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# *Household Consumption and $CO_2$ Emissions: The Influence of Technological and Final Demand factors.*

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**Summary:**

The change in structures of production and the modification of patterns of consumption are key factors in the fight against environmental damage. Initiatives such as Agenda 21, promoted by the UN, highlight the necessity to evaluate the relationship between production and consumption, the environment, innovation and demographic factors, in the attainment of sustainable development. In this context, our work studies in depth those factors that underlie the most recent $CO_2$ emissions linked to the economic activity of households, in a representative group of countries of the European Union and the USA. Within the framework of an input-output model, a Structural Decomposition Analysis is considered in order to identify the weight that the growth in demand, the changes in the patterns of consumption, the changes in the distribution of income, and the substitution of inputs or the change in energy intensity have on the evolution of CO2 emissions. The work specifically seeks to identify common patterns and differential behaviors among productive sectors and groups of households in the European social environment.

**Keywords:** CO2 emissions, consumption patterns, input-output, structural decomposition, advanced economies

## 1. Introduction

The evolution of the European economy in recent decades has clearly been positive, relying on a significant tempo of growth of GDP, which has allowed job creation and the increasing per capita income of citizens of the member countries. Nevertheless, the growth of the European economy has coincided, in some countries, with a considerable increase in greenhouse gases (GHG).

In this context it seems clear that policies designed to achieve sustainable economic development in the long term must analyze the effects on the environment generated by productive activities, as much in their structure as in their evolution and growth. This demand is reflected in important international initiatives, such as the Conference on Environment and Development held in Rio de Janeiro in 1992, the World Summit on Sustainable Development held in Johannesburg in 2002, the Kyoto Protocol, and Agenda 21, a United Nations program to promote sustainable development. European countries are among the group of nations publicly committed to the fight against environmental damage.

However, among these countries, positive actions have been noticeably mixed. Although some European countries have taken significant steps towards controlling their emissions, others, Spain among them, have provided little evidence that their model of production and consumption brings them close to fulfilling the Kyoto commitments. By way of example, table 1 reflects the most recent evolution of GHG emissions in the European Union, comparing it with the commitments made in Kyoto, and shows that countries such as Spain, Portugal, Ireland and Austria require urgent modifications in their production and consumption models as a way to reduce emissions.

(Insert Table 1)

There is a broad consensus that significant changes in production technologies, accompanied by changes in patterns of private consumption, are fundamental to the attainment of environmental improvements. In this context, chapter four of Agenda 21 is devoted to methods of consumption, and urges “the evaluation of the relationship between production and consumption, the environment, innovation…and demographics”. This is the framework within which our work is developed, attempting to show the relationship between environmental emissions, production technologies and patterns of household consumption, studying in depth the distinct responsibility that the factors of technology and demand have on the evolution of CO2 emissions.

The relationship between $CO_2$ emissions and the productive activities of a country has been dealt with at great length in the literature, considering input-output methodology as a powerful instrument in the quantification of emissions and in the description of the connections between the productive agents involved. Miller and Blair (1985), Weber and Perrels (2000), Munksgaard et al (2000), Herce et al. (2003), Sánchez-Chóliz and Duarte (2004), Gallego and Lenzen (2005), Kagawa (2005), Rodrigues et al. (2006), Tukker et al. (2006), Wiedmann et al. (2006) and, more recently, Sánchez-Chóliz et. al (2007), Roca and Serrano (2007) and Tarancón and Del Río (2007), are some of the authors who have evaluated the impact of a specific productive structure on $CO_2$ emissions (see Turner et al., 2007, and Wiedmann et al., 2007, for a review of the literature). Similarly, works such as Peet at al. (1985), Vringer and Blok (1995), Biesiot and Noorman (1999), Wier et al. (2001), Carlsson-Kanyama et al. (2002), Throne-Holst et al. (2002), Lenzen et al. (2004), Pachauri (2004), Carlsson-Kanyama et al. (2005),Cohen et al. (2005), Hertwich (2005), Nijdam et al. (2005), Moll et al. (2005), Lenzen et al. (2006) and Kerkof et. al. (2008, 2009a, 2009b), have focused on the relationship between patterns of household consumption in different countries and the use of energy, and $CO_2$ emissions and other GHG. From these works, it can be concluded that the existence of distinct consumption patterns of goods by households can have an effect on the variability of $CO_2$ emissions observed. However, in order to attain an effective reduction of these emissions within the framework of the Kyoto Protocol, it appears necessary to analyze in depth the relationships among household behaviors, their demand, and the socio-economic factors that influence them.

In this context, the objective of our work is to evaluate the impact that the current patterns of household consumption and production observed in European Union countries have on one of the main greenhouse gases, $CO_2$[1]. More specifically, our

[1] According to the European Environmental Agency, CO2 represents approximately 80% of the total GHG emissions of the Union (EEA, 2002).

study, through a Structural Decomposition Analysis (SDA) examines the explanatory factors of the most recent evolution of emissions in a significant group of European Union countries. Combining the most recent available information with respect to input-output tables (OECD, 2009), sectorial emissions of $CO_2$ (Eurostat -European Environmental Agency) and surveys of family budgets (compiled and reconciled by Eurostat), our work examines the role played by increases in expenditure, distribution of household expenditures on different goods (patterns of consumption), technological change, and intensity of emissions on the total emissions of these economies, as well as on the explanation of differences found by countries. The interest in the study lies in the fact that, as far as we know, it is the first work to analyze in a integrated way the effect of factors of demand (consumption patterns, scale of demand), and factors of production (intensity of emissions, productive structure) on $CO_2$ emissions for a significant group of advanced economies (European countries and the USA). The availability of information leads us to consider the following countries in the sample: Austria, Belgium, Germany, Denmark, Spain, France, United Kingdom, Greece, Italy, Netherlands and Portugal (there is insufficient data for Finland, Ireland, Luxembourg, Sweden and the United States[2]). For each, the changes in emissions are analyzed from 1995 to 2005 (specifically with reference to 1995-2000 and 2000-2005), the only period for which it is possible to find comparable information for this group of countries, productive sectors, and households. Although the period analyzed might not be sufficient to identify technological change and its contribution to the evolution of emissions, it can certainly be significant in understanding trends of consumption, as well as identifying production differences and habits of consumption on an international level. All of the information has been homogenized in order to make sectorial and international comparisons. We consider, in this sense, that the study makes advances in the understanding of the structures of consumption and their responsibility in the modulation of environmental damage, in line with the principles promulgated by Agenda 21.

[2] The inclusion of the United States in the analysis is due to its relevance in the emissions of greenhouse gases, being one of the principle polluters on a world level. On the other hand, its peculiarities in production, income distribution and consumption patterns make it a reference to compare the evolution of the European economies included in the analysis.

The paper is structured as follows: Section 2 presents the methodology, based on the application of the structural decomposition analysis to emissions associated with households in an input-output framework, as well as the description of the data-bases used and the criteria followed with respect to the homogenization of the information; Section 3 contains the analysis of our results, by country as well as by sectors of activity, and Section 4 presents our main conclusions.

## 2 Methodology and data.

*2.1. Methodological aspects*

Our starting point is the basic equilibrium equation of the Leontief model.

$$\mathbf{x} = \mathbf{Ax} + \mathbf{y} \Leftrightarrow \mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{y} = \mathbf{My} \qquad (1)$$

where **x** is the vector of total production of productive activities of the economy and **y** is the column vector of final demand; **A** is the matrix of technical coefficients, and **M** is the Leontief inverse. If the part of the final demand corresponding to household consumption ($\mathbf{y}^h$) is only taken in this expression, the result is the production associated to this demand ($\mathbf{x}^h$).

Let us denote by $D_i$ the emissions of $CO_2$ (in physical units) directly caused[3] by the household consumption of the good $i$ ($i=1,..N$). Similarly, let us denote $C_i$ as the emissions generated in the production process of the quantities of good i in demand by households. The total of $CO_2$ emissions, associated with household consumption, $E$, will be:

$$E = \sum_{i=1}^{N} D_i + \sum_{i=1}^{N} C_i = D + C \qquad (2)$$

If we define $\mathbf{d} = \{d_i\} = \{D_i / y^h_i\}$ as the vector of coefficients of direct emissions of households, $y^h_i$ being their demand for good $i$, and $\mathbf{c} = \{c_i\} = (C_i / x_i)$ as the vector of direct unit emissions of production, $\boldsymbol{\lambda}$, can be defined as the vector of *pollution values*[4] *in the production* whose elements show the total pollution directly and indirectly incorporated into the production of each unit of good $i$ purchased by households:

$$\boldsymbol{\lambda}' = \{\lambda_i\} = \mathbf{c}'\mathbf{M} \qquad (3)$$

[3] Emissions associated with home heating and fuel for cars, etc.

