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A Macro and Microeconomic Integrated Approach to Assessing the Effects of Public Policies*

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Abstract

Most public policies have not only efficiency but also distributional effects. However, there is a kind of trade-off between modelling approaches suitable for calculating each one of these impacts on the economy. For the former, most of the studies have been conducted with general equilibrium models, whereas partial equilibrium models represent the main approach for distributional analysis. This paper proposes a methodology which enables us to carry out an analysis of the distributional and efficiency consequences of public policies. In order to do so, we have integrated a microeconomic household demand model and a computable general equilibrium model for the Spanish economy. We illustrate the advantages of this approach by simulating a revenue-neutral reform in Spanish indirect taxation, with a reduction of VAT and a simultaneous increase of energy taxes. The results show that the reform brings about significant efficiency and distributional effects, in some cases counterintuitive, and demonstrate the academic and social utility of this approximation.

Keywords: Taxes, general equilibrium, micro modeling, efficiency, distribution
JEL Classification: C33, D58, H30, Q21

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1. Introduction

Most public policies produce efficiency and distributional effects. However, economists have traditionally focused on the measurement of the consequences of public intervention on economic efficiency. Yet the distributional effects of a certain public policy are often fundamental in determining its acceptability and also its eventual applicability. Moreover, it is common for policy makers to introduce measures to reduce the negative effects of public policies on different agents, simultaneously generating efficiency effects. Therefore, it is obvious that an integrated analysis of the efficiency and distributional issues associated with the application of public policies is of great academic and social interest.

Microeconomic models represent the standard approach to analyzing distributional issues. This approach requires the use of microeconomic data bases (with information from individuals, households or firms). The most interesting feature of this approach is that it allows us to take into account the heterogeneity between economic agents. In the case of the households, the heterogeneity is related to income, household composition or preferences. The main drawback of microsimulation models is that they are partial equilibrium models and therefore they do not endogenize relative prices, which may result in biased conclusions. Furthermore, they are not the best way to analyze the efficiency effects of public policies. It is in this context where we recognize the existence of a trade-off between efficiency and distribution and researchers have to choose among different analytical approaches.

On the other hand, applied or Computable General Equilibrium (CGE) models are useful tools to calculate the impact of public policies on the economy as a whole. Based on micro foundations, they are able to analyze the interactions among all sectors and institutions. Therefore, CGE models represent a powerful approach to analyzing efficiency and other macroeconomic effects of public policies that have been introduced or any potential measure that could be implemented. However, they may fail to evaluate the distributional effects of these policies on households and therefore may not properly analyze welfare changes. This is a common problem for those models which have only one representative household and also for models with a significant number of representative households. Indeed, creating households or individuals according to specific characteristics such as occupation, sources of income or place of residence has limitations because some information is lost (e.g. heterogeneity between households included in the same homogeneous group).

This paper proposes the use of a methodology which enables us to carry out a thorough analysis of the efficiency and distributive effects of public policies without losing any piece of information on heterogeneity in the surveys. To attain that objective, we use a microeconomic model of household demand that is integrated through prices in a CGE to know the policy effects on social welfare, relative prices and levels of activity of different sectors and institutions. Subsequently, by integrating the results from the CGE into the microeconomic model, it is possible to disaggregate the policy effects on household welfare and aggregate the results to the population.

For illustrative purposes, we simulate a 20% increase in consumption taxes on energy products (coal, electricity, oil products and natural gas) with a simultaneous revenue-neutral reduction of VAT on the remaining goods. This is an interesting policy reform given, first of all, its significant effects on both efficiency and distribution (Newbery, 2005). Moreover, its practical relevance is ensured by the current lax taxation of energy goods in Spain, which will probably have to change in the short term due to (i) EU initiatives to harmonize these taxes, (ii) the poor environmental performance of the Spanish economy and (iii) the high Spanish dependence on foreign energy stocks.

Our major results indicate that there are no significant changes in prices for capital and labor and thus all distributive effects take place through the impact on the prices for goods and services. However, such price effects on distribution are found to be significant, which obviously justifies the use of this methodology.

The article consists of four sections aside from this introduction. Section 2 underscores why we should integrate micro and macro models in some cases and explores the empirical literature on this issue. Section 3 sets out the methodological approach used, describing the theoretical models and their empirical implementation. The following section presents the policies considered and the results obtained from simulations. Finally, section 5 includes the main conclusions of the study and some policy implications.

2. Analytical approaches integrating micro and macroeconomic models

Following the reasoning presented above, it is natural to think about integrating micro and macro models in order to capture the advantages of each methodology and to assess the complex effects of public policies (Davis, 2004). Indeed, both approaches (micro and macro models) should be regarded as complementary since the CGE models lack the heterogeneity captured by micro models and the latter do not have some of the good properties of the former (Aaberge et al., 2004)[1]. It is however surprising the rather scarce academic interest in these questions, as revealed by a limited literature (which will be partially overviewed in this section).

When tackling this issue, it is obviously imperative to decide first on the modeling approaches to be integrated. Starting with the micro side, one could consider from pure arithmetic to dynamic micro models which incorporate the behavior of agents. Figure 1 illustrates those possibilities, diverging on whether or not they include a microeconometric model. The former are static or accounting models, as they do not take into account the reaction of individuals, and can only estimate the 'morning after' effect of any policy. The dynamic models simulate the behavior of individuals, which has to be introduced by econometric methods in order to endogenize the decisions made by individuals on labor supply, savings or consumption. Alternatively, the relevant parameters (mainly elasticities) could be taken from the empirical literature.

