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Atmospheric pollution and consumption patterns in Spain

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Abstract

In this paper we apply an environmentally extended input-output model to analyse a specific topic related to the Environmental Kuznets Curve hypothesis. The purpose is to study whether the consumption structure of 'wealthier' households may have a positive effect for reducing environmental pressures. Combining information from different databases we analyse the impact on atmospheric pollution of the consumption of different Spanish households in 2000. We consider nine gases, i.e. the six greenhouse gases (CO_2, CH_4, N_2O, SF_6, HFCs, and PFCs) and three other gases (SO_2, NO_x, and NH_3). We classify households by quintiles of per-capita expenditure and equivalent expenditure. We find that there is a positive and very high relationship between the level of expenditure and direct and indirect emissions generated by household consumption; however, the emission intensities tend to decrease with the expenditure level for the different atmospheric pollutants, with the exception of SF_6, HFCs and PFCs.

Keywords: consumption patterns, atmospheric pollution, environmental Kuznet curve, input-output analysis, Spain.

1. Introduction

Worldwide deterioration of environmental quality has been of growing interest amongst academics and politicians over the recent past. Specifically, there has been an important debate on the environmental effects of economic growth, which has been strongly influenced by the Environmental Kuznets Curve (EKC) hypothesis. This hypothesis postulates an inverted-U-shaped relationship between environmental pressures and per-capita income, i.e. as income increases environmental pressures augment until a certain level after that these pressures diminish (Grossman and Krueger, 1991; Shafik and Bandyopadhyay, 1992). However, following de Bruyn and Opschoor's (1997) differentiation it could be distinguished an absolute (or strong) and relative (or weak) delinking between economic growth and environmental pressures. In the first case, there would be an absolute reduction in environmental pressures; whereas in the second one, there would only be a reduction in environmental pressures per unit of income, which would not be enough for environmental improvement.

The EKC hypothesis is founded on the fact that per-capita income growth may involve changes in production processes and/or final demand towards less pollutant production and consumption patterns[1]. Specifically, according to the EKC literature there are three main factors, provoked by the own process of economic growth, which may explain this environmental improvement: technological changes, changes in the structure of the final demand, and changes in individual preferences. The last two factors may be linked with consumers' behaviour since consumer patterns and preferences tend to change as per-capita income increases. On one hand, it seems that consumption patterns move away from more pollutant goods and services towards less environmental deteriorating commodities; and, on the other hand, once a certain income level is achieved, consumers would shift the consumption of certain goods and services to consume more environmental quality[2]. Therefore, it seems important to focus the research not only on the supply-side such as the production process but also on the demand-side where consumers should play an active role in the process of reducing environmental pressures (United Nations, 2007).

The aim of this paper is not to test the existence of an EKC in Spain but to study one of the elements that determine the relationship between income growth and environmental

[1] In an open economy, besides, the 'delinking' could also be due to the importation of pollutant intensive commodities. In this case, however, it was no a genuine delinking but only a displacement of environmental costs (Arrow *et al.*, 1995; Suri and Chapman, 1998; Muradian and Martínez-Alier, 2001).

[2] It should be mentioned, however, that 'environmental quality' is in most cases a public good that cannot be bought in the market and, therefore, some environmental policies or any kind of regulation will be needed to solve some environmental problems (Roca, 2003).

pressures. In particular, this paper analyses the emissions associated with different levels of private consumption taking into account that when households reach a higher 'economic position' and their consumption increases, this increase is not homothetic, i.e. consumption structure changes whereas consumption level increases. Although this approach is not usually applied to study the EKC hypothesis, we consider that this kind of comparative static analysis is pertinent to the EKC debate as it includes significant elements for estimating the dimension of some key factors in the EKC hypothesis.

For doing so we combine statistic information from different databases. We use an environmentally extended input-output model to evaluate the impact of different Spanish household's consumption on atmospheric pollution in 2000, classifying households by quintiles of expenditure. We examine the emissions of nine gases: the six greenhouse gases (CO_2, CH_4, N_2O, SF_6, HFCs, and PFCs) and three gases associated with local and regional environmental problems (SO_2, NO_x, and NH_3). We find that the more a household spends the more emissions it generates; however, the atmospheric pollution emitted per unit of household consumption generally decrease with the expenditure level. These outcomes are confirmed by the values of expenditure elasticity of emissions we estimate for all the gases performing a multivariate regression. We find that the expenditure elasticity is always positive and lower than unit for almost all gases. The only exception to this is the synthetic greenhouse gases whose elasticity is higher than unit.

Generally, the passive representation of households as final consumers in the national accounts partially hide the role played for them into environmental pressures. For instance, until the end of the 1970's little attention was directed to household energy requirements; that is, how much energy a household requires to maintain its standard of living. The technique of linking energy requirements based on input-output analysis and household expenditure data was developed by Robert Herendeen, who applied this seminal work to the USA economy (Herendeen and Tanaka, 1976; Herendeen *et al.*, 1981) and to Norway (Herendeen, 1978). These studies examined the total energy cost of living for different types of households considering not only the direct demand for energy products, but also the indirect energy required to produce and distribute the commodities demanded by households. This methodology has been also applied in other countries such as the Federal Republic of Germany (Denton, 1975), New Zealand (Peet *et al.*, 1985), and the Netherlands (Vringer and Blok, 1995). Reinders *et al.* (2003) evaluated the average energy requirement of households in 11 member states of the European Union (EU), and Lenzen *et al.* (2006) analysed the relationship between income level and energy requirements for five countries, i.e. Australia, Brazil, Denmark, India and Japan.

Nevertheless, no research was undertaken on analysing the CO_2 emissions associated with the household energy requirements until the validation of the Kyoto protocol in 1997, from which various countries are concerning in limiting their emissions of greenhouse gases. According to our knowledge, the first study in analysing both energy requirements and CO_2 emissions was carried out by Lenzen (1998b) for Australia, which was followed by Weber and Perrels (2000) for West Germany, France, and the Netherlands; Munksgaard *et al.* (2000) and Wier *et al.* (2001) for Denmark; and Peters *et al.* (2004) for Norway. All these studies are based on energy input-output models combining energy and household expenditure data and none of them offers results for other emissions apart from CO_2[3]. So, according to our knowledge this is the first work in considering other gas emissions generated by the consumption of different households[4].

The rest of the paper is as follows. In Section 2, we present the model to evaluate total emissions embodied in household consumption. In Section 3, we describe the characteristics of Spanish data, the modifications that have been necessary to correlate data from different sources, and the procedure to estimate the parameters of the model. In Section 4, we present the results for Spanish households in 2000. In Section 5 some conclusions are given. Finally, the Appendix of this paper is devoted to present some detailed information.

2. Atmospheric emissions generated by households: the theoretical model

In analysing total emissions generated by household consumption we consider both direct and indirect household emissions (Figure 1). The former are emissions generated directly by some activities carried out by households such as using fuels for personal transport or heating; whereas the latter are emissions associated with production of goods and services purchased by households, i.e. food, clothes, furniture, electricity, etc. Thus, indirect household emissions also include direct and indirect emissions generated by different economic sectors.

Figure 1

[3] A good review about different input-output methods is Kok *et al.* (2006).
[4] It should be mentioned that Lenzen (1998a), Peters and Hertwich (2006), and Sánchez-Chóliz *et al.* (2007) take other gas emissions into account. On the other hand, Nijdam *et al.* (2005) and Huppes *et al.* (2006) also analyse other environmental impacts of private consumption such as acidification or eutrophication. However, the level of analysis of these studies is quite aggregate since they evaluate the emissions embodied in total private consumption of the average household without differentiating different types of households.

Let k be atmospheric pollutants, h be households, and s be consumption purposes, direct and indirect emissions generated by households are respectively $\mathbf{E}^{\mathbf{direct}}$ and $\mathbf{E}^{\mathbf{indirect}}$, which are two matrices of dimension kxh [5]:

$$\mathbf{E}^{\mathbf{direct}} = \mathbf{D}^{\mathbf{direct}}\mathbf{C} \quad (1)$$

$$\mathbf{E}^{\mathbf{indirect}} = \mathbf{D}^{\mathbf{indirect}}\mathbf{C} \quad (2)$$

Where $\mathbf{D}^{\mathbf{direct}}$ and $\mathbf{D}^{\mathbf{indirect}}$ are the kxs intensity matrices of direct and indirect household emissions whose respective elements d_{lp}^{direct} and $d_{lp}^{indirect}$ represent the direct indirect emissions of pollutant l measured in physical units associated with each monetary unit spent on a consumption purpose p. And $\mathbf{C}$ is a sxh matrix that indicates expenditure on different goods and services grouped according to consumption purposes carried out by each household.

So, total emissions associated with household consumption $\mathbf{E}^{\mathbf{household}}$ of dimension kxh can be easily calculated adding both expressions such that:

$$\mathbf{E}^{\mathbf{household}} = \mathbf{DC} \quad (3)$$

Where $\mathbf{D}$ is now the kxs intensity matrix of total household emissions that includes both direct and indirect household emissions coefficients, i.e. $\mathbf{D} = \mathbf{D}^{\mathbf{direct}} + \mathbf{D}^{\mathbf{indirect}}$.

3. Atmospheric emissions generated by households in Spain: from theoretical model to empirical application

In order to estimate direct and indirect household emissions, classifications and dimensions of all matrices have to be compatible. However, the model presented in the previous section requires combining data from different sources and with different classifications. Thus, we need to presuppose some assumptions and prepare the data before computing the model.

Specifically, four main data sources were employed: the 2000 supply and use tables from the Spanish input-output framework base 1995 (INE, 2005); the 2000 Spanish environmental accounts for air emissions base 1995 (INE, 2006); Spanish Household Budget Continuous Survey (HBCS) for 2000 base 1997 (INE, 2004); and Spanish transformation matrix that relates CPA and COICOP[6] groups for the year 1995 supplied by the Spanish national statistics institute (INE). These databases are described in Appendix A. The rest of the section is devoted to explain the procedures to compute the parameters of the model.

[5] Matrices are indicated bold, upright capital letters; vectors by bold, upright lower case letters; and scalars by italicised lower case letters. Vectors are columns by definition.
[6] CPA and COICOP stand for *Classification of Product by Activity* and *Classification of Individual Consumption by Purpose*, respectively.

Direct and indirect household emissions are determined by their corresponding intensity matrices of household emissions, i.e. $\mathbf{D}^{\mathbf{direct}}$ and $\mathbf{D}^{\mathbf{indirect}}$, and the household expenditure matrix $\mathbf{C}$, which can be derived directly from the 2000 Spanish HBCS. However, the two intensity matrices need to be estimated since they are not provided by any statistical source. That is, on one hand, we only have information about the aggregate of direct emissions for the total of Spanish households; and, on the other hand, from the above databases we can estimate the matrix of total emission intensity by economic products (or economic sectors) but not by expenditure purposes.

