579	45111	38948	42246	43391	41906	43394	46285
DJ	15596	14997	15344	15068	10673	13057	15138	15631	17487	20044
DK	752	717	724	730	563	618	651	642	675	728
DL	306	293	298	299	141	196	230	224	258	311
DM	2171	2057	2067	2082	1531	1827	2098	2168	2401	2722
DN	631	616	620	597	536	575	608	609	636	678
E	110630	102006	107936	90884	100654	105053	110295	110023	113465	119394
F	5359	5568	5798	5444	4120	4396	4313	3979	3997	4170
G	6503	6415	6665	6324	5920	6355	6813	6803	7089	7589
H	510	498	515	491	506	515	526	526	531	541
I	36146	36799	38984	37176	35884	38023	40505	40806	42566	45282
J	449	403	400	402	363	387	413	415	432	460
K	351	315	313	314	279	293	306	303	312	328
L	650	583	579	581	731	661	650	606	585	579
M	44	39	39	39	47	43	43	41	39	39
N	1502	1488	1495	1461	1755	1642	1641	1562	1531	1535
O	16074	16545	17137	17829	17740	17692	18273	17861	18001	18592