[4] The term "value" is assigned due to the similarity of these indicators to traditional work values used in other types of analysis, corresponding to vertically-integrated economic assessment.

If we denote by ω the vector of *pollution values of household*, that is, of the total emissions of $CO_2$ produced in the economy by unit of final household demand, the vector ω can be obtained as the sum of the vector of *pollution values in the production* and of the vector of coefficients of direct emissions from households, that is:

$$\boldsymbol{\omega}' = \boldsymbol{\lambda} + \mathbf{d}' = \mathbf{c}'\mathbf{M} + \mathbf{d}' \qquad (4)$$

In addition to the established definitions, the emissions associated directly and indirectly with the demand of households can be expressed as:

$$E = D + C = \mathbf{d}'\mathbf{y}^h + \mathbf{c}'\mathbf{x}^h = \mathbf{d}'\mathbf{y}^h + \mathbf{c}'\mathbf{M}\mathbf{y}^h = \mathbf{d}'\mathbf{y}^h + \boldsymbol{\lambda}'\mathbf{y}^h = \boldsymbol{\omega}'\mathbf{y}^h \qquad (5)$$

Moreover, in order to study in greater depth the factors that underlie the final demand of households in each country, this demand can be broken down into four factors associated with patterns of consumption, the distribution of the demand among different groups of households, the per capita expenditure, and the population size. Thus, the final demand of the households ($\mathbf{y}^h$) could be expressed as the product of four factors: the total population of the country of reference (*P*), the *per capita* final demand of the households (*Y*), the distribution of the demand among the different types of households, classified by quintiles of income (**z**), and the structure or pattern of consumption of each type of household, classified by quintiles of income (**H**):

$$\mathbf{y}^h = \mathbf{H} \cdot \mathbf{z} \cdot Y \cdot P \qquad (6)$$

and therefore the vector of emissions by sector associated with the demand of households ($\mathbf{e}^h$) could be expressed in the following way:

$$\mathbf{e}^h = \hat{\boldsymbol{\omega}} \cdot \mathbf{y}^h = \hat{\boldsymbol{\omega}} \cdot \mathbf{H} \cdot \mathbf{z}_j \cdot Y \cdot P = \left(\hat{\boldsymbol{\lambda}} + \hat{\mathbf{d}}\right)\mathbf{H} \cdot \mathbf{z} \cdot Y \cdot P \qquad (7)$$

To quantify the weight that these factors have on the evolution of emissions, we use a methodology frequently employed in the literature on Input-Output, Structural Decomposition Analysis (SDA) (see the excellent studies by Rose and Chen,1991, Rose and Casler,1996, Casler and Rose, 1998, De Haan, M., 2001, Hoekstra and Van der Berg, 2002, and Rørmose and Olsen, 2005, for a review).

The general idea on which SDA is based is the additive decomposition of the changes in a variable determined by a series of multiplicative factors that act as accelerators or retardants of their evolution. For example, in an expression like $y = x_1 \cdot x_2$, an explanation of the evolution of the variable dependent $y$ is attempted, (this is, $\Delta y$)

from a series of addends that express what part of that variation is due to the changes in $x_1$, what part responds to those produced in $x_2$, and which to a mixture of both.

The application of SDA on the base of the equation (7) leads us to the fact that the change in household emissions between two periods 0 and 1 can be obtained as:

$$\Delta\mathbf{e}^{h} = \mathbf{e}_1^{h} - \mathbf{e}_0^{h} =$$

$$= \hat{\boldsymbol{\omega}}_1 \cdot \mathbf{H}_1 \cdot \mathbf{z}_1 \cdot Y_1 \cdot P_1 - \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \mathbf{z}_0 \cdot Y_0 \cdot P_0$$

$$= \Delta\hat{\boldsymbol{\omega}} \cdot \mathbf{H}_1 \cdot \mathbf{z}_1 \cdot Y_1 \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_1 \cdot \mathbf{z}_1 \cdot Y_1 \cdot P_1 - \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \mathbf{z}_0 \cdot Y_0 \cdot P_0$$

$$= \Delta\hat{\boldsymbol{\omega}} \cdot \mathbf{H}_1 \cdot \mathbf{z}_1 \cdot Y_1 \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \Delta\mathbf{H} \cdot \mathbf{z}_1 \cdot Y_1 \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \mathbf{z}_1 \cdot Y_1 \cdot P_1 - \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \mathbf{z}_0 \cdot Y_0 \cdot P_0$$

$$= \Delta\hat{\boldsymbol{\omega}} \cdot \mathbf{H}_1 \cdot \mathbf{z}_1 \cdot Y_1 \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \Delta\mathbf{H} \cdot \mathbf{z}_1 \cdot Y_1 \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \Delta\mathbf{z} \cdot Y_1 \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \mathbf{z}_0 \cdot Y_1 \cdot P_1 - \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \mathbf{z}_0 \cdot Y_0 \cdot P_0$$

$$= \Delta\hat{\boldsymbol{\omega}} \cdot \mathbf{H}_1 \cdot \mathbf{z}_1 \cdot Y_1 \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \Delta\mathbf{H} \cdot \mathbf{z}_1 \cdot Y_1 \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \Delta\mathbf{z} \cdot Y_1 \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \mathbf{z}_0 \cdot \Delta Y \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \mathbf{z}_0 \cdot Y_0 \cdot P_1 - \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \mathbf{z}_0 \cdot Y_0 \cdot P_0$$

$$= \Delta\hat{\boldsymbol{\omega}} \cdot \mathbf{H}_1 \cdot \mathbf{z}_1 \cdot Y_1 \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \Delta\mathbf{H} \cdot \mathbf{z}_1 \cdot Y_1 \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \Delta\mathbf{z} \cdot Y_1 \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \mathbf{z}_0 \cdot \Delta Y \cdot P_1 + \hat{\boldsymbol{\omega}}_0 \cdot \mathbf{H}_0 \cdot \mathbf{z}_0 \cdot Y_0 \cdot \Delta P \quad (8)$$

Thus, we have a decomposition with five terms, each expressing the contribution to the total variation of **e** of the change in each of its components. As can be observed, while the incremental term (Δ), runs from left to right when we move from one component to another, the variables that remain on its left in each one are valued in the period 0 (initial), the ones on the right being referred to period 1 (final).

This decomposition is exact, in the sense that there are no residuals. Nevertheless, it is not the only possibility with such a property, since others can be obtained by simply changing the order of the components of **e**. Dietzenbacher and Los (1998) demonstrate that, if the expression used for the decomposition has *n* components, *n!* forms exist in which they can combine, giving rise to similar expressions. In this case they would have, therefore, 5!=120 forms to express Δ**e** in an exact way from the components considered.

In each of these 120 expressions, each addend would indicate the contribution of the term that is expressed as an increment between 0 and 1 to the total variation of **e**. In this work, the final contribution of each explanatory factor of Δ**e** is obtained as an average of its contribution to each of the 120 forms of setting out the exact additive decomposition, following Dietzenbacher and Los (1998), who present this option as an improvement to the polar solution. As support for this calculation we take the algorithm proposed by these authors, and developed also in Rørmose and Olsen (2005).

Once SDA is applied to analyze the change in the $CO_2$ emissions between 1995- 2000 and 2000-2005, in the 11 countries indicated, sufficient information will be provided about the influence that the variations in technological factors and in consumption have on changes in emissions, both global and sectorial.