First, we estimate the intensity matrix of direct household emissions $\mathbf{D}^{\mathbf{direct}}$. Since direct emissions are only important for CO_2 and NO_x[7], we only consider direct emissions of these two gases. Taking into account that CO_2 and NO_x emissions are closely linked to energy use, we share their emissions between 4.5 and 7.2 COICOP groups according to an expenditure criterion[8]. Finally, we calculate the emission intensity of these COICOP groups dividing total direct emissions of CO_2 and NO_x by total expenditure on 4.5 and 7.2, respectively[9]. So, we obtain a matrix $\mathbf{D}^{\mathbf{direct}}$ where the elements for the remainder seven gases not considered and also for those activities that do not used energy goods are zero.

Second, the intensity matrix of indirect household emissions $\mathbf{D}^{\mathbf{indirect}}$ is estimated from an environmentally extended input-output model. Our starting point is the open, static input-output model (see e.g. Bulmer-Thomas, 1982 or Miller and Blair, 1985 for an introduction), which is formally expressed as $\mathbf{x} = \mathbf{Ax} + \mathbf{y}$. For an economy of n sectors, $\mathbf{x}$ is the $nx1$ vector of gross output, $\mathbf{A}$ is the nxn matrix of total input coefficients, and $\mathbf{y}$ is the $nx1$ vector of final uses (including private and government consumption, private and government investments, inventory changes, and gross exports). The solution of the above input-output model is given by $\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{y} = \mathbf{Ly}$, where $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ is the Leontief inverse and $\mathbf{I}$ is a nxn identity matrix. Assuming fixed input coefficients, the amount of domestic outputs $\tilde{\mathbf{x}}$ necessary to satisfy any exogenously specified final uses vector $\tilde{\mathbf{y}}$ is determined by $\tilde{\mathbf{x}} = \mathbf{L}\tilde{\mathbf{y}}$, where the elements of $\mathbf{L}$ capture both direct and indirect effects of any change in the exogenous vector of final uses.

[7] According to 2000 Spanish NAMEA framework, the percentage of direct household emissions to total economy emissions represents 19.1% for CO_2, 1.8% for CH_4, 6.9% for N_2O, 0.7% for synthetic greenhouse gases, 1.7% for SO_2, 20.7% for NO_x, and 1.2% for NH_3 (INE, 2006).

[8] We consider total expenditure on 4521 (natural gas), 4522 (liquefied gas), 4531 (liquid fuels), 4541 (solid fuels), and 7221 (fuels and lubricants). Notice that this criterion implies the restrictive assumption that one monetary unit spent on any energy good of any of these groups generates the same direct emissions.

[9] The total expenditure of the economy is the mean expenditure of the HBCS sample by the number of official households in Spain in the year 2000. According to Spanish HBCS the number of households in Spain was 13,086,197 and the effective size of the sample is 9,628. This information is available at http://www.ine.es.

The above input-output model can easily be extended to account for k atmospheric pollutants. So, let $\mathbf{V}$ be the kxn matrix of direct emission coefficients whose elements v_{lj} represent the emission of pollutant l generated per unit of sector j's output; the level of atmospheric emissions associated with a given vector of total outputs will be determined by $\mathbf{e} = \mathbf{Vx}$, where $\mathbf{e}$ is the $kx1$ vector of emissions generated by the production of this economy. These emissions can also be expressed as a function of final uses as $\mathbf{e} = \mathbf{V(I - A)^{-1}y = Fy}$, where now $\mathbf{F}$ is the kxn matrix of total emission intensity. This expression can be used to analyse the emissions generated by the economy as a whole or by each component of the aggregated final uses such as household consumption, exports, or investment. For instance, if we define the household consumption by the $nx1$ vector $\mathbf{c}$, the above expression would be expressed as $\mathbf{e} = \mathbf{V(I - A)^{-1}c = Fc}$.

However, matrix $\mathbf{F}$ expresses the atmospheric impact of one unit spent by households on economic sectors' products classified according to CPA, whereas the expenditure household data from the HBCS is by expenditure purposes, i.e. COICOP. So, we need to 'translate' the household expenditures classified by COICOP into household expenditures classified by CPA. For doing so, we use a nxs matrix $\mathbf{T}$ that relates n CPA groups with s COICOP groups[10]. So, the intensity matrix of indirect household emissions $\mathbf{D^{indirect}}$ is obtained as:

$$\mathbf{D^{indirect}} = \mathbf{V(I - A)^{-1}T = FT} \qquad (4)$$

4. Empirical results

This section analyses total emissions generated in 2000 by Spanish households classified according to expenditure level. Due to the aim of this paper we only consider direct and indirect emissions associated with household consumption, neglecting those generated by other final uses (government expenditures, investment, exports, etc.) and the CH_4 associated to waste management. We compute the model in terms of nine atmospheric gases: the six greenhouse gases (CO_2, CH_4, N_2O, SF_6, HFCs, and PFCs) and three other gases (SO_2, NO_x, and NH_3)[11]; 9,628 households; 46 NACE sectors or CPA products; and 47 consumption purposes, i.e. goods

[10] It should be mentioned that the transformation matrix provided by INE converts 61 household expenditures classified by CPA into 47 household expenditures classified by COICOP valued at purchasers' prices for the year 1995. However, we need a matrix referred to the year 2000 that converted 47 COICOP groups into 46 CPA groups valued at basic prices. Thus, bearing in mind all these characteristics we estimate matrix $\mathbf{T}$ from the transformation matrix provided by INE.

[11] We grouped the SF_6, HFCs, and PFCs gases into a group so-called 'greenhouse synthetic gases' and we also present total emissions of the six greenhouse gases. The aggregation of the different gases has been done using CO_2 equivalent units according with the global warming potentials established by the Intergovernmental Panel of Climate Change (IPCC, 1997). See Appendix A for more details.

and services classified by COICOP groups. First, we present a general overview of the more pollutant consumption purposes; and then, we analyse total emissions from different households classified by expenditure level.

4.1 Different pollutant intensities for different goods and services

Let us start our analysis by presenting total emission intensities for different COICOP commodities, i.e. direct and indirect emissions generated by one monetary unit of household expenditure classified by consumption purposes. We have estimated pollutant intensities for 47 COICOP groups and the outcomes are presented in Appendix B. Generally, these groups are aggregated into 12 COICOP divisions; however, for the sake of clarity and in order to highlight the more pollutant commodities, in this study we prefer to aggregate them into 14 categories (or 'pseudo-divisions' as we called them). These 14 categories are the same 12 standard divisions but splitting up divisions 0.4 'Housing, water, electricity, gas and other fuels' and 0.7 'Transport' as Figure 2 shows[12].

Figure 2

Figures 3 and 4 present total emissions intensities for the six greenhouse gases and the three other gases, respectively. These figures show how the expenditure of one monetary unit in the purchase of a range of different goods and services may have very different implications in terms of quantity and type of emissions.

Figure 3

Figure 4

As these tables showed, one euro spent in IV.b 'Electricity, gas, and other fuels' generates more than eleven times emissions of SO_2 than one euro spent on the average household consumption. The expenditure on this pseudo-division is also the most pollutant in terms of CO_2 and NO_x. Regarding CO_2, SO_2, and NO_x VII.a 'Personal transport' stands out as the second pollutant pseudo-division[13]. In contrast, the most polluting goods in terms of CH_4,

[12] On one hand the pseudo-division IV.a 'Housing and water' includes all expenditures related with housing maintenance and water supply. Specifically, it includes: group 04.1 'Actual rentals for housing', group 04.2 'Imputing rentals for housing', group 04.3 'Maintenance and repair of the dwelling', and group 04.4 'Water supply and miscellaneous services relating to the dwelling'. The pseudo-division IV.b 'Electricity, gas, and other fuels' corresponds to the COICOP group 04.5 On the other hand the pseudo-division VII.a 'Personal transport' includes purchases of vehicles, i.e. group 07.1 'Purchase of vehicles', and all expenses associated with the use of private vehicle such as purchases of fuels and lubricants, i.e. group 07.2 'Operation of personal transport equipment'. The pseudo-division VII.b 'Transport services' is the group 07.3, which corresponds to non-private transport of persons and luggage by railway, road, air, and sea.

[13] Notice that CO_2 and NO_x emission includes both direct and indirect household emissions, whereas the remainder gases only include indirect ones.

N_2O, and NH_3 are those included in pseudo-divisions I ‘Food and non-alcoholic beverages’, II ‘Alcoholic beverages, tobacco, and narcotics’, and XI ‘Restaurants and hotels’, i.e. those groups related to agriculture and cattle raising CPA groups. In fact, the emission intensity of the most linked pseudo-division, ‘Food and non-alcoholic beverages’, is more than three times higher than the emission intensity of the average expenditure for these three gases. Finally, the synthetic greenhouse gases are relevant in pseudo-divisions VI ‘Health’ and V ‘Furnishings, household equipment, and routine household maintenance’. The former mainly caused by group 6.1 ‘Medical products, appliances, and equipment’[14].

So, we are therefore drawn to the conclusion that not only the amount of expenditures but also its distribution over expenditure categories is very relevant to explain emissions generated by different households.

4.2 The relationship between level of household expenditure and atmospheric emissions in Spain

As mentioned above, our aim is to analyse how emissions change when households reach a higher ‘economic position’. So, households should be classified in line with this purpose. In this paper we classify them according to their level of expenditure instead of income because of the next three reasons[15]. First, HBCS databases provide more complete and reliable data on expenditure than on income. Second, income levels are more variable over time than expenditure levels are. According to the permanent income hypothesis (Friedman, 1957) the choices consumers make regarding their consumption patterns are determined not by their current income but by their longer-term income expectations. So, consumers attempt to maintain their standard of living fairly constant although their incomes may vary over time. And third, because the analysis of emissions associated with different consumption patterns classifying households by income could be interpreted as savings do not generate emissions when, in fact, investments can be as environmentally problematic as consumption or even more so.

However, classifying households according to their level of expenditure also causes other drawbacks. These limitations are mainly the result of the purchase criterion used to

[14] It should be stressed that HBCS only refers to private expenditures on health; neither the consumption of public health nor subsidised medicines, which are usually consumed by lower expenditure quintiles, are considered. As a consequence, it should be expected that relative expenditure on the pseudo-division VI ‘Health’ will be higher in highest expenditure quintiles than in lower quintiles. The same would be also applied for expenditures on education.