(Figure 1, here)

The simplest approach to integrate models consists of adding some macro detail in a microsimulation model, which can be done by incorporating an input-output model. In fact, there are many applications of integrated approaches with micro

[1] Of course, it would be ideal to have a general equilibrium model with as many households as reported by statistical sources [e.g. Cogneau and Robilliard (2005)]. However, these models are so complex that their ability to fully capture the agents' heterogeneity with many productive sectors is seriously limited.

models and input-output tables [e.g. Labandeira and Labeaga (1999) for Spain]. Despite the analytical improvement of this approach with respect to a simple micro model, it still poses at least two problems: (i) it represents a partial equilibrium approach; (ii) input-output methods are static and therefore do not include behavior responses by sectors and institutions.

One step beyond, from a methodological point of view, is to integrate micro and CGE models. The most common approximations integrate a static general equilibrium model and a microeconomic model of household income generation and expenditure. Interaction can be accomplished through mainly two strategies that differ in the level of integration. The easiest way is to perform a sequential approach, as in Bourguignon et al. (2003) or Bussolo and Lay (2005), where a static CGE model first quantifies the effects of policy-induced macroeconomic shocks. The microeconometric model takes as exogenous variables the relative changes in prices and other macro variables with results from the CGE, thus solved as illustrated in Figure 2.

The main advantage of sequential approaches is that they provide micro information about household behavior and impacts while at the same time maintaining a high level of flexibility of the integrated model. The main drawback is the coherence between the two instruments in the integrated model, which is not always guaranteed because feedback effects from the micro model to the CGE are not included.

(Figure 2, here)

Other authors such as Aaberge et al. (2004), Avistland and Aasness (2004) and Savard (2003) overcome that drawback by incorporating a bi-directional link between the CGE model and the micro model. This can be done by introducing some restrictions so as to obtain a converging solution between the two instruments. For instance, the household behavior in the CGE model could be exogenous through simulations (it is fixed at the benchmark): (i) changes in prices and factors from the aggregate model feed the microeconometric model and that supplies the reaction of each household to macro effects, (ii) information which could be used as an input in the CGE model as new values for the households (previously exogenous), and (iii) the CGE model is run again and the interactive process continues until convergence between the two instruments is achieved (Figure 2).

It is not surprising, and quite relevant for the purposes of this paper, that most of the previous studies found significant differences in the distributional effects estimated by a simple CGE approach and an integrated micro-macro approximation. In fact, those differences arise not only in quantitative terms but also qualitatively, as in some cases the sign of the effects reported by each approximation was the reverse.

3. The integrated micro-macro model framework

In this section we describe the analytical approach followed in the paper to study the efficiency and distributional effects from a change in Spanish indirect taxation. The empirical exercise integrates the simulations carried out with a general equilibrium model specially designed to simulate energy policies and a microeconomic household demand system with a detailed modeling of energy goods. Therefore, we follow a top-down approach to study the main macroeconomic effects of the policy and a bottom-up approach mostly devoted to distributional concerns. We follow a sequential approach by taking the changes in prices and income estimated by the CGE as an exogenous variable for the household energy demand model. Therefore, we first calculate the changes in the relative prices for each good estimated by the CGE, $P_{inew}^{CGE} / P_{ibase}^{CGE}$ and then the new relative (post-reform) prices, P_{inew}^{MIS}, are calculated for the micro model by multiplying pre-reform prices, P_{ibase}^{MIS}, by the percentage changes in corresponding variables in the CGE model,

$$P_{inew}^{MIS} = (P_{inew}^{CGE} / P_{ibase}^{CGE}) P_{ibase}^{MIS}$$

We are interested in analyzing policies with important inter-sectoral effects on the supply and demand of goods and services but with negligible effects on income. Thus we only microsimulate the expenditure made by each household, leaving aside the income generation process. As a consequence, the sequential approach followed in this paper is not inferior to an iterative approach.

Our objective is to obtain in-depth information on the behavioral responses of households by allowing the maximum level of heterogeneity between them to determine the welfare effects of the tax reform and the impact on distribution. As usual in statistical sources, there are some inconsistencies between the national accounts and aggregate values from the CFES (Continuous Family Expenditure Survey, *Encuesta Continua de Presupuestos Familiares*), which represent the data bases for the CGE and the micro model, respectively. This is so because household expenditure surveys attempt to obtain good estimates of expenditures made by individual households (which should be representative enough for the whole population), whereas the objective of the national accounts is to obtain good estimates of macroeconomic variables (e.g., aggregated expenditure). The Spanish CFES reports grossing-up factors to estimate aggregate values for the entire population and these values were used to analyze the consistency with household expenditure values in the national accounts (see, e.g., Symons et al., 1994).

3.1. The CGE model

To evaluate the efficiency and sectoral distribution of effects associated to the considered public policy, we use a static CGE model that is described in this section. First, sectors and institutions are disaggregated the most with the available information, which is important as long as we want to take into account the heterogeneity of energy consumption between agents. Furthermore, the energy sector was disaggregated as much as possible because of the different services it provides (intermediate inputs for production of electricity, lighting, heating, transport services, etc), and the disparity of environmental effects. This is quite important because efficiency costs and (environmental) benefits depend on two key elements: price-induced energy conservation and fuel switching (from dirtier to cleaner energies on the basis of emission factors).

There are 17 price-takers productive sectors (and commodities) that minimize cost subject to constant returns to scale (therefore, null profits at the equilibrium). The production function is a succession of nested constant elasticity of substitution (CES) functions, as illustrated in Figure A1[2]. As usual in CGE models, total production in sector *i* is a combination through a Leontief function of intermediate inputs and a composite good consisting of capital, labor and different energies.