On this point, it is necessary to make special reference to the contribution assumed by $\Delta\omega$**.** Since $\boldsymbol{\omega} = \boldsymbol{\lambda} + \mathbf{d} = \left[\mathbf{c}'\,(\mathbf{I}-\mathbf{A})^{-1}\right] + \mathbf{d}$, $\Delta\omega$ brings together simultaneously the variations in **c**, **d** and **A**. It seems logical that decreases (increases) in the intensities of emission per monetary unit of the product (values of **c**), are related, not only to improvements in the technology of production, but also to variations in the combination of inputs used, which is precisely what the changes bring together in **A**. Hence, the variations of $\mathbf{c}'\,(\mathbf{I}-\mathbf{A})^{-1}$ are considered together. Regarding **d**, changes in its values indicate technological improvements in the composition of products of reference (fuel with less capacity to pollute) and in the goods (automotive vehicles, heating, etc.) that use them as an energy source (less polluting motors, catalytic converters, etc.). For this reason, the variations of this vector and that of λ will be considered simultaneously, in order to analyze the importance and total effect of the technological changes of **ω**, although afterwards a separate analysis will also be done. For that, a similar decomposition will be used, specifically that resulting from the expression:

$$\mathbf{e}_d^h = \hat{\mathbf{d}} \cdot \mathbf{H} \cdot \mathbf{z} \cdot Y \cdot P \qquad (9)$$

*2.2. Data*

The final selection of the 11 countries included in the study has also been conditioned by the availability of information in different data-bases, although always with a special effort to include the United States[5].

Specifically we have worked with the following information:

[5] When data for a certain country did not refer exactly to the years 1995, 2000 and 2005, the closest figures were used temporarily, extrapolating them with the support of other data.

- Collection of Input-Output Tables from the OECD 2009 (OECD Input-Output Database 2009). From this base, the corresponding symmetric tables and their vectors of final demand and added value have been extracted, updating them to constant prices from 1995 and homogenized in euros, using data of prices and rates of Exchange from the European Commission and from Eurostat. The tables were updated through techniques of adjustment type RAS and aggregated, finally, to the number of sectors considered. From these homogeneous tables, the values of output by industry and of the final demand by households were obtained, as well as the matrix of technical coefficients (**A**) and the inverse coefficient of Leontief (**M**).

- The data on emissions of $CO_2$ by productive sectors were obtained from Eurostat's data-base in electronic support[6] (web) *Air Emissions Accounts by activity (NACE industries and households)*, in which the emissions of polluting gases (by type) are provided for each branch of activity. For the United States, we have turned to the data published by the UN (electronic format, web) in the data-base *United Nations Framework Convention on Climate Change*, conducting from that an extrapolation to the classification NACE used for the European countries[7]. The combined use of these data with the output numbers from the tables allow us to obtain the vectors $\mathbf{c}$ and $\mathbf{d}$.

- Patterns of consumption from the European countries were estimated from Eurostat data, corresponding to surveys of household budgets from each country (Household Budget Surveys, HBS). For the years 1995 and 2000, the existing data for 1994 and 1999 was used (harmonized by Eurostat). Specifically, information related to expenditure structure is broken down according to the classification COICOP, by quintiles of income over the average expenditure in consumption by household in each quintile of income (in euros, and purchasing power parity). Additional transformations are necessary to complete the information in some cases, and to make it compatible with the classification followed in the Input-Output tables (NACE). (More information on the process of estimating patterns of consumption can be

[6] http://epp.eurostat.ec.europa.eu.

[7] It has not been possible to obtain data related to direct household emissions.

obtained in Mainar, 2010.) For the United States, the data on distribution of expense was estimated from publications (electronic support, web) by the Bureau of Labour Statistics (BLS) in its *Consumer Expenditure Survey*.

- Finally, the population data that make up the values of *P* and those that calculate the final total household demand per capita (*Y*), are extracted from the census and population statistics of each country, compiled by Eurostat (for the United States, data from the Census Bureau ).

## 3. Results. Evolution of emissions. Technological factors and factors of demand.

The application of SDA to analyze variations in $CO_2$ emissions caused by the final household demand produces a decomposition in all the explanatory factors indicated in the methodology. Nevertheless, for the purposes of clarity, the results are presented first with a certain level of aggregation, separating them into two blocks: on the one hand, the sum of all the factors related to the structure of demand, and on the other, the technological factors.

### *3.1. First approach to the effects of demand and the technological effects by countries*[8.]

A first look at the results for the entire period, 1995 to 2005 (see table 2 and picture 1), shows us that the factors of demand linked to household consumption caused $CO_2$ emissions to grow in all the countries analyzed except Denmark, where there is a small reduction of -0.3% in demand. Technological factors led to decreases in emissions during those ten years in France (-6.6%), Netherlands (-7.6%), Portugal (-8.9%), Germany (-9.7%), Spain (-9.8%), and, especially significant, in Austria (-16.7%) and Sweden (-19.5%). From these demand and technological factors, there were increases in CO2 emissions in most countries, those being especially high in Portugal, Spain[9] and Austria.

[8] These effects are obtained by adding the corresponding effects to the comprehensive implementation of SDA.

[9] Here, one must consider that what Kyoto was really requiring of Spain was a reduction in emissions.In effect, since Spanish income per capita was below the median of the European Union (around 80%), the growth needed to converge on this implied an increase in emissions much higher

(Insert Picture 1)

(Insert Table 2)

In considering the first period, 1995 to 2000, the results, summarized in table 2 and in picture 2, show how the factors of demand taken together have contributed to increase $CO_2$ emissions, except in Denmark, surpassing in almost all cases the improvements produced through technology. The factors of demand caused an especially significant increase in Portugal (37.6%), Spain (27.8%), the United Kingdom (24.6%) and the United States (30.9%), fluctuating between 6.5% and 16.3% in the remaining countries, excluding Denmark.

Apart from Spain and Italy, all countries reduced their emissions through technological factors, either through improvements in efficiency or by the substitution of inputs, notably Denmark (-14.5%), the United Kingdom (-15.9%) and the United States (-14.5%). In the European countries, these reductions were due primarily to the following sectors, *Electricity, gas and water and Transport*, while in the United States, in addition to reductions caused by improvements in the *Transport* sector, a key factor was an increase in efficiency in the service sectors in general.

(Insert Picture 2)

(Insert Picture 3)

For the period 2000 to 2005 (table 2 and picture 3), only Sweden (-5.8%), Germany (-3.8%) and Netherlands (-4.5%) maintain the decrease from the prior period due to technological factors. In this period, Spain (-14.5%) shows improvements in this component that had not been experienced in the prior time period considered. On the other hand, between 2000 and 2005, we observe three cases of a drop in $CO_2$ emissions due to factors related to the evolution of demand: Sweden (-2.8%), the United Kingdom (-22.5%) and the United States (-13.6%), although in the latter two cases, decreases were more than offset by increases due to technological factors .

In short, we notice through a first approximation that, generally, in this period, technological factors contribute to a reduction of $CO_2$ emissions, while demand drives

than the 15% permitted, if technological factors did not change. Therefore, what was required was a reduction of emissions per unit of product.

emissions up. Likewise, factors of demand predominate over technological factors, justifying the increase in emissions observed in most of the economies.

*3.2. Decomposition of the demand effect by countries.*

Table 3 shows the decomposition of variations in $CO_2$ emissions attributable to demand factors for the entire period, and for the sub-periods 1995-2000 and 2000-2005. Picture 4 shows these components for the entire period.

(Insert Table 3)

(Insert Picture 4)

As can be seen in Table 3, in the period 1995 to 2000, of the four components of the demand effect, two are the most significant: the pattern of consumption and the demand per capita. The table also shows that the demand per capita is the main driver of the growth of $CO_2$ emissions. On the other hand, changes in the patterns of consumption in practically all the countries have contributed to reduce the volume of emissions.

The first aspect, growth in demand per capita, was significant in the United States during that period, where it generated an increase of $CO_2$ emissions greater than 28%. Spain also stood out (25.4%), as did the United Kingdom (26.6%) and Portugal (33.6%). In the rest of the countries analyzed, the increase in emissions from demand per capita was around 13 to 15%, except in Denmark where it barely exceeded 6%. Patterns of consumption have allowed for reductions in emissions during this period in all countries considered, except Spain, Austria and Portugal, where slight increases were generated (0.2%, 2.2% and 1.7%, respectively). Nevertheless, the decreases were generally less significant than the increases generated by demand per capita in the majority of the countries.