[15] Clearly, income and expenditure are not the only variables to classify household. In order to consider other factors influencing lifestyles, alternative perspectives have been adopted such as multivariate econometric approach (Lenzen *et al.*, 2006), and/or household classifications compiled on the basis of several characteristics, e.g. Duchin (1998) classifies United States households using 40 “geo-demographic lifestyle clusters”.

evaluate expenditures in the HBCS. This measure causes that those households who have bought durable goods in the current year will be classified in the highest percentile. This accountant criterion contrasts with the technical point of view, according to which total expenditures on durable goods should be distributed amongst their shelf life. In this study, however, we are not able to measure the consumption of durable goods in economic terms since we do not have at our disposal all the required data.

Besides, it should be pointed out another important aspect concerning household classification. That is, how to deal with the relevant fact that households usually have different size and composition. Actually, there are several approaches to take it into account. Due to the fact that each approach presents different pros and cons, we decide to apply several of them. One alternative, which is the most extensively applied, is to divide total household expenditure by the number of household members; in this case we analyse per-capita emissions and per-capita emission intensities. A second alternative is to construct 'equivalent consumer units' weighing each household according to the number of members and the age of them. In this case, there are different mathematical transformations that yield different 'equivalent consumer units'[16]. Amongst them, the scale recommended by EUROSTAT is the so-called modified OECD scale[17]. In this alternative we analyse emissions and emission intensities generated by the 'equivalent' expenditure of each household. The latter method has the advantage that it handles the household size and composition issues. However, it can be also argued that the choice of the scale parameters may be arbitrary unless they were supported by some empirical evidence. On the other hand, both methods entail different hypothesis on economies of scale in consumption and on necessities of monetary expenditures to meet consumption necessities of children and adults. Whereas the former considers that there are economies of scale and that consumption necessities of adults are greater than those of children; the latter only considers that the consumption necessities are the same regardless of the age.

The third alternative is to group households according to their size and perform the same analysis in each group. For instance, we analyse the emissions and emission intensities for one member households, two member households, three member households, four member households, and households with five and more members[18]. Finally, a fourth alternative, is a 'statistical' method that explains household emissions performing a multivariate regression including as independent variables different household characteristics. In this study we consider

[16] In fact, the first alternative (the 'per-capita' expenditure) is the simplest way to make this mathematical transformation.
[17] Wier *et al.* (2001) applied this method. According to the modified OECD scale the first person counts 1, additional adults count less than the first (0.5), and children count less than adults (0.3).

as explicative variables the household expenditure and household size[19]. Both the 'group-household' method and the 'statistical' method have the advantage that they do not make any arbitrary assumption about the importance of economies of scale even though they implicitly assume that the household size is relevant whereas the age composition is not.

For explanatory and clarity reasons, in Section 4.2.1 we present –only using a graphical analysis– the results obtained from the first and second alternatives. Since the results of the third alternative (the 'group-household' method) do not contribute new conclusions and its interpretation is far to be synthetic we decide to present them graphically in Appendix C. Section 4.2.2 is devoted to the 'statistical' method. And finally, Section 4.2.3 shows some complementary information to analyse how the composition of different households' consumption baskets would explain different emission patterns.

4.2.1 Graphical analysis: average emissions and average emission intensities

Figures 5 and 6 show the mean emissions of the greenhouse and the three other gases by per-capita expenditure quintiles and equivalent expenditure quintiles. As these figures illustrate, emissions increased monotonically with household expenditure for all pollutants confirming that the more households spent, the more emissions they generated. The strong increase, particularly for the synthetic greenhouse gases, from the forth to the fifth quintile may be due to the limitations of choosing the expenditure as a classifying variable, i.e. the treatment of durable goods and the unreported consumption of subsidised goods and services such as public health.

Figure 5

Figure 6

However, when analysing the evolution in emission intensity terms (Figures 7 and 8), we observe that the pollutants emitted per unit of household consumption generally decreased with the expenditure level. That is, the consumption patterns of higher quintiles were less pollutant that those of lower quintiles. The exception to this was the synthetic greenhouse gases. The most significant, albeit also moderate, decrease was reported for those pollutants closely associated directly with food and indirectly with agriculture and cattle raising, i.e. CH_4, N_2O, and NH_3.

Figure 7

Figure 8

[18] This approach was applied by Herendeen and Tanaka (1978), Herendeen (1978), Herendeen *et al.* (1981), and Vringer and Blok (1995).

Regarding the EKC debate, it can be stated that in general terms as the expenditure level increases it could be expected a change in the consumption structure that may show a relative delinking between increasing expenditure and emissions. However, there was not any decrease in absolute terms neither any turning point was recorded for any gas; thus, we cannot state the existence of an absolute delinking. The latter only could happen if the more pollutant commodities were 'inferior goods', which should be supported by negative expenditure elasticity. However, there could be other factors not considered in this study, such as technological improvements, which may explain an absolute delinking for some gases over the time (see Roca and Serrano, 2007).

4.2.2 Statistical analysis: expenditure and size elasticity of emissions

As pointed out above, we also carry out a multivariate regression to analyse the relation between emissions and expenditure corrected by the effect of household size. We apply the same functional form used by Wier *et al.* (2001) and Lenzen *et al.* (2006) to analyse household energy requirements and/or the embodied emissions in other countries[20]:

$$E^{household} = \alpha C^{\beta_1} * \exp(\beta_2 N) \quad (5)$$

Where α is a constant, $E^{household}$ are per-capita household emissions, C are per-capita household expenditure, and N the number of household members. This expression lends itself easily to linear regression analysis by taking logarithm of both sides. Thus, we estimate the expenditure elasticity of emissions β_1 and the relationship between the variation of household size and emissions β_2 by performing a regression considering 9,628 different households. We apply the ordinary least-squares method to:

$$\ln E^{household} = z + \beta_1 \ln C + \beta_2 N \quad (6)$$

The results of the regression are shown in Table 1. We find that the expenditure variable was significant for all gases, whereas size it was only for CO_2, synthetic greenhouse gases, SO_2, and NO_x but not for CH_4, N_2O, and NH_3[21].

Table 1

[19] Lenzen *et al.* (2006) carried out a multivariate regression considering seven variables.
[20] Wier *et al.* (2001) showed that this functional form yields a better correlation than power, logarithmic, or polynomial functions.
[21] Given the purpose of this paper, we are not particularly interested in analysing the values of 'size elasticity' β_2 but those related to the 'expenditure elasticity' β_1. For this reason we only analyse the outcomes of the latter. Moreover, it should be mentioned that the values of β_2 are really small and in some cases not statistically significant.

As expected, all gas emissions had positive expenditure elasticity β_1 and for the synthetic greenhouse gases it was higher than unit. The elasticity values oscillated from 0.71 to 1.11. The energy gases, i.e. CO_2, SO_2, and NO_x, had high elasticity values but inferior to unit. The lowest values corresponded to those gases linked with food consumption, i.e. CH_4, N_2O, and NH_3. These results indicate that increase of the household expenditure generates an increase of emissions less than proportional. In the case of CH_4, N_2O, and NH_3 it could be explained because 'wealthier' households spend less percentage of their budget on food. In both cases, these values indicate that the emission intensity diminishes with the expenditure level as Figures 7 and 8 showed, which could be explained if households of higher quintiles purchase more commodities with low energy intensities. In contrast, the highest value ($\beta_1 = 1.11$) corresponded to synthetic greenhouse gases, i.e. when household expenditures increase by 10% synthetic greenhouse gas emissions increase more than proportionally 11.1%. In this case, it may be due to the higher expenditure of 'wealthier' households on those COICOP categories with high emission intensity such as medical products and/or on furniture and other household equipment as air conditioning.

It should be mentioned that due to the aggregation level of the data, this approach does not allow for specific consumer choices between different types of goods and services of the same category such as high-quality versus low-quality products or hand-made versus manufactured goods. High-quality and hand-made commodities usually have a higher price; whereas total emissions embodied in them do not need to increase in the same magnitude or even can decrease. Thus, for high-quality and hand-made goods it should be expected lower emission intensities (Weber and Perrels, 2000). However, due to input-output aggregation, we are assuming that one euro spent either on a high-quality good or on a low-quality good will result in the same amount and type of pollutant. Consequently, the actual expenditure elasticity of emissions may be smaller than those reported in this study (Vringer and Blok, 1995).

As discussed above, most of the studies examined direct and indirect energy requirement for household consumption and only few of them estimated emissions embodied in it (mainly CO_2 emissions). Moreover, according to our knowledge, no research has been undertaken on other types of atmospheric pollutants. However, given the strong relationship between energy requirements and associated CO_2 emissions we can compare our per-capita expenditure elasticity for CO_2 emissions with the per-capita expenditure elasticity of energy requirements of others works. Thus, our result of a high elasticity less than one agrees with other studies. Specifically, Lenzen *et al.* (2006) calculated the per-capita expenditure elasticity of energy requirements for five countries. They report values that range from 0.64 of Japan to 1 of Brazil, with values of 0.78 for Australia, and 0.86 for Denmark and India. Although we cannot strictly compare these results with our per-capita expenditure elasticity for CO_2 emissions, our outcome $(\beta_1 = 0.91)$ lies within those values[22].

4.2.3 Analysis of the composition of households' consumption baskets

From the above results, it appears that as expenditure increases consumption patterns tend to move away from goods and services with high emission intensities towards less emission intensive commodities. This is so for all gases but for synthetic greenhouse gases that present an opposite tendency.

Figure 9

Figure 9 breaks down household equivalent expenditure into the 14 COICOP pseudo-divisions. It confirms the previous statement. That is, on one hand, higher quintiles spent a higher proportion of their budgets on those categories with lower emission intensities such as X 'Education'. And, on the other hand, their expenditure percentages on more polluting categories were lower. This was so in I 'Food and non-alcoholic beverages', II 'Alcoholic beverages, tobacco, and narcotics', and IV.b 'Electricity, gas, and other fuels'. However, the previous hypothesis seems not to have been supported in two categories with relatively high emission intensities, i.e. VII.a 'Personal transport' and XI 'Restaurants and hotels'. Regarding the synthetic greenhouse gases the results are as expected: higher quintiles spent relatively more income on V 'Furnishings, household equipment, and routine household maintenance' and VI 'Health'.

Nevertheless, pseudo-divisions represented in Figure 9 group different goods and services, which can present different behaviour. For instance VII.a 'Personal transport' includes the purchase of vehicles (group 7.1) but also expenditures on fuels and lubricants for vehicles (group 7.2). In Table 2, we display the expenditure percentages of total household expenditure on 47 COIOCP groups. The criteria to select those commodities were two: first, the level of pollutant intensity and, second, the relative weight of each COICOP group of total expenditure.