We follow the Armington approach to model international trade of goods. Imported products are imperfect substitutes of national production. Therefore, the total supply of goods and services in the economy is a combination of production from different origins by means of a CES function. Maximization of profits by each sector, determined via a constant elasticity of transformation (CET) function[3], allocates the supply of goods and services between the export market and domestic consumption. Since the Spanish economy is small and most commodity trade is with EMU countries, there is not an exchange rate (it is fixed) and all agents face exogenous world prices[4].

Capital supply is inelastic (exogenously distributed between institutions), perfectly mobile between sectors, but immobile internationally. The model assumes a competitive labor market and therefore an economy without involuntary unemployment. Labor supplied by households to maximize utility is also perfectly mobile between sectors but immobile internationally.

The public sector collects direct taxes (income taxes from households, and labor taxes from households and sectors) and indirect taxes (from production and consumption). Endowment of capital for the government (K_G), transfers with other institutions (TR_G) and public deficit (DP) are exogenous variables[5]. The consumption of goods and services (D_{iG}) by the government is determined by a Cobb-Douglas function, where PD_i stands for domestic prices. Therefore, total public expenditure, capital income (where r is the price for capital services) and tax revenues (REV) have to be balanced in order to satisfy the budget restriction,

[2] The CGE takes as a basis Böhringer et al. (1997).
[3] For more on this, see Shoven and Whalley (1992).
[4] We assume that the policy simulated has no significant impact on the euro exchange rate, as the policy has a relatively small impact on the Spanish economy and Spain's major business partners are part of the European Monetary Union (EMU).
[5] As a general criterion, the notation used follows the following conventions: Endogenous variables are written in capital letters whereas exogenous variables are in capital letters with a line on top.

$$\overline{DP} = r \cdot \overline{K}_G + \overline{TR}_G + REV - \sum_{i=1}^{17} PD_i \cdot D_{Gi} \tag{1}$$

The representative household has a fixed endowment of time which is allocated between leisure (*LS*) and labor supply. They maximize utility (*W*), which is a function of leisure and a composite good (*UA*) consisting of goods and savings, subject to the budget constraint[6].

$$W = \left(s_{UB} LS^{\frac{\sigma^{UB}-1}{\sigma^{UB}}} + \left(1 - s_{UB}\right) UA^{\frac{\sigma^{UB}-1}{\sigma^{UB}}} \right)^{\frac{\sigma^{UB}}{\sigma^{UB}-1}} \tag{2}$$

It is assumed, as in Böhringer and Rutherford (1997), that consumers have a constant marginal propensity to save, which is a function of disposable income (Y_H). The latter is equal to the sum of capital income, plus labor income (w is the nominal wage and SC_H stands for social contributions or labor taxes) and transfers (*TR*), minus income taxes (T_H is the tax rate). Consumption of goods and services is defined by a nested CES function as shown in Figure A2, with special attention paid to the consumption of energy goods. An important contribution of this CGE model is the distinction, common in microeconomic models, between energy for the house, energy for private transport and other products.

$$Y_H = \left(1 - T_H\right)\left[r \cdot \overline{K}_H + w\left(1 - SC_H\right) \cdot \left(\overline{TIME} - LS\right) + \overline{TR}_H \right] \tag{3}$$

The CGE represents a structural model based on the Walrasian concept of equilibrium. Therefore, for each simulated policy, the model should find a set of prices and quantities in order to clear up all markets (capital[7], labor and commodities). Total savings (*SAVINGS*) in the economy is defined endogenously and equal to the sum of savings made by each of the institutions. The macroeconomic equilibrium of the model is determined by the exogenous financing capacity/need of the economy with the foreign sector (*CAPNEC*), i.e. the difference between national savings, public deficit and national investment. Investment is an aggregated good by means of a Leontief function that includes the different commodities used in gross capital formation, INV_i,

[6] σ^{UB} is the elasticity of substitution and S_{UB} is the share parameter for leisure on welfare.

[7] There is no quantity adjustment in total supply of capital in the economy because the capital endowment between institutions is an exogenous variable. There are only changes in the utilization of capital between sectors. The equilibrium condition is attained through changes in the price of capital services (r).

$$SAVINGS + \overline{DP} - \sum_{i=1}^{17} PD_i \cdot INV_i = \overline{CAPNEC} \tag{4}$$

International prices PXM_i, transfers between the foreign sector and other institutions and the consumption of goods and services in Spain by foreigners (D_{iRM}) are exogenous variables. Therefore, exports (EXP_i) and imports (IMP_i) have to be balanced in order to satisfy the restriction faced by the foreign sector,

$$\sum_{i=1}^{17} \overline{PXM}_i \cdot EXP_i + \overline{TR}_{RM} + CNR - \sum_{i=1}^{17} \overline{PXM}_i \cdot IMP_i = \overline{CAPNEC} \quad \text{where} \quad CNR = \sum_{i=1}^{17} PD_i \cdot \overline{D}_{iRM} \tag{5}$$

An important efficiency consequence from the application of a public policy on the energy domain is related to its environmental effects. Thus this model also incorporates a major environmental indicator: energy-specific CO_2 (carbon dioxide) emissions produced by different sectors and institutions. Emissions are generated during the combustion processes of fossil fuels only, with a technological relationship between the consumption of fossil fuels in physical units and emissions (θ_C , θ_R and θ_G; for coal, refined oil products and natural gas, respectively). In this sense, CO_2 emissions from sector i are

$$CO2_i = \theta_{Ci} \cdot COAL_i + \theta_{Ri} \cdot REF_i + \theta_{Gi} \cdot GAS_i \tag{6}$$

3.1.1. Data and calibration

In order to conduct policy analysis with this tool, it is necessary to calculate a national accounting matrix for the Spanish economy (NAM-95). We did this by taking the national accounts for 1995 as the departure point[8]. Furthermore, we extended the database with environmental data relating consumption of different fossil fuels and emissions for each sector and institution. Unfortunately, there are not any environmental statistics that report the level of disaggregation needed for this study, so we had to estimate the environmental data from different sources [IEA (1998) and INE (2002a, 2002b)].