Regarding the other two integral factors of the component *final demand of households*, distribution of the demand by quintiles (**z**) and population (*P*), it can be seen that the contribution of the former, during the period 1995 to 2000, has been of little impact, with values around 0.1% of increase or decrease in $CO_2$ emissions due to this factor (only Italy and Portugal reached a 0.4% increase). While population increases for all countries resulted in increases in the volume of emissions, the levels ranged between 0.1% for Italy, 0.5 % for Sweden, 0.8% for Austria and Germany, and 5.7% for the United States, surpassing the 2.1% estimated for Spain and France.

However, the effects change over time and global results from the period 1995 to 2000 cannot be generally applied for 2000 to 2005 (Table 2). Thus, consumption patterns generate growth as much as they do decreases in emissions, depending on the country concerned. Italy (0.6%), Germany, (1.3%), Portugal (4.2%), Spain (6.4%) and Austria (24.8%) show growth in $CO_2$ emissions due to changes produced in consumption patterns, while in the remaining countries, especially the United Kingdom (-12.0%), the reduced character of this aspect of final demand is maintained.

Regarding demand per capita, the level of contributions to $CO_2$ emissions changes in the cases of the United Kingdom (-13.1%) and the United States (-16.3%), compared to 26.6% and 28.3% from the prior period, although in the remaining countries, increases in the levels of pollution continue to be produced, although less than those from 1995 to 2000.

The changes associated with income distribution are practically insignificant[10]. However, the rise in population produces greater increases in $CO_2$ emissions than in the previous five-year period. This is especially significant in Spain, where the rise in population between 2000 and 2005 led to an increase of 7.5% in the volume of $CO_2$ emissions caused by household demand. The United States (5.3%), France (3.6%) and Portugal (3.5%) also showed significant rises in pollution due to the same factor.

A study of the whole period from 1995 to 2005 (Table 3, picture 4), leads to similar conclusions as those of the first five-year period: significant reductions in emissions through changes in patterns of consumption (except in Austria, Spain and Portugal), and large increases caused by demand per capita, especially in Portugal, Spain, France, Netherlands and Germany. Population growth is especially significant in the United States and in Spain, where it has been the cause of nearly an 11% rise in emissions. Nevertheless, the tendency for change that the data from 2000 to 2005 reflect must not be overlooked.

### *3.3. Effects by sectors.*

[10] This is about developed countries, with high levels of social well-being. The use of this factor in the decomposition of emissions for under-developed or developing countries would probably be more significant.

Having seen the effects, and their decomposition by countries, an analysis by sectors is carried out, adding[11] the results of each sector for the European countries[12] described, in order to synthesize the information. As seen in table 4, technology has contributed in a very different way in the two sub-periods. Between 1995 and 2000, in practically all sectors, these technological factors caused a reduction of $CO_2$ emissions, since, in general it was industrial activity that achieved large reductions, together with energy and mining. The dominant sectors are *Energy products* (-15.7%), *Metals and machinery and equipment* (-14.1%), *Chemical products, pharmaceuticals and plastics* (-11.3%) and *Hotels and Restaurants* (-11.2%). Increases due to technology, although of little importance, are only produced in the *Construction* (5.6%) and *Transport* (0.7%) sectors.

However, in the following five-year period, 2000 to 2005, reductions due to technological factors were only produced in *Communications* (-3.5%), *Chemical products, pharmaceuticals and plastics* (-0.9%) and *Construction* (-0.1%), with increases in the emissions of $CO_2$ in the remaining sectors, confirming the idea that the period 2000 to 2005 represents a period of change. Together, the European economies studied increased their $CO_2$ emissions from household demand by 4.8% due to technological factors during that period, compared to a reduction of -6.3% experienced in the prior period. Thus, the combined effect of both periods is a drop of 1.5%, based on reductions experienced in the sectors *Energy products* (-15.0%), *Chemical products, pharmaceuticals and plastics* (-4.0%), *Metal products, machinery and equipment* (-8.7%) and *Hotels and Restaurants* (-8.0%), reductions basically due to those in the first sub-period.

[11] Here, it is important to keep in mind that this aggregation does not represent a whole economy, rather it simply attempts to show average behavior.

[12] The reason for omitting sectors from the United States from this aggregation is based on criteria of analysis and availability of data. Regarding the former, it seems reasonable to add the productive sectors, considering the member countries of the European Union separately. The existence of common policies, in industrial as well as in environmental matters, enables a more coherent integration. On the other hand, the peculiarities of the United States' productive system, as well as its different ways of tackling the problem of emissions of greenhouse-effect gases, reinforce this choice. Regarding the availability of data, the different sources of data used to estimate emissions in both zones (Eurostat and UNFCCC, respectively) advise against mixing both types of assessments in each of the sectors.

Demand factors caused an increase in emissions in all sectors, not only for the combined periods, but also in the initial sub-period 1995 to 2000. Especially remarkable is the *Communications* sector, which had an increase of 122% in those 10 years. *Metal products, machinery and equipment* (74.9%), *Chemical products, pharmaceuticals and plastics* (56.6%), *Credit and insurance* (56.5%) and *Transport material* (49.4%), also had significant increases, mostly during the first sub-period. The only reductions caused by factors of demand were produced between 2000 and 2005 in *Electricity, gas and water* (-3.2%) and in service sectors such as *Trade* (-.6%), *Hotels and Restaurants* (-2.3%), *Transport* (-0.3%) and *Credit and insurance* (-0.5%). Thus, emissions grew, on average, a scant 1.8% between 2000 and 2005, compared to 14.0% in the prior sub-period.

Regarding distribution of demand (indicator of income disparity), the variations were only slightly reflected in the changes of volume of emissions, since in the countries studied there was no significant redistribution of income.

(Insert Table 4)

*3.4. Effects of direct household emissions by countries.*

We now examine the factors that underlie direct household emissions and their evolution in time. As has already been pointed out, the decomposition of changes in direct emissions is similar to the decomposition done of total emissions, (9). Table 5 and picture 5 summarize the results obtained from the decomposition of variations in technological factors and of demand, while Table 6 presents the decomposition of the latter. As was already mentioned, in this analysis the United States is once again omitted due to the unavailability of sufficiently homogeneous data regarding direct emissions.

(Insert table 5)

(Insert Picture 5)

(Insert table 6)

Results for the combined period 1995 to 2005 clarify, more so in the case of direct emissions, the continuous evolution in the countries analysed. With the exception of Italy, the countries under study can be classified in three blocks, according to their position in picture 5. On the one hand, Denmark and the United Kingdom are the only countries in the quadrant with growth in emissions from technological causes and decreases from factors related to demand (basically due to patterns of consumption), while Portugal, Austria and Spain are located in the opposite block, with very high emissions growth generated by factors of demand and reductions of the same due to improvements in the technology (direct intensity) of use of related products (energy, except for electricity, and fuel). In this same quadrant, but with relatively inferior values, the remaining countries (except for Italy) are found. As a whole, only three countries reduce their total emissions - Germany, Denmark and Sweden. It should also be noted that in seven of the ten countries analysed, technological factors help to reduce emissions, although unfortunately only in two of those seven, Sweden and Germany, do technological factors totally compensate for increases generated by demand factors.

Only Germany showed a decrease in direct household $CO_2$ emissions between 1995 and 2000, caused by the simultaneous influence of technological and demand factors (see Table 5). Germany, together with Denmark, reduced the total of direct emissions from demand. However, while in Germany both technology and demand factors drove the reduction, in Denmark the total reduction of emissions was due to the decrease in demand that cancelled the increases from technology. Factors of demand, however, contributed in a very negative way to the increase in emissions in the remaining countries considered, significantly in Portugal (57.8%), Spain (29.6%) and the United Kingdom (19.5%). Technological factors generated improvements in all countries except Italy and Denmark, allowing for reductions in direct $CO_2$ emissions of -34.7% in Portugal, -21.3% in Austria and -23.8% in Sweden. The total global balance in 1995-2000 is negative for five of the countries and positive for the other five.

Between 2000 and 2005, technology once again played a positive role. This allowed reductions from technology in direct household emissions in all countries, except in France where there was a slight growth of 2.6%, in Italy an increase of 5.1%, and in the United Kingdom, with growth of 28.9%. The evolution of final demand again involved growth in direct emissions, except in Italy, Sweden and the United Kingdom, where there were reductions of -0.3%, -10.5% and -29.4%, respectively.

Detailed analyses of the variations in final household demand show similar qualitative behavior in the two sub-periods, as outlined in Table 6.