Table 2

Obviously, this table confirms previous results but it also helps us to understand better some of them. For instance, from Table 2 we can see that the behaviour of VII.a 'Personal transport' is mainly due to the group 7.1 'Purchase of vehicles'. As mentioned above, purchases

[22] Lenzen *et al.* (2006) carried out a multivariate regression considering seven variables and only evaluate the per-

of durable goods such vehicles are concentrated in the highest quintile. Probably, the 10.89% of the fifth quintile would also explain the evolution of synthetic greenhouse gases. Regarding the COICOP groups linked with CH_4, N_2O, and NH_3 emissions, we see that expenditures on 01.1 'Food' decrease as expenditure level increase; whereas 11.1 'Catering services', which gathers expenditures on restaurants and analogous, increased until the forth quintile and then decreased smoothly. However, if we consider the global expenditure on both groups, i.e. 01.1 and 11.1 together, we see that it decreased as the level of expenditure increased.

5. Final remarks

In this paper we applied the input-output approach to analyse a specific topic related to the EKC hypothesis. The purpose of this paper was not to test the existence of an EKC in Spain but to study whether the structure of consumption of 'wealthier' household could have a positive effect for reducing environmental pressures. With this aim in mind, we applied the environmentally extended input-output model to analyse the impact on atmospheric pollution of the consumption of different Spanish households in 2000. Combining information from different databases we estimated total emissions from household consumption of nine gases, i.e. the six greenhouse gases (CO_2, CH_4, N_2O, SF_6, HFCs, and PFCs) and three other gases (SO_2, NO_x, and NH_3). Households were classified by quintiles of expenditure and we applied two approaches: on one hand, we estimated the per-capita emissions and, on the other hand, the emissions associated with the expenditure of equivalent consumer units applying the modified OECD scale.

In connection with the EKC debate, we can say that the more a household spends the more emissions it generates; however, the atmospheric pollution emitted per unit of household consumption decreases with the expenditure level. In fact, in 2000 Spanish households with higher 'economic position' spent a lower proportion of their budgets on those categories more pollutant, i.e. on 'Electricity, gas, and other fuels' (CO_2, NO_x, and SO_2) and on 'Food' (CH_4, N_2O, and NH_3). On the contrary, the expenditure percentage on 'Furnishing, household equipment, and routine household maintenance' was higher, which could explain the opposite trend of the synthetic greenhouse gases.

These outcomes were confirmed by the values of expenditure elasticity of emissions that we estimated for all the gases performing a multivariate regression. We found a positive elasticity significantly lower than unit for almost all gases. The only exception to this was the synthetic greenhouse gases, which presented a positive elasticity higher than unit in keeping

capita energy requirement but not the emissions associated.

with the graphical analysis. These results could be arguments to justify a relative delinking between increasing consumption and emissions but it would not be sufficient to expect an absolute one. The latter should be supported by negative expenditure elasticity, which only could happen if the more pollutant commodities were 'inferior goods'. Obviously, it could be other factors that have not been considered in this paper that may explain an absolute delinking for some gases along the time. One of these factors is technological changes, which induced by environmental policy or by themselves could act in the opposite direction.

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Appendix A. Spanish data and data preparation

A.1 The NAMEA framework

From the supply and use framework and environmental accounts for air emissions (INE, 2005, 2006) we estimate the Spanish environmentally extended input-output table for 2000 consistent with the National Accounting Matrix including Environmental Accounts (NAMEA) framework. According to NAMEA system, environmental information is compiled consistently with the way economic activities are represented in national accounts (de Haan and Keuning, 1996; Keuning *et al.*, 1999). The Spanish NAMEA for air emissions is organised according to the supply and use table structure. Thus, the economic accounts cover 110 CPA products, 72 NACE sectors plus a fictitious sector 'Financial Intermediation Services Indirectly Measured' (FISIM), and 7 categories of final uses. On the other hand, the environmental accounts gather information about direct emissions produced by 46 NACE sectors and by households. Air emissions are reported in physical units for different pollutants, amongst them the nine gases considered in this work.

Following the NAMEA principles air emissions related to incineration and decomposition of waste in landfills (mainly CO_2 and CH_4) are placed under NACE 90 'Sewage and refuse disposal services, sanitation, and similar services'. However, this sector is aggregated jointly with NACE 91 'Membership organisation services', NACE 92 'Recreational, cultural, and sporting services', and NACE 93 'Other services'. Due to the nature of these four sectors, one can logically infer that the most part of CH_4 emissions and also a smaller amount of CO_2 emissions should be generated almost exclusively by NACE 90; however, this information remains hidden because the above aggregation. Consequently, an increase of household expenditures on cultural or sporting services (NACE 92), for instance, should cause an increase of CH_4 emissions even though this sector only emitted a small amount of this gas. The consequences of this example will not be important if CH_4 emissions of the four-aggregated sector were relatively small compared with total CH_4 emissions, which was not the case (28.30% in 1995 and 31.28% in 2000). Therefore, following Keuning *et al.* (1999) we have assumed that all CH_4 emissions generated by this four-aggregated sector correspond to NACE 90 and we have reallocated them to a new category called 'other sources'.

Taking into account this, we estimate a 46x46 environmentally extended symmetrical input-output table according to the technology industry hypothesis. From which we obtain the total coefficient matrix $\mathbf{A}$ and the emission coefficient matrix $\mathbf{V}$.

Finally, the so-called synthetic greenhouse gases (SF_6, HFCs, and PFCs) and the six greenhouse gases have been aggregated in accordance with the global warming potential (GWP100) of each gas as established by the Intergovernmental Panel on Climate Change (IPCC, 1997). These conversion factors are: 1 for CO_2, 21 for CH_4, 310 for N_2O, and 23,900 for SF_6. For the group of HFCs and PFCs those values oscillate depending on each specific gas between 140 and 11,700 and 6,500 and 9,200, respectively. In this study we have calculated a warm potential for HFCs and PFCs groups based on the weight average of each group, hence the GWP100 for HFCs is 6,812.65 and for PFCs 6,728.51.

A.2 The Spanish household budget continuous survey

The Household Budget Continuous Survey (HBCS) mainly informs about amount and structure of household expenditures. It also collects information on household incomes and other socio-economic characteristics regarding living standards such as household equipment, number of members, and level of studies and/or professional activity of breadwinner. The sample size of the 2000 Spanish HBCS is 9,631 representative households[23] and for each household the survey records expenditure on goods and services for final consumption classified by COICOP. These goods and services are arranged in 47 groups grouped into 12 main divisions. The expenditures are evaluated using the purchase criterion, i.e. they are recorded at the moment of availability of commodity by household regardless whether it has been paid in cash or not. This criterion has important consequences for durable goods because following it total amount of expenditure on goods, such as cars or appliances, is registered completely in the current year, although they are going to be consumed for more than one year.

A.3 The transformation matrix

Finally, we have used the matrix that relates products and consumption purposes. This matrix is essential to apply the model since the data sources described above use different criteria to classify products. That is, input-output framework classifies goods and services by CPA whereas HBCS classified them by COICOP. Concretely, the 1995 Spanish transformation matrix is a coefficient matrix that converts household expenditures on 61 products classified by CPA into equivalent expenditure on 47 products classified by COICOP.

[23] In fact we compute the model with 9,628 because in the original database there are three households whose income register was zero. Since it does not have sense to work with expenditures of non-income households we decided to eliminate them.

Appendix B. Total emission intensities of 47 COICOP groups

Figure B.1

Table B.1

Table B.2

Appendix C. Graphical analysis for different size households

Figure C.1

Figure C.2

Figure C.3

Figure C.4

Tables:

Table 1: Expenditure elasticity and size elasticity of per-capita emissions of nine gases, Spain 2000

	Expenditure			Size			
	β_1		|t|	β_2		|t|	R^2
CO_2	0.91	±0.005	175.028*	0.03	±0.002	16.551*	0.77
CH_4	0.72	±0.006	122.333*	0.00	±0.002	0.966	0.64
N_2O	0.78	±0.005	155.364*	0.00	±0.002	1.031	0.74
Synthetic gases**	1.11	±0.004	258.771*	0.03	±0.002	17.506*	0.88
Total in CO_2 equivalent	0.89	±0.005	194.363*	0.03	±0.002	15.336*	0.81
SO_2	0.86	±0.003	247.921*	-0.03	±0.001	25.061*	0.89
NO_x	0.87	±0.005	168.676*	0.04	±0.002	18.298*	0.76
NH_3	0.71	±0.006	109.721*	0.00	±0.003	0.907	0.58
Correlation coefficient							0.33
Variance Inflation Factor							1.13

* Significant variables at the 95% confidence level.
** Synthetic gases are total SF_6, HFCs and PFCs emissions measured in CO_2 equivalent units.
Source: own elaboration.

Table 2: Equivalent expenditure in key commodities for emissions as percentage of total equivalent expenditure of each quintile, Spain 2000

Units: percentage of total expenditure.

	First quintile	Second quintile	Third quintile	Forth quintile	Fifth quintile
CO_2, NO_x, and SO_2					
04.5. Electricity, gas, and other fuels	5.00	4.10	3.56	3.04	2.31
07.2. Operation of personal transport equipment	4.05	5.46	5.93	5.73	4.75
CH_4, N_2O, and NH_3					
01.1. Food	24.69	21.78	19.83	16.89	11.94
11.1. Catering services	5.51	6.79	7.81	8.39	7.94
Synthetic greenhouse gases					
06.1. Medical products, appliances, and equipment	1.35	1.38	1.25	1.22	1.05
12.1. Personal care	2.06	2.09	2.04	1.96	1.69
05.6. Goods and services for household maintenance	1.57	1.68	1.66	1.77	2.26
07.1. Purchase of vehicles	0.20	0.44	0.93	2.81	10.89
03.1. Clothing	4.74	5.98	6.41	6.59	6.04

Source: own elaboration.