[8] It is based on a NAM published by Fernández and Manrique (2004). The Spanish national accounts for 1995 follow the European System of Accounts (ESA-95).

Based on the information from the NAM-95, some parameters of the model can be obtained through calibration: effective tax rates, technical coefficients in the production functions, and parameters in the utility function. As it is well known, the criterion for calibrating the model is that the CGE can replicate the information contained in the NAM-95 as an optimum equilibrium, which will be used as a benchmark[9].

Certain parameters, such as elasticities of substitution, have not been calibrated but taken from the literature. For instance, the wage elasticity of the labor supply is equal to -0.4, similar to estimations for Spain in Labeaga and Sanz (2001). In order to gauge the elasticity of labor supply, we have followed the procedure used in Ballard et al. (1985) assuming, as in Parry et al. (1999), that leisure represents a third of the working hours effectively carried out in the benchmark. We made a sensitivity analysis by increasing and reducing the labor elasticity by 50%. From this analysis, we can conclude that results from the CGE are robust.

3.2. The microeconomic model for household demand

To evaluate the distributional effects of the simulated policy we employ a demand system estimated with microdata for Spanish households, Labandeira et al. (2006), that is highlighted in this section. The theoretical model on the basis of which we have econometrically estimated the empirical model is the quadratic extension proposed by Banks et al. (1997) from the Almost Ideal Demand Model (Deaton and Muellbauer, 1980). The model estimates the participation of each good in the total expenditure on non-durable goods made by each household as a function of the prices for each good, total expenditure and the square of total expenditure, and some demographics,

$$w_{iht} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_{jt} + \beta_i \log \frac{x_{ht}}{a(p_t)} + \frac{\lambda_i}{b(p_t)} \left(\log \frac{x_{ht}}{a(p_t)} \right)^2 \quad (7)$$

$$\log a(p_t) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \log p_{it} + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \log p_{it} \log p_{jt} \quad (8)$$

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[9] The general equilibrium model has been programmed using GAMS/MPSGE. Calibration has been implemented following the method proposed in Rutherford (1999), using the solver-algorithm PATH.

$$b(p_t) = \prod_{i=1}^{n} p_{it}^{\beta_i} \tag{9}$$

where *i, j =1, 2, ...n* represents the consumer goods considered by the demand system {electricity, natural gas, Liquefied Petroleum Gases (LPG), fuel for private transport, public transport, food and other non-durable goods}, w_{iht} is the participation of commodity *i* in total household spending *h* at time *t*. Prices are represented by p_{it} , and x_{ht} is total real income of each household (deflated by a Stone price index).

The distinction between different energies for the household and other types of energy is crucial (see Baker et al., 1989). For instance, electricity gives the household many services like artificial light, food conservation, cooking, washing, heat for the house, etc. However, coal, natural gas and refined oil products provide more limited and even completely different services (mainly heating and transport). Therefore, a demand system is estimated for the seven goods (a demand equation for each good, simultaneously) which enables us to impose symmetry and zero-degree homogeneity conditions in prices and income so as to make the demand system coherent with the consumer theory.

To take into account demographics, we included several dummies among the explanatory variables (educational level attained by the head of the household, geographical location of the home, for ownership of the main dwelling, etc). In addition, we also included a variable measuring the number of household members by age and a trend variable to register possible tendencies in any of the expenditure groups.

The data we used to estimate the demand system is a combination of comprehensive microdata surveys with information on expenditure, income and household demographic characteristics. We combined the Family Expenditure Survey (FES) for 1973-74 and 1980-81 and the CFES for the period 1985-1995, both provided by the Spanish National Institute of Statistics (INE). The 1973-74 FES includes information concerning more than 170 goods and services whereas the 1980-81 FES yields data for more than 600 goods and services. The sample size of both sources is around 24,000 households. We eventually used a sample from the

CFES that provides information on about 26,000 households and more than 270 goods and services. In order to make the data from the three surveys compatible, we aggregated the expenditures in homogeneous goods, attending to survey definitions. Demographic variables are calculated by using the same definitions in the three surveys.

The main reason for combining the three surveys is to solve the major problem in estimating complete demand systems, the identification of price effects (elasticities). This is due to low variation of prices and high collinearity among price series for different goods and services. Even using data from as long a time period as 1985-1995, the multicollinearity among price series does not allow for precise estimates of own and cross-price responses for most goods. By using a combination of data from 1973 to 1995, we were able to estimate adequate responses to price changes. In any case, it is important to have good estimates of price responses when the objective is to use the parameters to simulate fiscal policies that affect prices.

The results of the demand system estimation underlined the importance of using micro data, especially to account for the heterogeneity on demand and supply. For instance, households living in rural areas do not have access to the same energy goods as those living in large cities (e.g. natural gas) and also have some difficulties using services like public transport. A relationship between household composition and consumption was also found as, for instance, households with a retired head spend a smaller proportion on transport services because they use private transport less and they can benefit from public transport subsidies.

We report significant income effects on the consumption of the several goods considered in the demand system. Among energy goods, LPG is preferred by low-income households because it represents a cheap substitute for natural gas. On the other hand, car fuel consumption is associated with the possession of one or more vehicles which is, in turn, highly correlated to the income level of the household. All goods show a negative own price effect as expected according to the theory. Energy goods are relatively inelastic whereas other non-durable goods present the most important price effects.