As can be seen in this table, the evolution in patterns of consumption by households has allowed reductions in direct emissions in all cases except Austria, Spain and Portugal. Decreases in emissions between 1995 and 2000 were -26.0% in Denmark and -16.8% in Germany, and between 2000 and 2005 were -19.4% in the United Kingdom and -14.4% in Sweden.

The growth in emissions due to the influence of demand per capita was especially significant in the first sub-period (1995 to 2000), reaching 24.1% in Spain and 26.4% in the United Kingdom, and climbing to 33.6% in the case of Portugal. In the second sub-period, the increase, especially in Spain, France and Germany, contributed once again in a significant way to the increase in the volume of $CO_2$ emissions, although to a lesser degree. The fall in demand in the United Kingdom, however, led to a reduction of -12.7%.

Again, the influence of the distribution of household demand according to income (by quintiles) is not at all significant, while that of population can be said to be the same as in the case of total effects, making it necessary to emphasize the important effect of this factor on the growth of direct emissions in Spain, with a 10.5% increase between 1995 and 2005 (the major part in the second sub-period, 7.5% between 2000 and 2005). In this sense, the population increase becomes especially significant, since direct emissions demonstrate a special relationship to this factor. Thus increases in population entail, for example, a greater need of energy goods for heat, independent of the existence, or not, of economic growth and its consistent increase in total expenditure. Growth in population has also resulted in a greater demand for private vehicles, leading to increased fuel consumption, which has a significant effect on the case of direct emissions in Spain.

## 4. Conclusions.

In this work, we sought to quantify existing relationships among a series of technological and demand factors and the variations in the volume of $CO_2$ emissions generated by satisfying the needs of households, while keeping in mind compliance with the Kyoto Protocol. We began with the hypothesis of a relationship among the characterization of households, patterns of consumption, and intensity and effective generation of emissions, incorporating into the analysis not only other explanatory factors of demand, such as income distribution or population size, but also the explanation corresponding to technological improvements that could take place in the production of goods and services, improvements that in many cases involve a reduction in the generation of emissions.

The obtained results confirm the expected norms: that growth in demand and therefore in production, largely absorbs the limited effect that technological improvements and efficiency have, on the one hand, and the incipient changes in patterns of consumption on the other.

The technological effort undertaken by the countries analysed in their attempts to comply with the criteria of the Kyoto Protocol is evident. From the analysis done here, it is obvious that respective improvements have occurred in productive processes, due to improvements in environmental efficiency. These improvements, which occurred in practically all sectors during the period 1995 to 2000, have been especially significant in the combined period 1995 to 2005 in the sectors of *Energy products, Chemical products, Pharmaceuticals and plastics*, *Metal products, machinery and equipment*, *Hotels and restaurants, Real Estate and other business activities*. Consistent reductions in the evolution of the magnitude of $CO_2$ correspond to the reductions experienced in the *pollution values* of $CO_2$ , due fundamentally to improvements in technology, strictly speaking, more than from the use of technology inputs incorporating less pollution. In any case, it is necessary to point out the difference in the evolution of technological efficiency in the two sub-periods considered, with a much greater degree of improvement in the five-year period 1995 to 2000, the result no doubt of a greater effort in that regard, followed by a relaxing of effort in the following period.

This technological improvement is also reflected in improvements corresponding to direct household pollution. In spite of some ups and downs, and certain exceptions, these show a reduction in the emissions caused by consumption of fuel for private cars and for home heating.

However, the combined effect in variations of demand has generally contributed to an increase in emissions. With the exception of certain countries (Denmark between 1995 and 2000, and the United Kingdom and Sweden between 2000 and 2005), increases in demand have led to increases in $CO_2$ emissions related to household demand, increases that in the majority of cases have concealed the effects of the technological improvements achieved.

Nevertheless, this combined effect of demand is not homogeneous in all its components. The evolution of household demand has two main explanatory factors: on the one hand, changes in patterns of consumption cause alterations in the weight that goods and services have within family expenses, that is, they vary the final sectorial demand. On the other hand, there exists economic growth that reflects increases in that demand.

The contribution of household consumption to the reduction of $CO_2$ emissions is evident, as much in that directly caused by households as in that prompted by their demand for goods and services. The incipient changes in patterns of consumption, and the consistent changes in the composition of household expenses, have contributed to a reduction of $CO_2$ emissions in the countries analyzed (with the exception of Austria, Spain and Portugal). The substitution of some goods for others has allowed a decrease in pollution which, nevertheless, has been compensated for and overcome by the absolute increase in demand.

The influence of changes in income distribution has also been analyzed. The results show that the relevance of this distribution aspect is small. Changes in income distribution, and of demand, have little impact on the growth or decrease of $CO_2$ emissions corresponding to household demand. There is a dual explanation for this: on the one hand, variations in income distribution in the periods studied have not been substantial, with certain exceptions, probably since developed economies have less capability for improvement in this sense. On the other hand, the possible transfers of households from one income quintile to another do not represent a great change in their intensity of emissions, and hence the combined effect is not significant.

Repercussions from the other two components of household demand, demand per capita and population, on the increase in $CO_2$ emissions have been vital. The extent of their effect has superseded, in general, the improvements produced through changes in patterns of consumption. Thus, while the effects of the increases in demand per capita are clear, for as much as the economic growth experienced during the period considered caused increases in household consumption, the population increase maximized this effect in some countries. Countries such as Spain and the United States, both with a large influx of immigrants between 1995 and 2005, have seen significant increases in demand due to this population growth.

The results presented are consistent with those obtained by other studies in the international field, such as those of Munksgaard et al. (2000), Wier et al. (2001) and Kerkhof et al. (2009a y 2009b), in which relationships are established among households, their behavior or typology, and the evolution of emissions related to their demand and consumption.

We can conclude that the growth in $CO_2$ emissions on the part of households has essentially been due to the global increase in demand. Significant efforts have been made in the fields of innovation and efficiency, noticeable in the sectors and countries analyzed. Moreover, changes in patterns of consumption leading to the demand for less polluting goods and services can be observed. However, the increase in final demand due to economic growth itself and from the pressure of population growth offset these positive effects, causing $CO_2$ emissions attributed to household demand to rise in all countries, except Germany, Denmark and Sweden.

These contrasting effects should be kept in mind when planning economic or environmental policies leading to compliance with the Kyoto Protocol. Aspects that have been shown to contribute to the reduction of emissions - continuing improvements in the technological efficiency of production and maximizing the changes in patterns of household consumption, which is especially significant when speaking of the emissions associated with final household demand - must be stressed in order to make the criteria established by the Kyoto Protocol compatible with economic growth. The combination of both aspects must be a primary objective of policies leading to the reduction of $CO_2$ emissions.

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**Table 1.**

**Change from base year and targets under Kyoto Protocol of GHG emissions in UE-15.**

| | Change from Kyoto Protocol base year* | | | | Target 2008-12 under Kyoto Protocol and "EU burden sharing" (%) |
|---|---|---|---|---|---|
| | 1995 | 2000 | 2005 | 2008 | |
| **Austria** | 1.3% | 1.3% | 17.7% | 9.6% | -13.0% |
| **Belgium** | 3.0% | -0.5% | -3.2% | -8.6% | -7.5% |
| **Denmark** | 9.7% | -1.9% | -7.6% | -7.9% | -21.0% |
| **Finland** | 0.0% | -2.8% | -4.2% | -1.2% | 0.0% |
| **France** | -1.2% | -1.2% | -1.4% | -6.5% | 0.0% |
| **Germany** | -10.7% | -16.8% | -20.6% | -22.3% | -21.0% |
| **Greece** | 0.9% | 16.8% | 24.3% | 18.6% | 25.0% |
| **Ireland** | 4.3% | 22.3% | 24.1% | 21.3% | 13.0% |
| **Italy** | 2.3% | 6.4% | 10.9% | 4.8% | -6.5% |
| **Luxembourg** | -24.2% | -24.2% | -1.5% | -5.1% | -28.0% |
| **Netherlands** | 5.6% | 0.9% | -0.5% | -2.9% | -6.0% |
| **Portugal** | 16.5% | 34.8% | 44.8% | 30.3% | 27.0% |
| **Spain** | 8.7% | 31.5% | 50.1% | 40.0% | 15.0% |
| **Sweden** | 2.5% | -4.4% | -5.8% | -11.3% | 4.0% |
| **United Kingdom** | -8.3% | -13.3% | -15.6% | -19.1% | -12.5% |
| **UE-15** | -3.0% | -3.6% | -2.8% | -6.9% | -8.0% |

* $CO_2$, $CH_4$ and $N_2O$, 1990 for all countries; HFC, PFC, $SF_6$, 1995 for all countries except Austria, France and Italy (1990).