Table B.1: Total emission intensity of the greenhouse gases of different COICOP groups, Spain 2000

Units: Index numbers, mean emissions of total expenditure of households 2000 base = 100

CO_2		CH_4		N_2O		Synthetic gases		CO_2 equivalent	
COICOP codes	*Intensity*	*COICOP codes*	*Intensity*	*COICOP codes*	*Intensity*	*COICOP codes*	*Intensity*	*COICOP codes*	*Intensity*
04.5.	755.75	**01.1.**	358.07	**01.1.**	319.32	**06.1.**	823.71	**04.5.**	658.12
07.2.	512.19	**01.2.**	323.54	**01.2.**	289.60	**12.1.**	329.90	**07.2.**	440.99
05.4.	141.23	**02.1.**	227.62	**02.1.**	205.55	**05.6.**	306.35	**05.4.**	126.96
06.1.	94.34	**09.3.**	163.24	**09.3.**	160.95	**05.2.**	279.93	**01.1.**	113.50
04.3.	88.87	**04.5.**	140.96	**06.1.**	134.83	**07.1.**	213.10	**01.2.**	106.91
04.4.	80.19	**02.2.**	119.71	**12.1.**	113.00	**03.1.**	169.79	**06.1.**	102.88
07.1.	79.21	**11.1.**	116.70	**02.2.**	110.97	**05.5.**	163.40	**02.1.**	83.05
01.1.	77.51	**11.2.**	115.17	**11.1.**	106.72	**09.3.**	159.54	**04.3.**	82.21
01.2.	74.90	**05.2.**	67.97	**11.2.**	105.41	**05.4.**	130.48	**04.4.**	76.37
05.5.	67.17	**03.2.**	61.32	**09.4.**	102.04	**03.2.**	128.83	**07.1.**	75.06
05.2.	65.37	**04.4.**	45.74	**04.5.**	82.74	**09.2.**	127.33	**09.3.**	73.67
12.1.	63.82	**09.4.**	43.57	**05.2.**	81.16	**09.1.**	125.89	**05.2.**	69.66
02.1.	61.51	**03.1.**	43.48	**04.4.**	63.63	**04.3.**	125.26	**12.1.**	69.16
07.3.	60.91	**12.1.**	42.23	**03.2.**	56.17	**05.1.**	122.44	**05.5.**	63.58
08.2.	59.91	**09.2.**	36.76	**03.1.**	53.46	**06.3.**	118.12	**05.1.**	56.24
05.1.	58.68	**06.1.**	32.51	**12.7.**	52.81	**06.2.**	118.11	**02.2.**	56.08
09.3.	58.03	**07.2.**	32.50	**05.6.**	52.16	**12.4.**	117.91	**08.2.**	55.97
09.5.	57.04	**12.3.**	29.91	**12.4.**	50.98	**08.2.**	115.02	**07.3.**	55.73
05.3.	56.27	**04.3.**	29.37	**06.2.**	50.90	**12.3.**	109.32	**09.2.**	55.03
09.2.	56.15	**05.1.**	28.85	**06.3.**	50.90	**09.5.**	108.60	**09.5.**	54.47
12.3.	54.10	**05.4.**	28.29	**05.4.**	48.26	**05.3.**	105.63	**03.1.**	52.98
09.1.	53.79	**09.5.**	27.29	**09.2.**	44.49	**01.2.**	95.54	**05.3.**	52.85
09.6.	52.25	**07.1.**	26.98	**04.3.**	43.98	**01.1.**	94.28	**12.3.**	52.07
03.1.	51.78	**12.7.**	25.90	**07.1.**	43.28	**02.1.**	83.28	**09.1.**	51.99
03.2.	49.09	**05.5.**	25.60	**09.1.**	43.13	**09.6.**	70.70	**11.1.**	51.71
02.2.	46.31	**09.1.**	24.12	**07.2.**	42.23	**02.2.**	69.36	**03.2.**	51.59
11.1.	42.09	**09.6.**	23.84	**05.1.**	39.87	**04.4.**	63.18	**11.2.**	51.39
11.2.	41.94	**05.3.**	21.63	**09.5.**	38.96	**07.2.**	60.67	**09.6.**	48.90
12.5.	35.55	**07.3.**	20.37	**12.3.**	37.40	**07.3.**	53.55	**09.4.**	39.83
05.6.	35.50	**08.2.**	19.81	**05.5.**	36.44	**11.2.**	48.39	**05.6.**	38.85
12.6.	35.18	**12.4.**	16.93	**08.2.**	31.39	**11.1.**	48.26	**12.7.**	32.66
09.4.	34.85	**06.2.**	16.87	**05.3.**	30.87	**12.7.**	44.96	**12.5.**	32.55
08.1.	32.81	**06.3.**	16.87	**09.6.**	27.74	**09.4.**	43.84	**12.6.**	32.41
08.3.	32.70	**12.6.**	14.17	**07.3.**	27.43	**04.5.**	42.02	**12.4.**	32.36
12.7.	31.56	**05.6.**	13.66	**04.1.**	17.72	**04.2.**	40.25	**06.3.**	32.34
12.4.	30.87	**12.5.**	13.34	**04.2.**	17.65	**04.1.**	40.25	**06.2.**	32.34
06.3.	30.86	**08.3.**	11.47	**12.6.**	17.04	**08.3.**	28.98	**08.3.**	29.93
06.2.	30.85	**04.1.**	11.21	**12.5.**	16.12	**12.6.**	28.72	**08.1.**	29.61
04.1.	27.98	**04.2.**	11.13	**08.3.**	14.19	**12.5.**	25.13	**04.1.**	26.28
04.2.	27.97	**10.5.**	9.58	**08.1.**	11.80	**08.1.**	22.33	**04.2.**	26.26
10.5.	18.74	**10.2.**	9.58	**10.5.**	11.01	**10.5.**	15.71	**10.5.**	17.54
10.2.	18.74	**10.1.**	9.58	**10.2.**	11.01	**10.2.**	15.70	**10.2.**	17.54
10.1.	18.74	**10.4.**	9.58	**10.1.**	11.01	**10.1.**	15.70	**10.1.**	17.54
10.4.	18.74	**08.1.**	9.29	**10.4.**	11.01	**10.4.**	15.69	**10.4.**	17.54
02.3.	*	**02.3.**	*	**02.3.**	*	**02.3.**	*	**02.3.**	*
10.3.	**	**10.3.**	**	**10.3.**	**	**10.3.**	**	**10.3.**	**
12.2.	*	**12.2.**	*	**12.2.**	*	**12.2.**	*	**12.2.**	*

Source: own elaboration.
Notes: * data not available. Although HBCS gives information about 02.3. 'Narcotics' and 12.2. 'Prostitution', these activities are not included in National Accounts.
** in National Accounts estimation of 10.3. 'Post-secondary non-tertiary education' is included in group 10.4. 'Tertiary education'.

Table B.2: Total emission intensity of other gases of different COICOP groups, Spain 2000

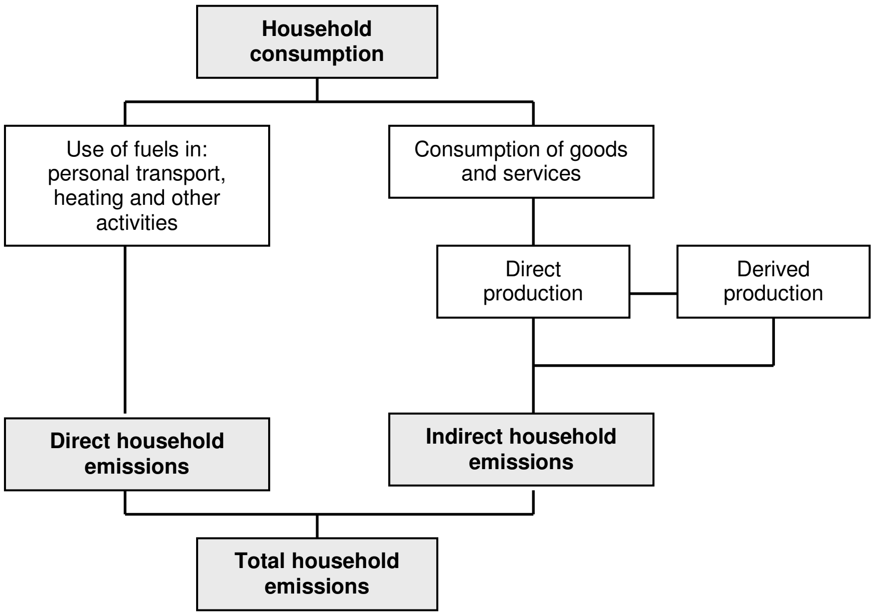
Units: Index numbers,
mean emissions of total expenditure of households 2000 base = 100

SO_2		NO_x		NH_3	
COICOP codes	*Intensity*	*COICOP codes*	*Intensity*	*COICOP codes*	*Intensity*
04.5.	1124.62	**04.5.**	613.98	**01.1.**	381.44
05.4.	154.99	**07.2.**	502.96	**01.2.**	343.35
04.4.	142.41	**01.1.**	128.35	**02.1.**	240.06
06.1.	132.04	**01.2.**	111.99	**09.3.**	171.81
07.2.	119.67	**05.4.**	91.16	**02.2.**	123.88
07.1.	111.72	**02.1.**	86.65	**11.1.**	121.72
04.3.	98.96	**06.1.**	69.12	**11.2.**	120.06
05.2.	89.90	**09.3.**	67.99	**09.4.**	94.88
05.5.	89.81	**04.3.**	65.73	**12.1.**	76.96
12.1.	87.82	**04.4.**	60.40	**05.2.**	62.15
09.5.	81.76	**07.1.**	59.87	**06.1.**	52.98
08.2.	81.11	**05.2.**	59.34	**04.4.**	48.57
05.3.	73.55	**02.2.**	57.97	**03.2.**	46.60
09.1.	72.92	**09.6.**	55.73	**12.7.**	45.53
09.2.	72.91	**05.5.**	55.18	**03.1.**	39.12
01.2.	71.88	**11.1.**	53.99	**09.2.**	30.53
05.1.	70.92	**11.2.**	53.63	**09.1.**	25.48
01.1.	70.50	**05.1.**	53.08	**05.1.**	23.88
03.1.	70.26	**12.1.**	51.86	**12.3.**	23.40
09.3.	66.67	**07.3.**	51.43	**04.3.**	23.07
12.3.	66.11	**12.3.**	48.91	**05.6.**	21.77
03.2.	64.05	**09.2.**	48.19	**09.5.**	21.15
02.1.	62.07	**09.5.**	47.81	**12.4.**	18.04
12.5.	58.10	**08.2.**	46.73	**06.2.**	17.89
09.6.	56.82	**03.1.**	46.66	**06.3.**	17.88
12.6.	56.10	**03.2.**	46.06	**05.5.**	16.76
11.1.	52.58	**05.3.**	46.04	**07.1.**	16.62
11.2.	52.39	**09.1.**	44.11	**05.4.**	15.71
02.2.	50.88	**09.4.**	32.34	**07.3.**	15.54
05.6.	49.60	**12.7.**	27.82	**07.2.**	15.24
08.1.	48.39	**12.6.**	26.65	**09.6.**	14.92
07.3.	48.28	**05.6.**	26.42	**05.3.**	14.47
06.3.	47.68	**12.5.**	26.01	**08.2.**	12.83
06.2.	47.68	**08.3.**	25.30	**04.5.**	11.80
12.4.	47.67	**08.1.**	23.80	**04.1.**	10.38
08.3.	46.87	**12.4.**	23.20	**04.2.**	10.30
09.4.	46.35	**06.3.**	23.17	**12.6.**	9.41
12.7.	42.98	**06.2.**	23.17	**12.5.**	8.41
04.1.	40.66	**04.1.**	21.76	**08.3.**	6.98
04.2.	40.66	**04.2.**	21.74	**10.5.**	6.97
10.5.	31.98	**10.5.**	13.89	**10.2.**	6.97
10.2.	31.98	**10.2.**	13.89	**10.1.**	6.97
10.1.	31.98	**10.1.**	13.89	**10.4.**	6.97
10.4.	31.98	**10.4.**	13.88	**08.1.**	4.53
02.3.	*	**02.3.**	*	**02.3.**	*
10.3.	**	**10.3.**	**	**10.3.**	**
12.2.	*	**12.2.**	*	**12.2.**	*

Source: own elaboration.
Notes: * data not available. Although HBCS gives information about 02.3. 'Narcotics' and 12.2. 'Prostitution', these activities are not included in National Accounts.
** in National Accounts estimation of 10.3. 'Post-secondary non-tertiary education' is included in group 10.4. 'Tertiary education'.