We employed the same methodology of Baker et al. (1989) for simulations, which were implemented with annual CFES data for 1995. They allowed us to calculate changes in consumption, tax payments and welfare measures [reported as equivalent variations as in Banks et al. (1997)][10].

4. A macro-micro assessment of a tax change in Spain

In this section we analyze the effects of a reform that raises taxes on the consumption of energy goods (electricity, refined oil products, natural gas and coal) by 20%. The reform is revenue neutral and affects only to indirect taxes by financing a proportional reduction of VAT rates of all the remaining goods. In a previous preliminary and descriptive paper we assessed the effects of a green tax reform, with the introduction of a pure environmental tax and the reduction of direct personal taxes (see Labandeira et al., 2004a).

There are several reasons to illustrate this paper with such a reform. First of all, the distributional effects of altering energy prices are evident as many of these goods are household necessities and the sectoral effects may also vary. Secondly, the efficiency effects are also relevant from both macro and micro perspectives because the simulated policy affects prices, economic activity and emissions. Moreover, the EU context (excise tax harmonization, climate change policies) favors actions in this field when countries have less-than-average energy taxes, as is the case with Spain. Finally, the Spanish government has been repeatedly announcing an increase of energy taxes in the last few months.

4.1. Results

The simulated tax reform would increase Gross Domestic Product (GDP) by approximately one percent with a null impact on employment and prices for labor and capital in real terms[11]. Yet the sectoral effects of the policy vary, as showed by

[10] See Labandeira et al. (2004b) for a thorough description of the simulation procedure.
[11] Relative prices with respect to the consumer price index.

Figure 3 for the case of production and CO_2 emissions. Therefore, the CGE model also provides information on the distributional profile of the macro effects.

In particular, refined oil products is the only energy sector with a significant drop in production (-8%) because the tax burden on this sector was already very high and thus the new tax increase has a substantial effect on gross prices (see Table 1). For the other energy goods the effective tax rates are relatively low and so a substitution occurs between them and oil products, which explains in part the results on their levels of activity. Among non-energy sectors, it is worth mentioning the negative impact on the production of some services like culture and leisure, education, health and sanitation and public administration (*SERV2*). Indirect tax rates on these sectors are very low at the benchmark because they enjoy reduced VAT rates, so they are unable to benefit from the considered revenue-neutral tax reform. There is also a significant reduction in the production of transport services (*TRANSP*) and chemical products (*CHEMICAL*) as both depend heavily on the consumption of refined oil products. On the other side, the simulated policy has positive effects on manufactures (*MANUF*), construction (*CONSTRUC*), mineral products (*MINERAL*) and metal products (*METAL*).

(Figure 3, here)

The simulated tax reform would also reduce Spanish CO_2 emissions by 5.7%, which is clearly an efficiency outcome as it involves the reduction of a negative external effect[12]. Again, there is a great heterogeneity among sectors on CO_2 abatement (Figure 3), with some sectors substantially reducing their emissions (refined oil products and transport services by more than 9%). On the contrary, electricity generators only reduce their CO_2 emissions by 2%, which may be explained by the importance of nuclear and hydroelectric production in Spain (around 50% of electricity generation) and by the scarce effect of the tax changes on coal, the main source of CO_2 emissions from this sector.

Regarding prices, Table 1 depicts the effects of the simulated tax reform on the goods considered in the household energy demand model. These price effects will be incorporated in the micro model to analyze the household distributional impact of the tax changes. As mentioned before, there would be an important increase in the prices of motor fuels (more than 23%), although the effects on the other goods are rather small. In the case of other energy goods this is due to relatively low tax rates. Finally, as a result of the tax modifications there would be a reduction in the prices for food and other goods (around 1%) and this will be determinant for the overall distributional effects of the simulated policy.

(Table 1, here)

Table 1 also illustrates the reaction of Spanish households to the tax-induced price shifts, as obtained from microsimulation through the household energy demand model. The second column in Table 1 describes changes in the average expenditure on each good and service by the households in the micro data base. As expected, there would be an important increase in the expenditure on car fuels even though it would be lower than the price change. On the other hand, the relative rise in the price of electricity causes a reduction in the expenditure on electricity (6.5%) and an increase in the consumption of other energies for the house (more than 10% on natural gas and LPG). There is also a reduction in the expenditure on transport services, food and other goods. In sum, the important rise in car fuel prices, together with the low response by households (low price elasticity), is compensated with reductions in the expenditure on the other goods. However, in some cases the changes are scarcely relevant when accounting for the own price changes (e.g. food).

Focusing on distribution, we now deal with the welfare changes for different household groups with regard to income status and idiosyncratic characteristics. It is important to recall that the effects of the simulated policy on employment and revenue from labor and capital are not significant. Consequently, heterogeneity of price effects among goods and services and between households (because of diversity in preferences, income and idiosyncrasies) remain as the only origin for distributional outcomes.

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[12] This can contribute to the much needed effort to curb Spanish greenhouse gas emissions, as Kyoto commitments for 2012 allow a maximum increase of 15% with respect to 1990 and at the moment of

The welfare effects of the contemplated tax reform on Spanish households is moderate, as shown in Table 2 for households grouped in income deciles. The table presents the equivalent variations in welfare, in both Euros and as percentage changes with respect to total expenditure[13]. On average there is a relative welfare improvement of around 1.5%, which may appear inconsistent with the previously reported energy demand rigidities. However, this is due to the fact that the sum of expenses on energy goods by each household represents, on average, less than 10% of total expenditure.