Source: Own elaboration from Annual European Union Greenhouse gas Inventory 1990-2008 and inventory report 2010. European Environment Agency.

**Table 2. Decomposition of the growth of $CO_2$ emissions, caused from household demand, technological factors, and factors of demand.**

| | 1995 - 2000 | | | 2000 – 2005 | | | 1995 - 2005 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Technological factors | Demand factors | Total | Technological factors | Demand factors | Total | Technological factors | Demand factors | Total |
| **Austria** | -12.3% | 16.3% | 4.0% | 0.5% | 28.1% | 28.6% | -16.7% | 50.5% | 33.8% |
| **Germany** | -5.6% | 6.5% | 0.9% | -3.8% | 4.8% | 1.0% | -9.7% | 11.6% | 1.9% |
| **Denmark** | -14.5% | -2.1% | -16.6% | 21.6% | 1.7% | 23.3% | 3.1% | -0.3% | 2.8% |
| **Spain** | 6.7% | 27.8% | 34.5% | -14.5% | 21.4% | 6.9% | -9.8% | 53.7% | 43.9% |
| **France** | -9.5% | 13.6% | 4.1% | 3.8% | 6.9% | 10.7% | -6.6% | 21.8% | 15.2% |
| **Netherlands** | -2.6% | 9.7% | 7.1% | -4.5% | 8.5% | 4.0% | -7.6% | 18.9% | 11.3% |
| **Italy** | 3.1% | 8.0% | 11.1% | 4.7% | 5.1% | 9.8% | 8.4% | 13.6% | 22.0% |
| **Portugal** | -12.0% | 37.6% | 25.6% | 3.5% | 14.6% | 18.1% | -8.9% | 57.2% | 48.3% |
| **United Kindgdom** | -15.9% | 24.6% | 8.7% | 29.3% | -22.5% | 6.8% | 14.6% | 1.5% | 16.1% |
| **Sweden** | -13.8% | 12.9% | -0.9% | -5.8% | -2.8% | -8.6% | -19.5% | 10.1% | -9.4% |
| **United States** | -14.5% | 30.9% | 16.4% | 19.2% | -13.6% | 5.6% | 6.0% | 16.9% | 22.9% |

**Table 3. Variations in CO2 emissions attributed to final household demand caused by determinant factors of this demand.**

| | 1995 - 2000 | | | | | 2000- 2005 | | | | | 1995 - 2005 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pattern of consumption | Distribution of the demand | Demand per capita | Populatio n | Total factors of demand | Pattern of consumptio n | Distribution of the demand | Demand per capita | Populatio n | Total factors of demand | Pattern of consumptio n | Distribution of the demand | Demand per capita | Populatio n | Total factors of demand |
| **Austria** | 2.2% | -0.3% | 13.6% | 0.8% | 16.3% | 24.8% | 0.3% | 0.0% | 2.9% | 28.0% | 30.9% | 0.0% | 15.8% | 3.9% | 50.6% |
| **Germany** | -8.7% | 0.0% | 14.5% | 0.8% | 6.6% | 1.3% | -0.1% | 3.1% | 0.4% | 4.7% | -7.3% | -0.1% | 17.8% | 1.2% | 11.6% |
| **Denmark** | -10.5% | -0.1% | 6.4% | 2.0% | -2.2% | -4.3% | -0.1% | 4.5% | 1.7% | 1.8% | -15.1% | -0.2% | 11.2% | 3.7% | -0.4% |
| **Spain** | 0.2% | 0.1% | 25.4% | 2.1% | 27.8% | 6.4% | 0.0% | 7.6% | 7.5% | 21.5% | 7.4% | 0.1% | 35.2% | 10.9% | 53.6% |
| **France** | -2.9% | 0.0% | 14.4% | 2.1% | 13.6% | -6.7% | 0.0% | 10.0% | 3.6% | 6.9% | -9.4% | 0.0% | 25.4% | 5.9% | 21.9% |
| **Netherlands** | -6.7% | 0.3% | 13.2% | 2.9% | 9.7% | -5.1% | 0.2% | 10.5% | 2.8% | 8.4% | -11.9% | 0.5% | 24.5% | 5.9% | 19.0% |
| **Italy** | -4.4% | 0.4% | 11.9% | 0.1% | 8.0% | 0.6% | 0.0% | 1.6% | 2.8% | 5.0% | -4.2% | 0.5% | 14.2% | 3.1% | 13.6% |
| **Portugal** | 1.7% | 0.4% | 33.6% | 2.0% | 37.7% | 4.2% | -0.3% | 7.2% | 3.5% | 14.6% | 6.2% | 0.1% | 44.7% | 6.2% | 57.2% |
| **United Kingdom** | -3.2% | -0.3% | 26.6% | 1.5% | 24.6% | -12.0% | 0.3% | -13.1% | 2.2% | -22.6% | -16.4% | 0.0% | 14.0% | 3.9% | 1.5% |
| **Sweden** | -0.8% | -0.1% | 13.3% | 0.5% | 12.9% | -6.9% | 0.0% | 2.5% | 1.6% | -2.8% | -7.1% | -0.1% | 15.2% | 2.1% | 10.1% |
| **United States** | -3.1% | 0.0% | 28.3% | 5.7% | 30.9% | -2.5% | -0.1% | -16.3% | 5.3% | -13.6% | -6.0% | -0.1% | 11.4% | 11.6% | 16.9% |

**Table 4. Decomposition in technological factors and in factors of demand, by sectors, of the growth of $CO_2$ emissions attributed to final household demand. European countries analyzed.**

| | | 1995 - 2000 | | | 2000 – 2005 | | | 1995 - 2005 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Technological factors | Factors of demand | Total | Technological factors | Factors of demand | Total | Technological factors | Factors of demand | Total |
| S.01 | Agriculture and food | -6.3% | 13.1% | 6.8% | 2.6% | 7.8% | 10.4% | -3.5% | 21.5% | 18.0% |
| S.02 | Energy products | -15.7% | 21.0% | 5.3% | 2.1% | 3.6% | 5.7% | -15.0% | 26.3% | 11.3% |
| S.03 | Metals and non- metals | -5.0% | 21.0% | 16.0% | 2.3% | 14.2% | 16.5% | -3.5% | 38.7% | 35.2% |
| S.04 | Textiles and footwear | -4.2% | 13.7% | 9.5% | 1.2% | 1.9% | 3.1% | -3.2% | 16.2% | 13.0% |
| S.05 | Publishing, graphic arts and paper | -10.0% | 19.6% | 9.6% | 11.6% | 10.3% | 21.9% | 0.0% | 33.5% | 33.5% |
| S.06 | Chemical products, pharmaceuticals and plastics | -11.3% | 29.1% | 17.8% | -0.9% | 21.9% | 21.0% | -14.0% | 56.6% | 42.6% |
| S.07 | Metal products, machinery and equipment | -14.1% | 46.7% | 32.6% | 5.1% | 20.3% | 25.4% | -8.7% | 74.9% | 66.2% |
| S.08 | Transport material | -8.2% | 37.8% | 29.6% | 2.4% | 9.0% | 11.4% | -5.0% | 49.4% | 44.4% |
| S.09 | Manufacture, wood and furniture | -6.9% | 25.8% | 18.9% | 8.8% | 3.5% | 12.3% | 1.2% | 32.3% | 33.5% |
| S.10 | Electricity, gas and water | -7.0% | 7.5% | 0.5% | 9.1% | -3.2% | 5.9% | 2.6% | 3.9% | 6.5% |
| S.11 | Construction | 5.6% | 29.8% | 35.4% | -0.1% | 3.5% | 3.4% | 6.9% | 33.1% | 40.0% |
| S.12 | Trade | -1.7% | 9.9% | 8.2% | 4.7% | -7.6% | -2.9% | 2.7% | 2.4% | 5.1% |
| S.13 | Hotels and restaurants | -11.2% | 17.3% | 6.1% | 3.4% | -2.3% | 1.1% | -8.0% | 15.1% | 7.1% |
| S.14 | Transport | 0.7% | 6.8% | 7.5% | 3.0% | -0.3% | 2.7% | 3.5% | 6.8% | 10.3% |
| S.15 | Communications | -1.1% | 70.4% | 69.3% | -3.5% | 32.5% | 29.0% | -4.2% | 122.7% | 118.5% |
| S.16 | Credit and insurance | -1.5% | 56.9% | 55.4% | 6.6% | -0.5% | 6.1% | 8.3% | 56.5% | 64.8% |
| S.17 | Real estate and other business activities | -10.7% | 13.7% | 3.0% | 4.7% | 4.5% | 9.2% | -6.5% | 18.8% | 12.3% |
| S.18 | Public Administration, Education, Healthcare and other personal and social services for the community | -6.5% | 17.9% | 11.4% | 8.3% | 3.4% | 11.7% | 2.1% | 22.5% | 24.6% |
| TOTAL | | -6.3% | 14.0% | 7.7% | 4.8% | 1.8% | 6.6% | -1.5% | 16.4% | 14.9% |