Figures:

Figure 1: Direct and indirect emissions from household consumption



Source: own elaboration from Munksgaard *et al.* (2000).

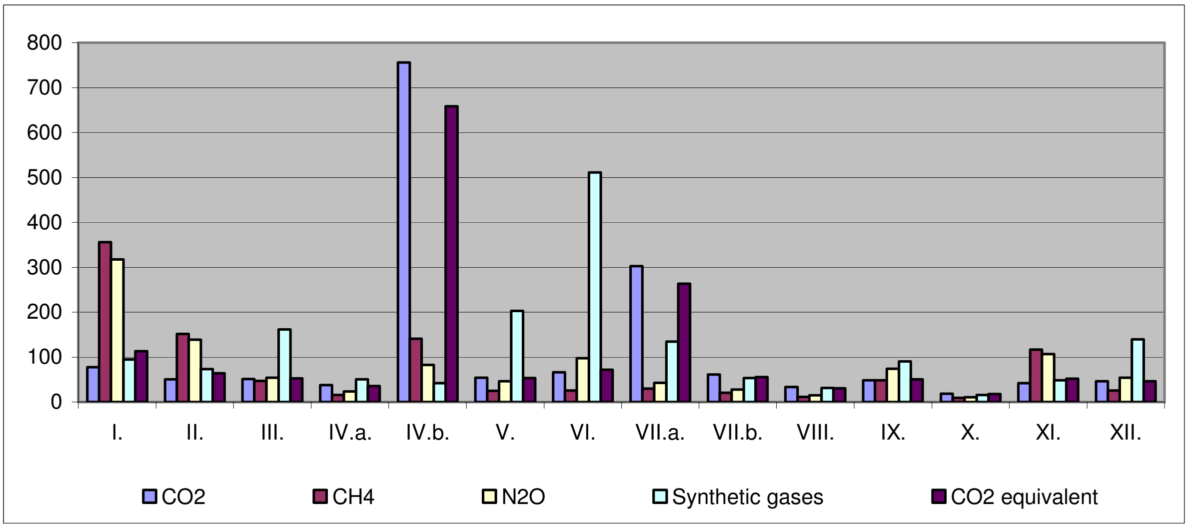
Figure 2: Correspondence between COICOP pseudo-divisions and COICOP divisions

COICOP pseudo division codes	COICOP pseudo divisions	COICOP division codes
I.	Food and non-alcoholic beverages	01
II.	Alcoholic beverages, tobacco, and narcotics	02
III.	Clothing and footwear	03
IV.a.	Housing and water	04.1 – 04.4.
IV.b.	Electricity, gas, and other fuels	04.5.
V.	Furnishings, households equipment, and routine household maintenance	05
VI.	Health	06
VII.a.	Personal transport	07.1. – 07.2.
VII.b.	Transport services	07.3.
VIII.	Communication	08
IX.	Recreation and culture	09
X.	Education	10
XI.	Restaurants and hotels	11
XII.	Miscellaneous goods and services	12

Source: own elaboration from 2000 Spanish HBCS (INE, 2004).

Figure 3: Total emission intensities of greenhouse gases of COICOP pseudo-divisions, Spain 2000

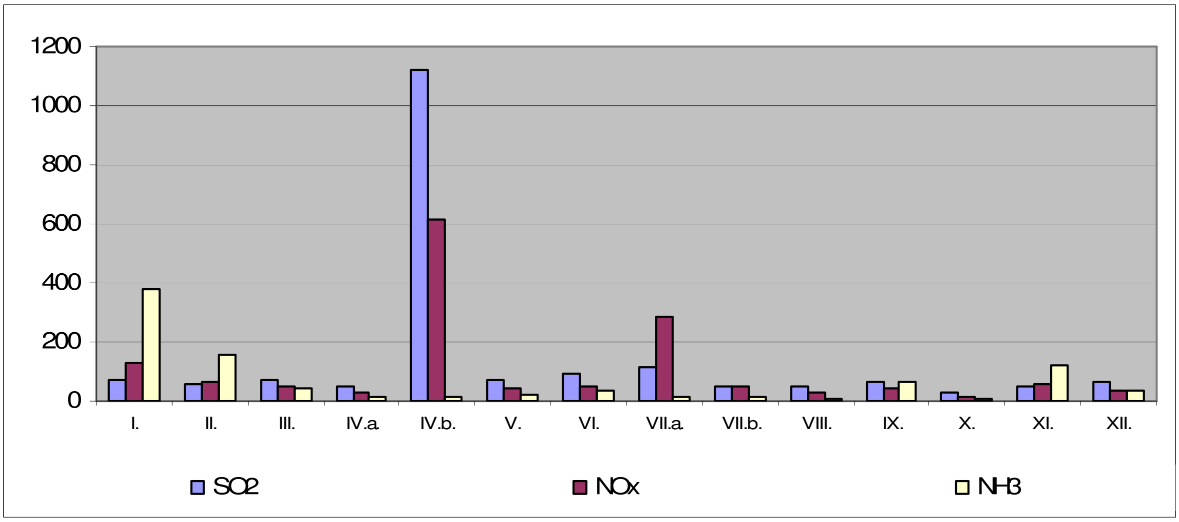
Units: index numbers, mean emissions of total expenditure of households 2000 base = 100.



Source: own elaboration.

Figure 4: Total emission intensities of other gases of COICOP pseudo-divisions, Spain 2000

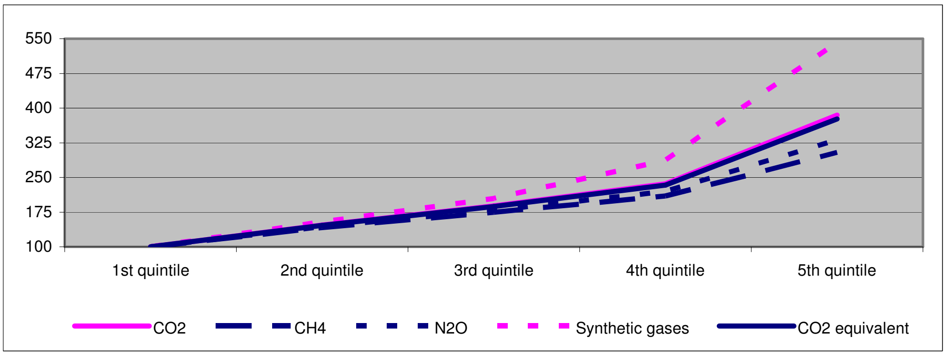
Units: index numbers, mean emissions of total expenditure of households 2000 base = 100.

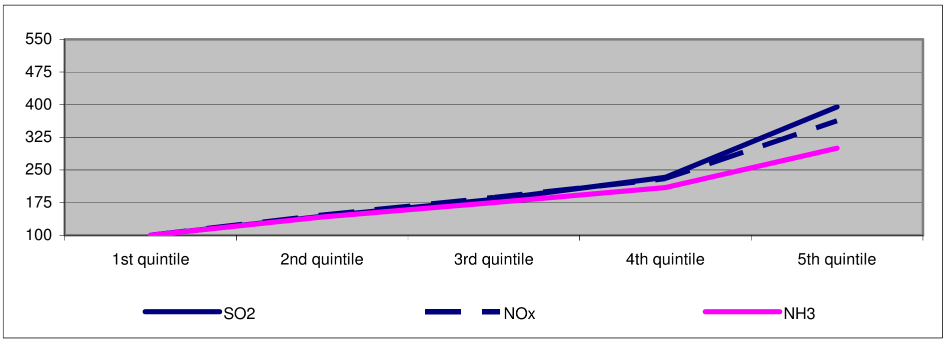


Source: own elaboration.

Figure 5: Per-capita mean emissions of greenhouse gases and other gases by quintiles of expenditure, Spain 2000

Units: first quintile base = 100.

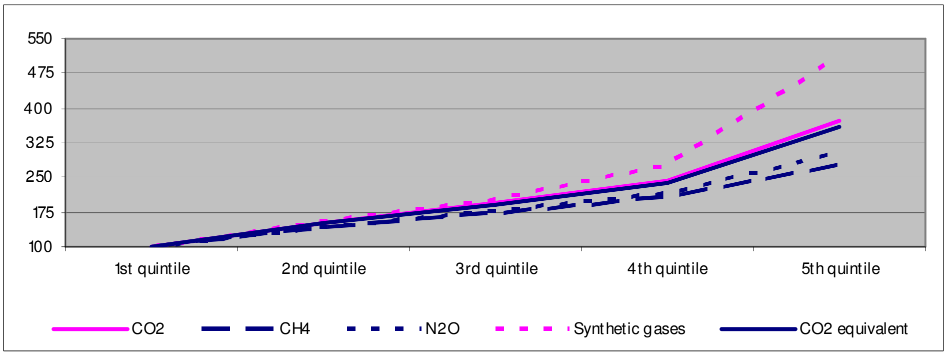


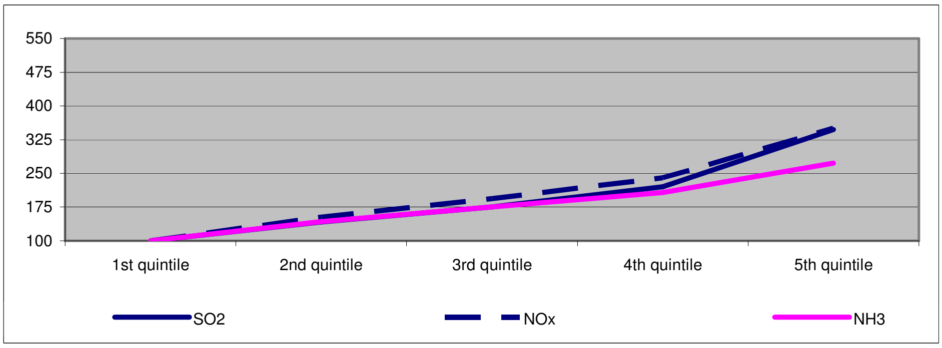


Source: own elaboration.