(Table 2, here)

Table 2 shows that the simulated tax policy would have a moderate progressive impact on distribution. Households in the first decile would improve welfare by about 2.1% in equivalent variation with respect to total expenditure, whereas households in the top decile would raise welfare by only 1.3%. These results are a consequence of mainly three diverging forces: (i) energy is in general a necessity good, so any increase in taxation will be regressive, (ii) taxes on car fuels (which account for the largest tax increase) generally have a progressive effect because this consumption is related to the possession of vehicles and they are positively correlated with income and (iii) the reduction in VAT rates generally have a regressive effect because of the greater share of goods with reduced VAT rates in low-income household consumption (e.g. food).

Moreover, the distributional profile of the policy can be completed when households are grouped according to idiosyncratic characteristics that are relevant for the policy to evaluate. This is done in Table 3, where the variation of distributional effects is less pronounced. The households that benefit less from the simulated policy are those with several children younger than 15 years old and residents in urban areas (municipalities with more than 50,000 inhabitants). This result is connected to the positive correlation between the prior variables and income and also to the relation between income and the impact of the simulated tax reform on welfare (see above). Rural households compensate the fact that they have to rely more on private transport (more expenditure on motor fuels) with the generally

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writing the figure approaches 50%.

[13] To calculate equivalent variations in welfare we follow Banks et al. (1997).

lower level of income. Households with retired heads enjoy the best results, probably because pensioners have less expenditure on transport. This is a very interesting feature, contrary to the existing evidence in other European countries, and could ease the way for these reforms in Spain as they are usually opposed by fear of negative effects on poor and elderly people.

(Table 3, here)

5. Conclusions

Public policies designed to improve efficiency in the economy often have indirect and perhaps undesirable effects on income distribution and poverty. Trade, tax and energy-environmental policies represent some excellent and common examples in both developed and developing countries. From regulatory and academic perspectives this represents a powerful challenge because of the different methodologies available to analyze the efficiency and distributional consequences of public policies. On the one hand, microeconomic models are suitable for performing comprehensive analysis on distribution and poverty, but are partial equilibrium approaches and not suitable for precise efficiency analysis. On the other hand, standard general equilibrium models are usually inadequate for analyzing the distributional consequences of policies.

In this paper we presented a method which enables us to carry out a thorough analysis of the efficiency and distributional effects of public policies in Spain. We integrated a general equilibrium model, able to cope with the efficiency effects of public policies, and a microeconomic energy demand model, able to disaggregate with precision the impacts policies on households without any prior restriction. We employed this methodology to simulate some of the efficiency and distributional effects of a reform on Spanish indirect taxation. The analyzed policy includes a 20% rise in energy taxes, with the extra revenues devoted to a general reduction in VAT rates in the remaining goods. It is justified by the simultaneous and significant efficiency and distributional effects associated to this type of tax reform, but also by the practical plausibility in the European and Spanish current tax and energy policy contexts.

The reported results indicate that the simulated indirect tax reform increases GDP, although the effects on production are uneven. The activity in energy-intensive sectors is reduced, while it increases in other sectors. The effects on market prices are also variable, as prices in energy-intensive sectors increase but are slightly reduced in the most important goods in the household shopping basket. No significant changes are found in the income factor, so heterogeneity of price effects among goods and services and between households is the only foundation for distributional outcomes. Moreover, the tax reform achieves relevant reductions in Spanish CO_2 emissions and thus contributes to a much needed effort in this field.

The disaggregated effects among households are significant but moderate, with a welfare improvement and a progressive impact on distribution. The ratio between equivalent variation and total expenditure is greater than one percent for all households, but net benefits for the households in the first decile (the poorest) were 6% larger than for those in the last decile. This result is somehow surprising, as most international empirical literature considers the effects of energy taxes to be regressive, although it coincides with the meager evidence for developed Mediterranean countries. It is also noticeable that households with retired head constitute one of groups that most benefit from the simulated policy.

References

Aaberge, R., Colombino, U., Holmoy, E., Strom, B., Wennemo, T., 2004. Population ageing and fiscal sustainability: an integrated micro-macro analysis of required tax changes. Discussion Paper 366, Statistics Norway.

Baker, P., Blundell, R. W., Micklewright, J., 1989. Modelling household energy expenditures using micro-data. The Economic Journal 99, 720-738.

Ballard, C., Shoven, J., Whalley, J., 1985. General equilibrium computations of the marginal welfare costs of taxes in the United States. American Economic Review 751, 128-138.

Banks, J., Blundell, R. W., Lewbel, A., 1997. Quadratic Engel curves and consumer demand. Review of Economics and Statistics 79 (4), 527-539.

Böhringer, C., Ferris, M., Rutherford, T., 1997. Alternative CO_2 abatement strategies for the European Union. In: Proost, S., Brader, J. (Eds.), Climate Change, Transport and Environmental Policy. Edward Edgar, Cheltenham.

Böhringer, C., Rutherford, T., 1997. Carbon taxes with exemptions in an open economy: A general equilibrium analysis of the German tax initiative. Journal of Environmental Economics and Management 32, 189-203.

Bourguignon, F., Robilliard, A., Robinson, S., 2003. Representative versus real households in the macro-economic modeling of inequality. Document de Travail 2003-05, DELTA.

Bussolo, M., Lay, J., 2005. Globalisation and poverty changes in Colombia. In: Bussolo, M., Round, J. (Eds.), Globalisation and Poverty. Channels and Policy Responses. Routledge, Oxford.

Cogneau, D., Robilliard, A., 2005. Poverty alleviation policies in Madagascar: a micro-macro simulation model. In: Bourguignon, F., Pereira, A. (Eds.), The Impact of Economic Policies on Poverty and Income Distribution: Macro-Micro Linkage Models. Oxford University Press, New York.