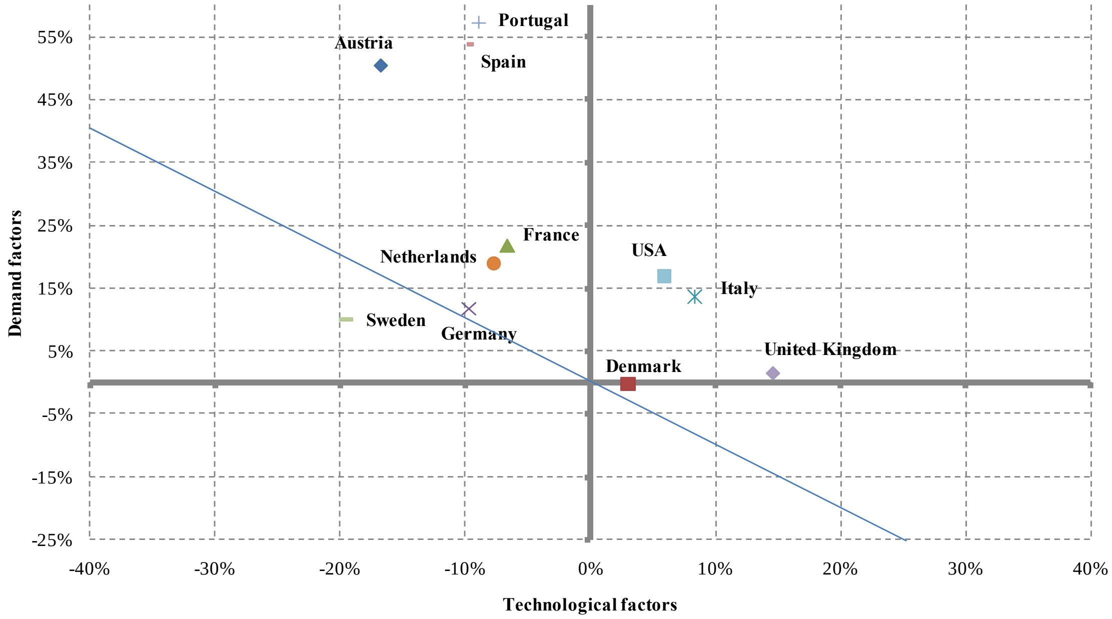
**Table 5. Decomposition of the growth of direct $CO_2$ emissions causes for household demand, in technological factors and in factors of demand.**

| | 1995 - 2000 | | | 2000 – 2005 | | | 1995 - 2005 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Technological factors | Factors of demand | Total | Technological factors | Factors of demand | Total | Technological factors | Factors of demand | Total |
| **Austria** | -21.3% | 16.0% | -5.3% | -19.5% | 38.6% | 19.1% | -46.9% | 59.6% | 12.7% |
| **Germany** | -2.4% | -1.9% | -4.3% | -7.2% | 3.8% | -3.4% | -9.9% | 2.3% | -7.6% |
| **Denmark** | 15.5% | -16.9% | -1.4% | -9.0% | 3.9% | -5.1% | 5.8% | -12.3% | -6.5% |
| **Spain** | -8.3% | 29.6% | 21.3% | -7.5% | 18.4% | 10.9% | -17.4% | 51.8% | 34.4% |
| **France** | -11.9% | 15.4% | 3.5% | 2.6% | 2.0% | 4.6% | -9.4% | 17.7% | 8.3% |
| **Netherlands** | -8.1% | 7.8% | -0.3% | -8.7% | 9.1% | 0.4% | -17.7% | 17.7% | 0.0% |
| **Italy** | 7.5% | 4.4% | 11.9% | 5.1% | -0.3% | 4.8% | 14.2% | 3.2% | 17.4% |
| **Portugal** | -34.7% | 57.8% | 23.1% | -10.6% | 11.3% | 0.7% | -47.4% | 71.3% | 23.9% |
| **United Kingdom** | -12.1% | 19.5% | 7.4% | 28.9% | -29.4% | -0.5% | 17.9% | -11.1% | 6.8% |
| **Sweden** | -23.8% | 13.2% | -10.6% | -7.3% | -10.5% | -17.8% | -30.3% | 3.7% | -26.6% |

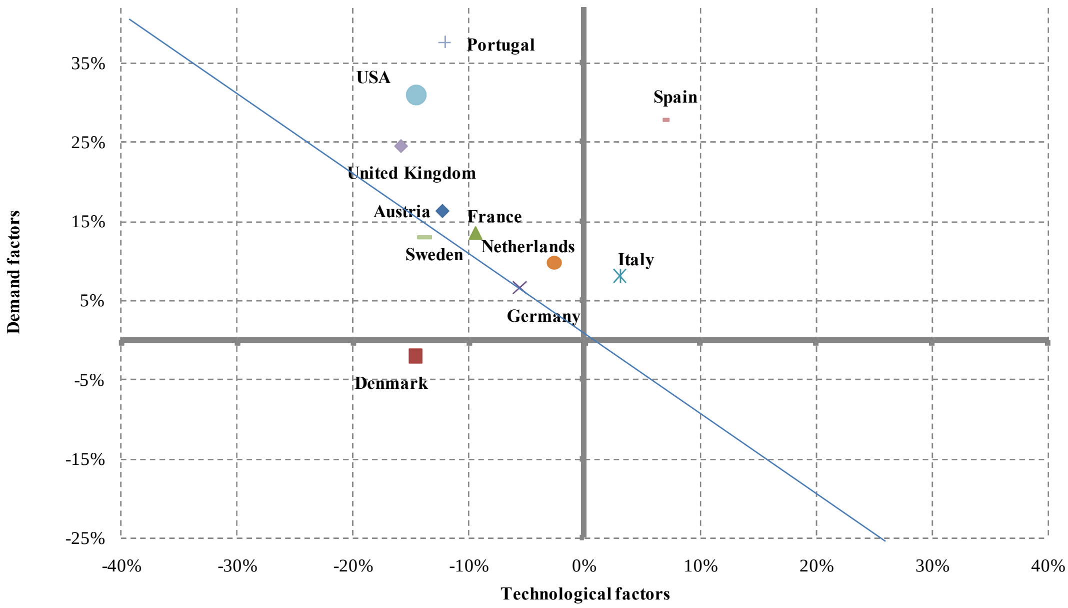
**Table 6. Changes in <u>direct</u> $CO_2$ emissions attributed to household demand, caused by the determinant factors of its demand.**