Figure 6: Equivalent mean emissions of greenhouse gases and other gases by quintiles of equivalent expenditure, Spain 2000

Units: first quintile base = 100.

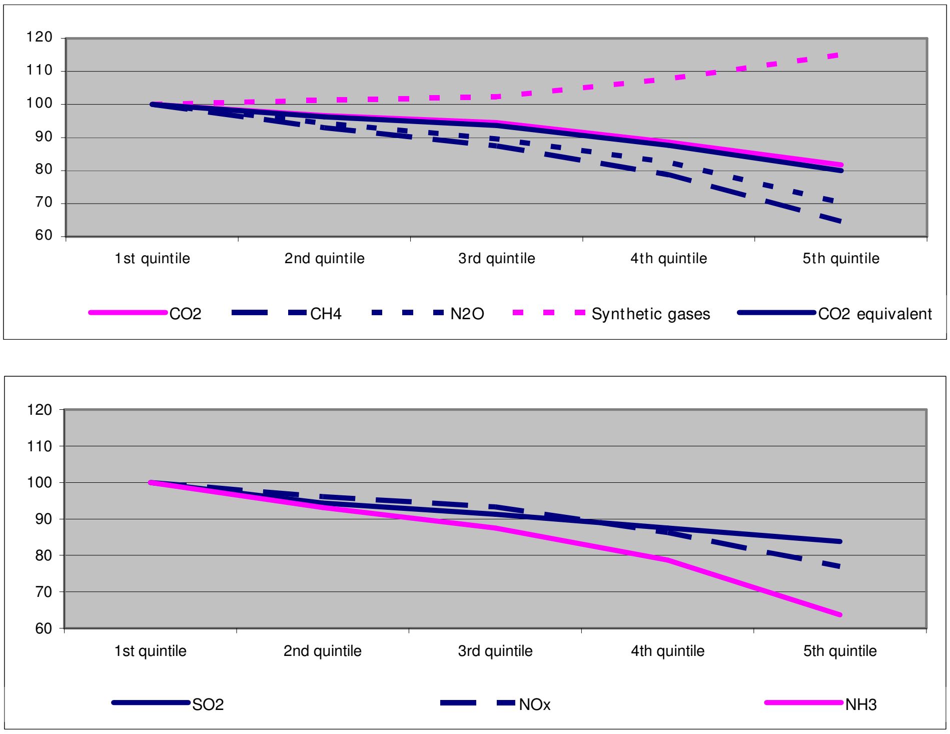




Source: own elaboration.

Figure 7: Per-capita mean intensities of greenhouse gases and other gases by quintiles of expenditure, Spain 2000

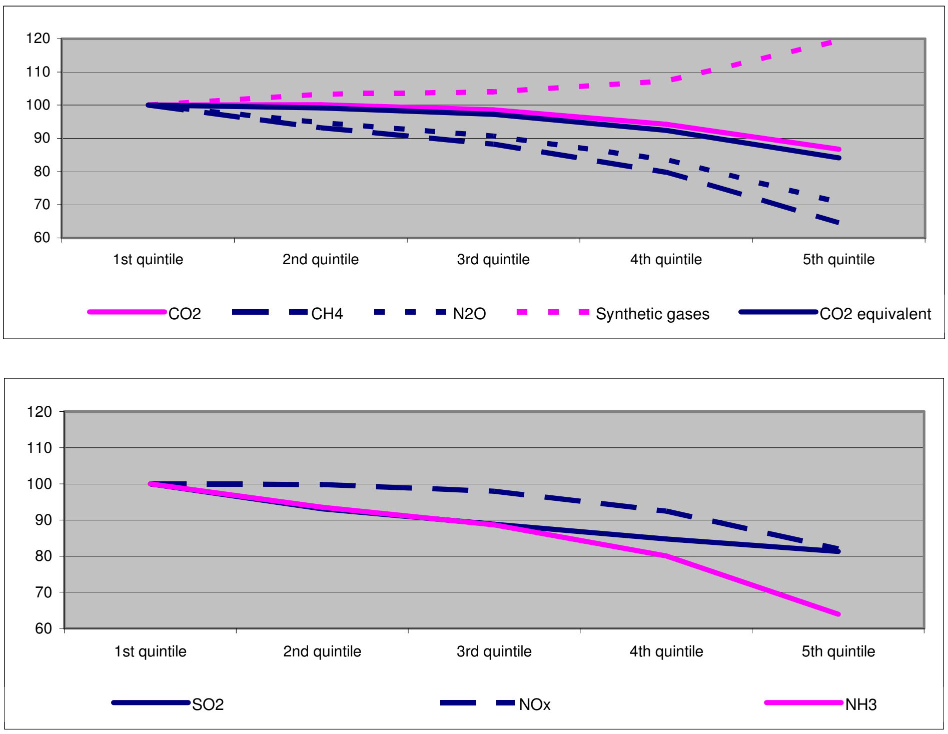
Units: first quintile base = 100.



Source: own elaboration.

Figure 8: Equivalent mean intensities of greenhouse gases and other gases by quintiles of equivalent expenditure, Spain 2000

Units: first quintile base = 100.



Source: own elaboration.

Figure 9: Distribution of equivalent expenditure per quintiles of expenditure, Spain 2000

Source: own elaboration.

Figure B.1: COICOP divisions and groups

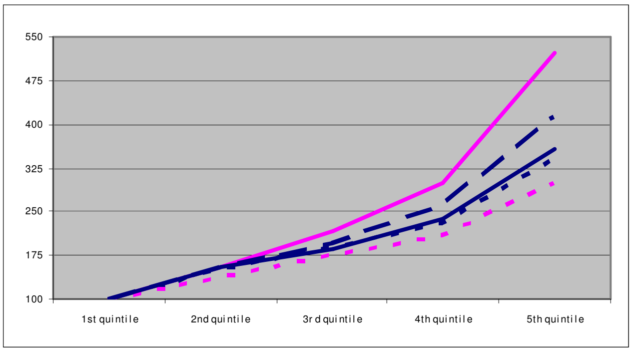
12 COICOP DIVISIONS	47 COICOP GROUPS
01. Food and non-alcoholic beverages	01.1. Food 01.2. Non-alcoholic beverages
02. Alcoholic beverages, tobacco, and narcotics	02.1. Alcoholic beverages 02.2. Tobacco 02.3. Narcotics
03. Clothing and footwear	03.1. Clothing 03.2. Footwear
04. Housing, water, electricity, gas, and other fuels	04.1. Actual rentals for housing 04.2. Imputed rentals for housing 04.3. Maintenance and repair of the dwelling 04.4. Water supply and miscellaneous services relating to the dwelling 04.5. Electricity, gas, and other fuels
05. Furnishings, household equipment, and routine household maintenance	05.1. Furniture and furnishings, carpets, and other floor coverings 05.2. Household textiles 05.3. Household appliances 05.4. Glassware, tableware, and household utensils 05.5. Tools and equipment for house and garden 05.6. Goods and services for routine household maintenance
06. Health	06.1. Medical products, appliances, and equipment 06.2. Outpatient services 06.3. Hospital services
07. Transport	07.1. Purchase of vehicles 07.2. Operation of personal transport equipment 07.3. Transport services
08. Communication	08.1. Postal services 08.2. Telephone and telefax equipment 08.3. Telephone and telefax services
09. Recreation and culture	09.1. Audio-visual, photographic, and information processing equipment 09.2. Other major durables for recreation and culture 09.3. Other recreational items and equipment, gardens, and pets 09.4. Recreational and cultural services 09.5. Newspapers, books, and stationery 09.6. Package holidays
10. Education	10.1. Pre-primary and primary education 10.2. Secondary education 10.3. Post-secondary non-tertiary education 10.4. Tertiary education 10.5. Education not definable by level
11. Restaurants and hotels	11.1. Catering services 11.2. Accommodation services
12. Miscellaneous goods and services	12.1. Personal care 12.2. Prostitution 12.3. Personal effects n.e.c. 12.4. Social protection 12.5. Insurance 12.6. Financial services n.e.c. 12.7. Other services n.e.c.

Source: own elaboration from INE (2004).
Note: n.e.c. means not elsewhere classified.

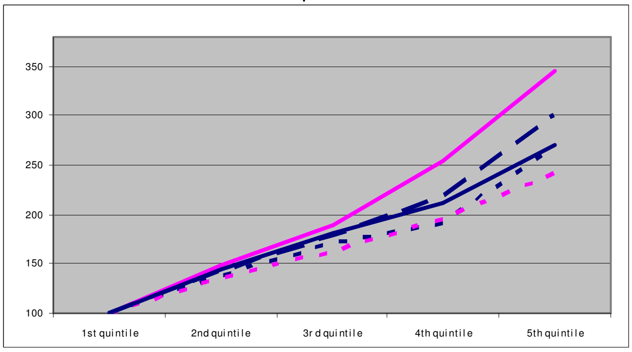
Figure C.1: Member household mean emissions of greenhouse gases by quintiles of expenditure, Spain 2000

Units: first quintile base = 100.