Davies, J., 2004. Microsimulation, CGE and macro modelling for transition and developing economies. Discussion Paper 2004-08, UNU World Institute for Development Economics Research.

Deaton, A.S., Muellbauer, J. N., 1980. An almost ideal demand system. American Economic Review 83, 570-597.

Fernández, M., Manrique, C., 2004. La matriz de contabilidad nacional: un método alternativo de presentación de las cuentas nacionales. Documento de Traballo AE-30, IDEGA.

IEA, 1998. Energy Statistics of OECD Countries. 1995-1996. OECD, Paris.

INE, 2002a. Contabilidad Nacional de España. Base 1995. Serie Contable 1995-2000. Marco Input-Output 1995-1996-1997. Instituto Nacional de Estadística, Madrid.

INE, 2002b. Estadísticas de Medio Ambiente. Cuentas Ambientales. Instituto Nacional de Estadística, Madrid.

Labandeira, X., Labeaga, J. 1999. Combining input-output analysis and micro-simulation to assess the effects of carbon taxation on Spanish households. Fiscal Studies 20 (3), 303-318.

Labandeira, X., Labeaga, J. M., Rodríguez, M., 2004a. Green tax reforms in Spain. European Environment 14 (5), 290-299.

Labandeira, X., Labeaga, J. M., Rodríguez, M., 2004b. Microsimulating the effects of household energy prices changes in Spain. Nota di Lavoro 161.2004, Fondazione Eni Enrico Mattei.

Labandeira, X., Labeaga, J. M., Rodríguez, M., 2006. A residential energy demand system for Spain. Energy Journal, 27 (2).

Labeaga, J., Sanz, J., 2001. Oferta de trabajo y fiscalidad en España. Hechos recientes y tendencias tras el nuevo IRPF. Papeles de Economía Española 87, 230-243.

Newbery, D., 2005. Why tax energy? Towards a more rational policy. Energy Journal 26 (3), 1-40.

Parry, I., Williams, R., Goulder, L., 1999. When can carbon abatement policies increase welfare? The fundamental role of distorted factor markets. Journal of Environmental Economics and Management 37, 52-84.

Rutherford, T., 1999. Applied general equilibrium modeling with MPSGE as a GAMS subsystem: an overview of the modeling framework and syntax. Computational Economics 14, 1-46.

Savard, L., 2003. Poverty and inequality within a CGE framework: a comparative analysis of the representative agent and micro-simulation approaches. International Development Research Center IDRC, Dakar.

Shoven, J., Whalley, J., 1992. Applying General Equilibrium. Cambridge University Press, Cambridge.

Symons, E., Proops, J., Gay P., 1994. Carbon taxes, consumer demand and carbon dioxide emissions: a simulation analysis for the UK. Fiscal Studies 15 (2), 19-43.

APPENDIX

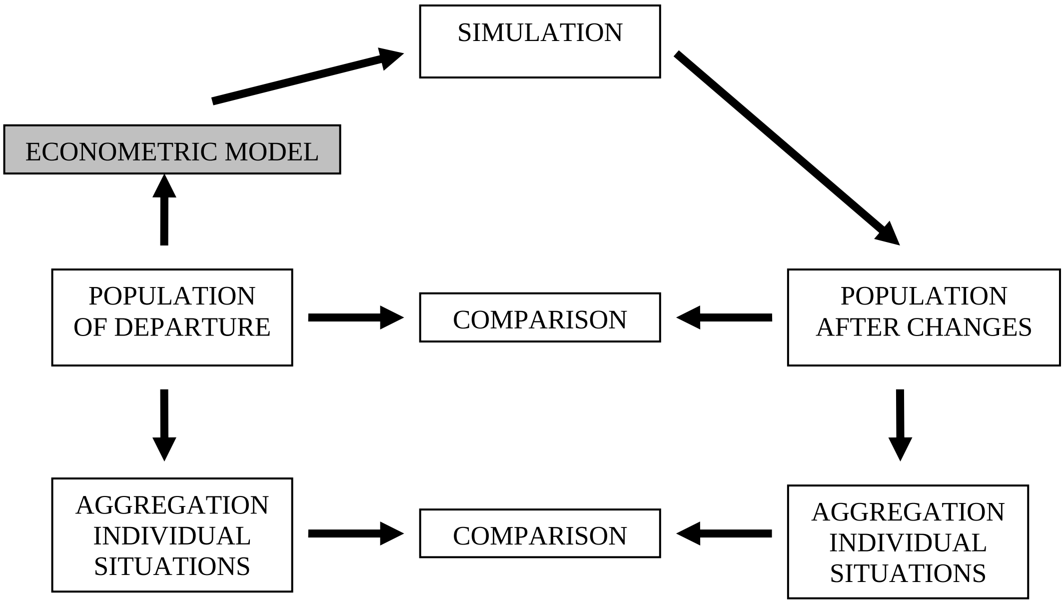
(Table A.1, here)

(Figure A.1, here)

(Figure A.2, here)