| | 1995 - 2000 | | | | | 2000- 2005 | | | | | 1995 - 2005 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pattern of consumption | Distribution of the demand | Demand per capita | Population | Total factors of demand | Pattern of consumption | Distribution of the demand | Demand per capita | Population | Total factors of demand | Pattern of consumption | Distribution of the demand | Demand per capita | Population | Total factors of demand |
| **Austria** | 2.5% | -0.4% | 13.1% | 0.7% | 15.9% | 35.2% | 0.7% | 0.0% | 2.9% | 38.8% | 41.0% | 0.0% | 14.9% | 3.7% | 59.6% |
| **Germany** | -16.8% | -0.1% | 14.2% | 0.8% | -1.9% | 0.4% | -0.1% | 3.1% | 0.4% | 3.8% | -15.9% | -0.1% | 17.2% | 1.2% | 2.4% |
| **Denmark** | -26.0% | -0.1% | 7.0% | 2.2% | -16.9% | -1.2% | -0.3% | 3.9% | 1.5% | 3.9% | -26.3% | -0.3% | 10.8% | 3.6% | -12.2% |
| **Spain** | 3.4% | 0.1% | 24.1% | 2.0% | 29.6% | 3.1% | -0.1% | 7.8% | 7.6% | 18.4% | 7.1% | 0.0% | 34.1% | 10.5% | 51.7% |
| **France** | -1.2% | 0.0% | 14.5% | 2.1% | 15.4% | -11.2% | 0.0% | 9.7% | 3.5% | 2.0% | -12.7% | 0.0% | 24.7% | 5.7% | 17.7% |
| **Netherlands** | -8.3% | 0.5% | 12.8% | 2.8% | 7.8% | -4.3% | 0.4% | 10.3% | 2.8% | 9.2% | -12.0% | 0.7% | 23.3% | 5.6% | 17.6% |
| **Italy** | -7.2% | -0.4% | 11.9% | 0.1% | 4.4% | -4.6% | 0.0% | 1.6% | 2.7% | -0.3% | -13.3% | -0.4% | 13.9% | 3.1% | 3.3% |
| **Portugal** | 21.4% | 0.8% | 33.6% | 2.0% | 57.8% | 1.9% | -0.5% | 6.6% | 3.3% | 11.3% | 24.0% | 0.2% | 41.4% | 5.7% | 71.3% |
| **United Kingdom** | -8.0% | -0.4% | 26.4% | 1.5% | 19.5% | -19.4% | 0.5% | -12.7% | 2.2% | -29.4% | -28.5% | 0.1% | 13.5% | 3.8% | -11.1% |
| **Sweden** | 0.3% | -0.2% | 12.7% | 0.5% | 13.3% | -14.4% | 0.0% | 2.3% | 1.5% | -10.6% | -11.9% | -0.1% | 13.8% | 1.9% | 3.7% |

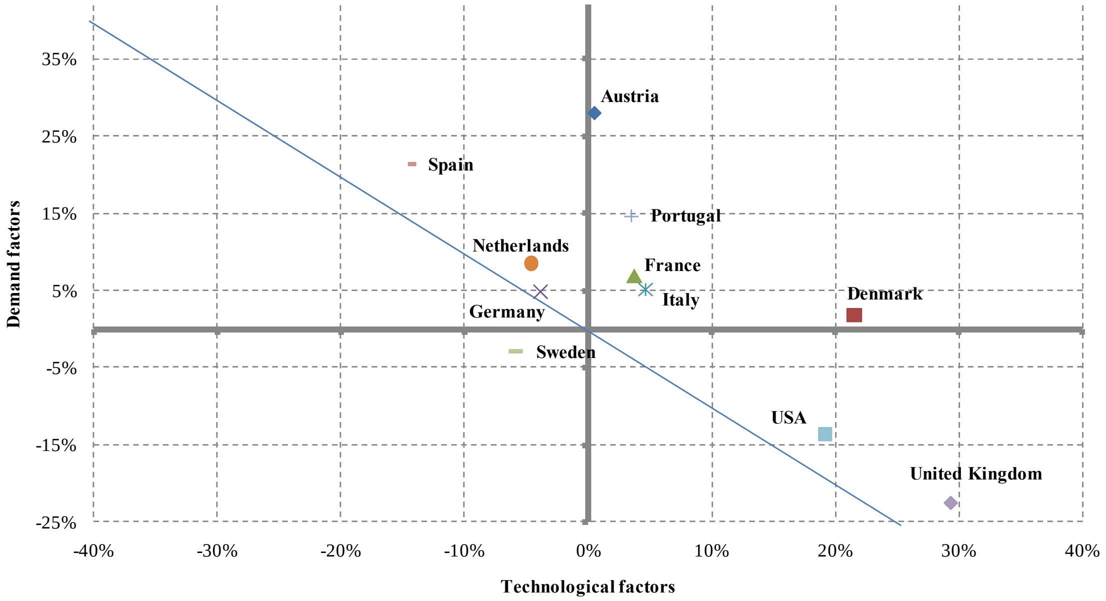
**Picture 1. Position of the countries analyzed according to the influence of their technological factors and of their factors of demand in the evolution of <u>total $CO_2$emissions</u> caused by final household demand. Period 1995-2005.**



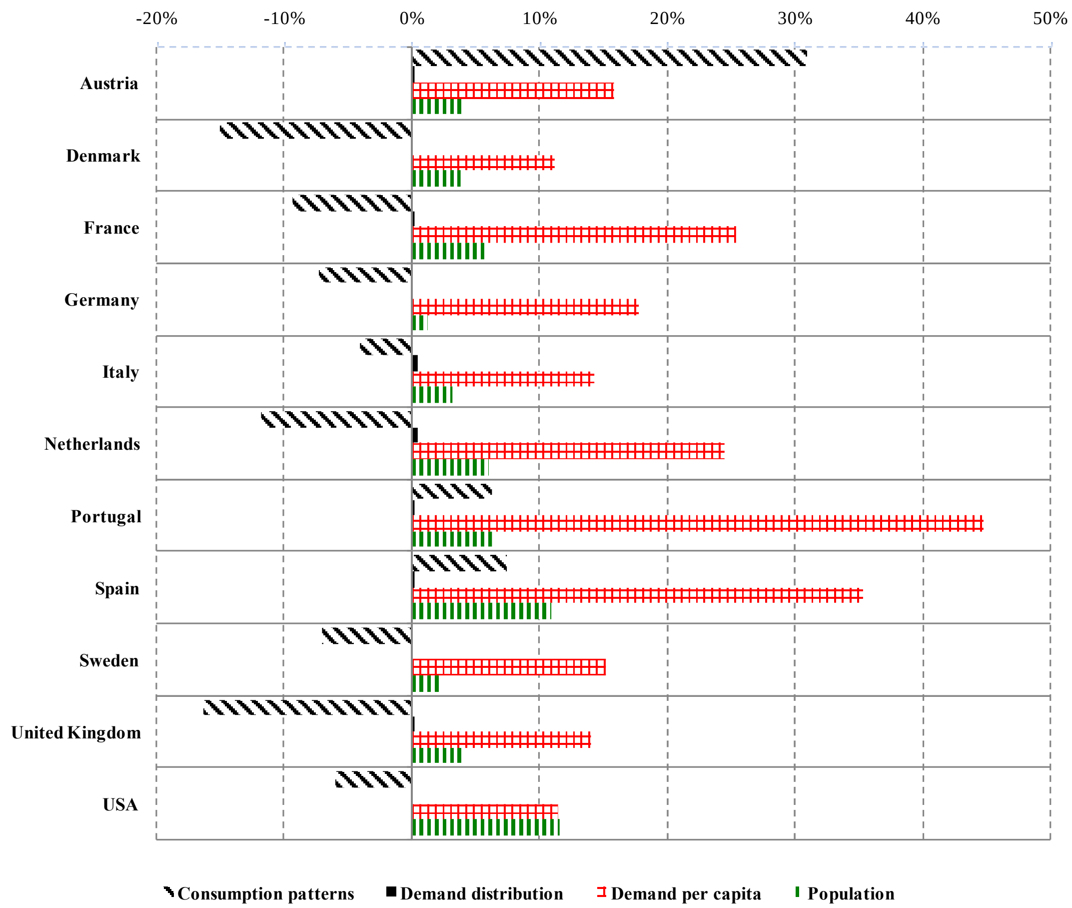

**Picture 2. Position of the countries analyzed according to the influence of their technological factors and of their factors of demand in the evolution of <u>total $CO_2$emissions</u> caused by final household demand. Period 1995-2000.**



**Picture 3. Position of the countries analyzed according to the influence of their technological factors and of their factors of demand in the evolution of total $CO_2$ emissions caused by final household demand. Period 2000-2005.**




**Picture 4. Variations in $CO_2$ emissions attributed to the final household demand caused by their determinant factors. Period 1995-2005.**



**Picture 5. Position of the countries analyzed according to the influence of their technological factors and of their factors of demand in the evolution of their direct $CO_2$ emissions on the part of households. Period 1995-2005.**