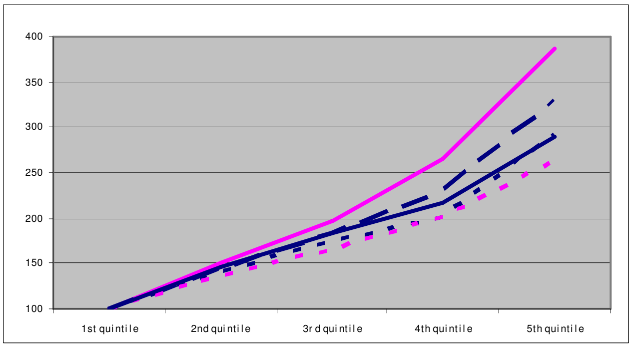
CO_2



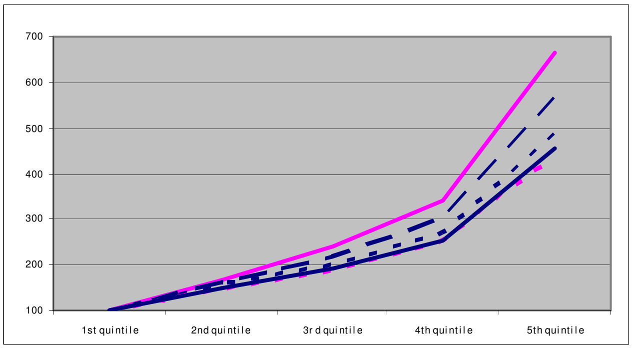
CH_4



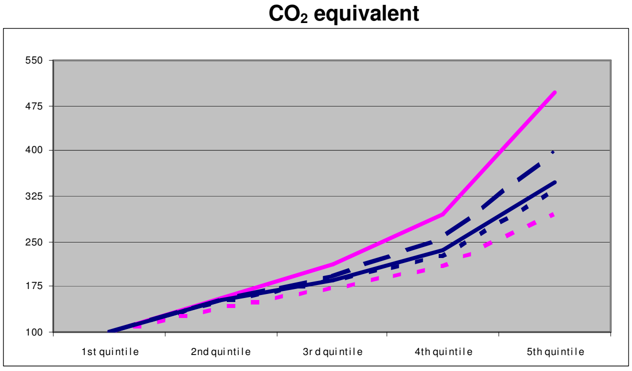
N_2O



Synthetic gases



CO_2 equivalent



1 member household

2 member household

3 member household

4 member household

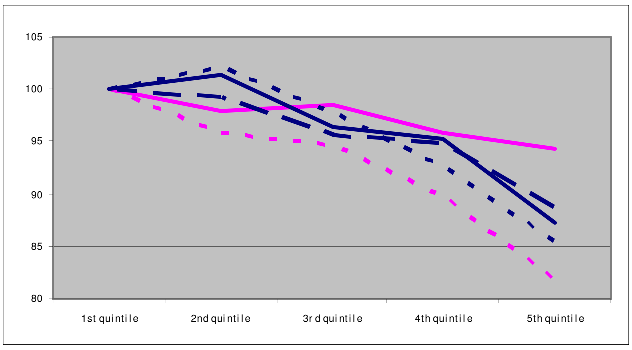
>4 member household

Source: own elaboration.

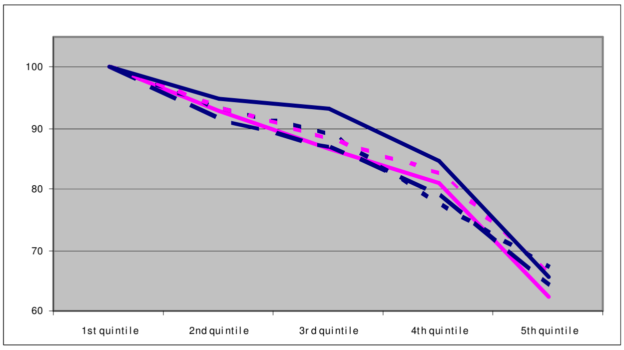
Figure C.2: Member household mean intensities of greenhouse gases by quintiles of expenditure, Spain 2000

Units: first quintile base = 100.

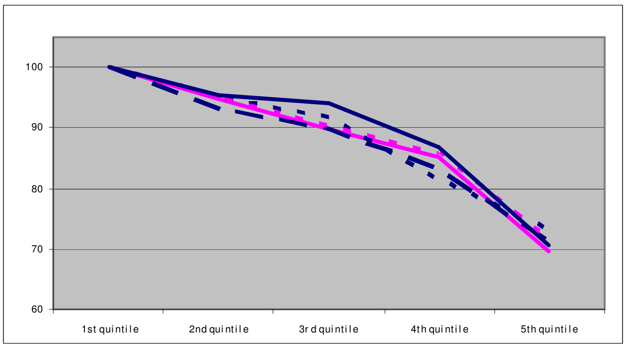
CO_2



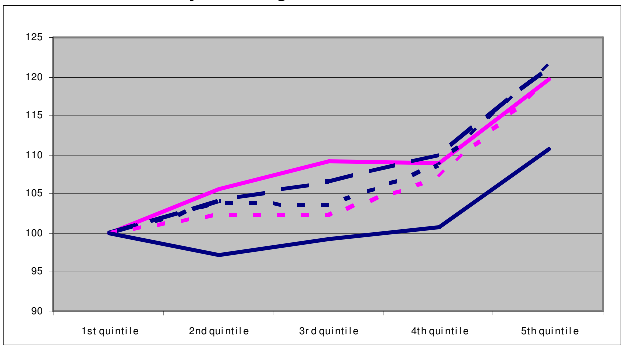
CH_4



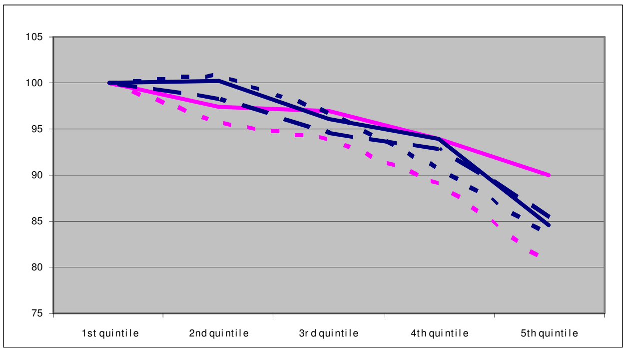
N_2O



Synthetic gases



CO_2 equivalent



1 member household

2 member household

3 member household

4 member household

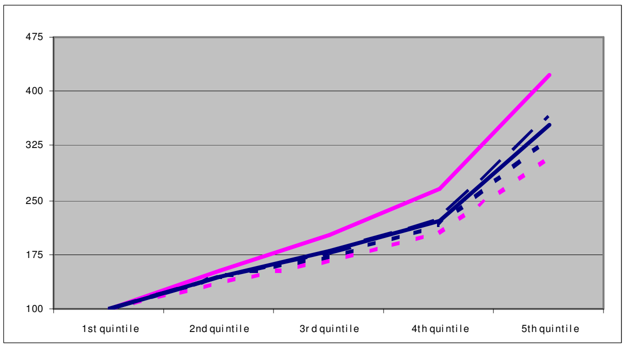
>4 member household

Source: own elaboration.

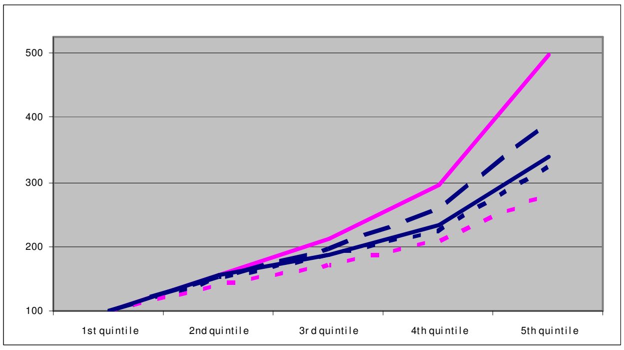
Figure C.3: Member household mean emissions of other gases by quintiles of expenditure, Spain 2000

Units: first quintile base = 100.

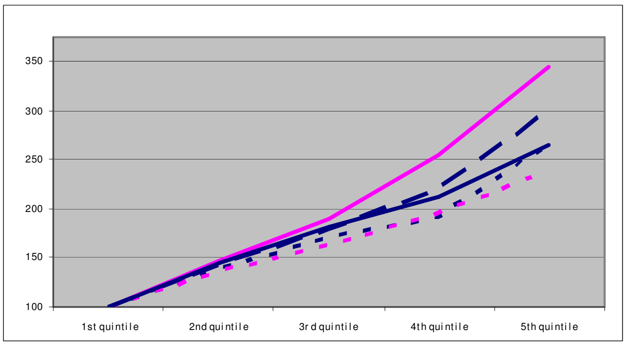
SO_2



NO_x



NH_3



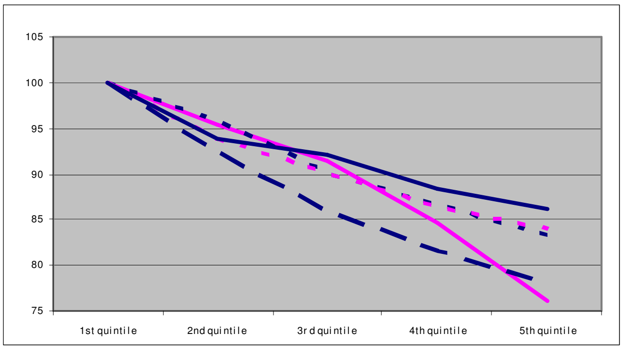
1 member household — 2 member household — 3 member household
4 member household — >4 member household

Source: own elaboration.

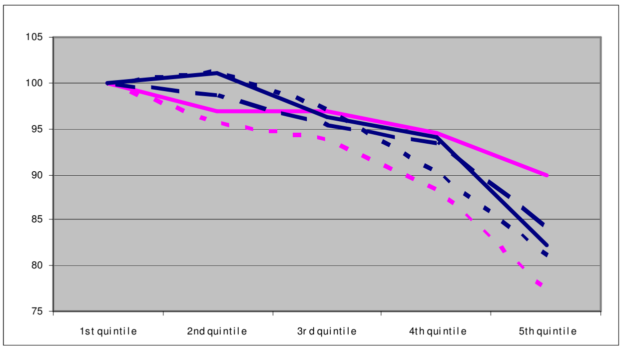
Figure C.4: Member household mean intensities of other gases by quintiles of expenditure, Spain 2000

Units: first quintile base = 100.

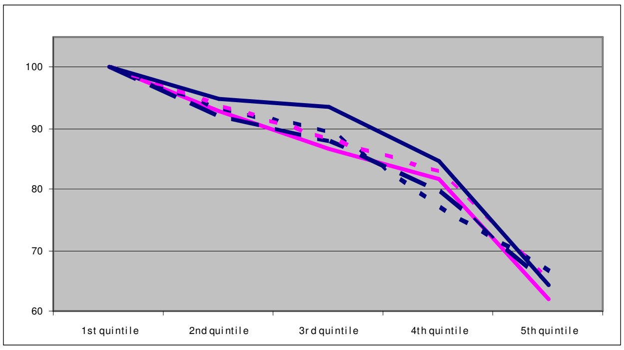
SO_2



NO_x



NH_3



1 member household
2 member household
3 member household
4 member household
>4 member household

Source: own elaboration.