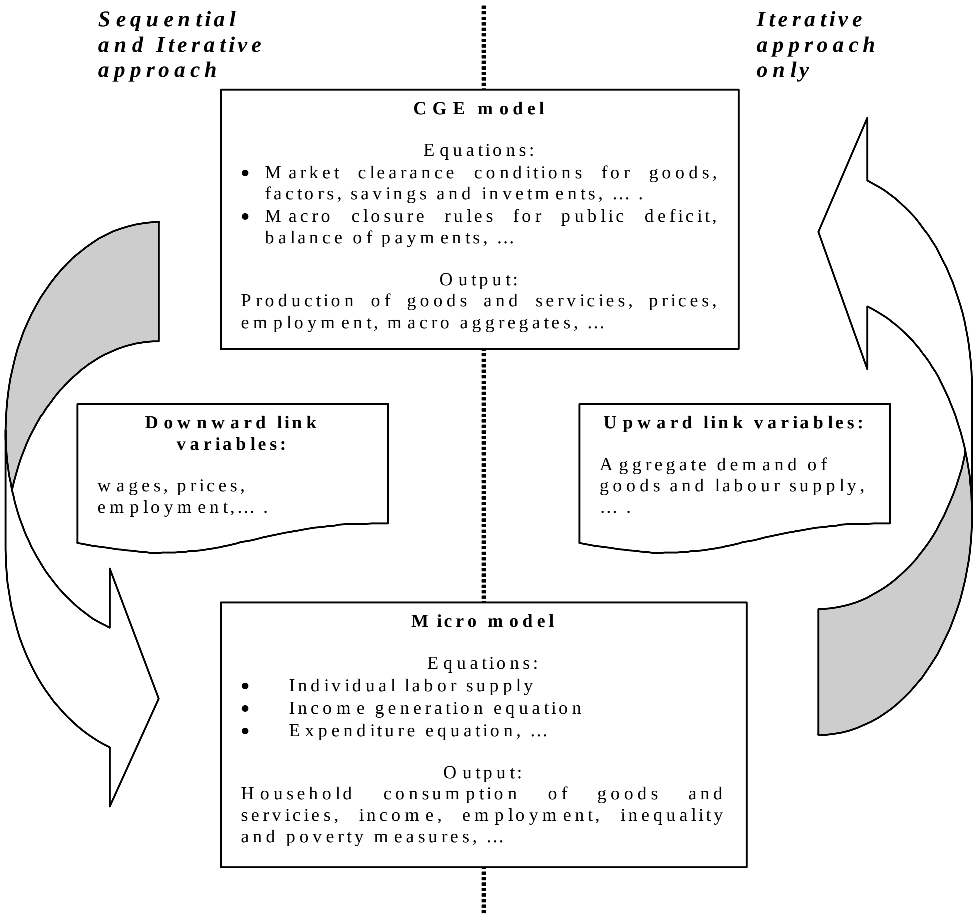
FIGURES AND TABLES

Figure 1. Standard structure of microsimulation models



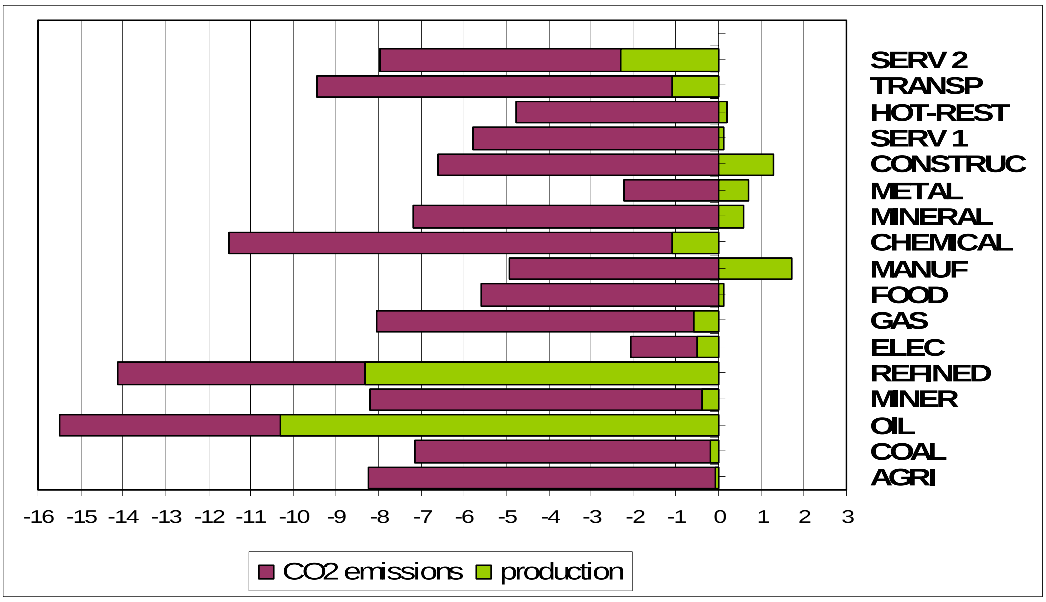
Source: draw up for this study

Figure 2. Sequential vs. iterative procedures for integration of CGE and micro models



Source: draw up for this study

Figure 3. Percent changes in production and CO_2 emissions



Source: Own calculations.

Table 1. Percent changes in prices and expenditure by group of goods

	prices	average expenditure
Electricity	2.79	- 6.49
Natural/mains gas	1.70	11.21
LPG	1.00	16.40
Car fuels	23.35	17.60
Public transport	1.40	- 2.50
Food and beverages	- 0.83	- 1.72
Other non-durables	- 1.09	- 0.73

Source: Own calculations.
Notes: Changes in relative prices with respect to the consumer price index. Changes in expenditure correspond to average values for the households in the database.

Table 2. Distributional effects by decile. Average tax payments and percent increases over pre-reform

Decile	Euros	%
1	101	2.06%
2	141	1.89%
3	166	1.80%
4	189	1.70%
5	210	1.60%
6	235	1.56%
7	260	1.50%
8	290	1.47%
9	332	1.39%
10	442	1.26%

Source: Own calculations.
Note: Average values for the households in each decile.

Table 3. Distributional effects by group of taxpayers. Average equivalent variations and percent increases over pre-reform

	Euros	%
Retired	223	1.80%
No children	234	1.57%
2 children	233	1.38%
4 Children	244	1.33%
Rural	211	1.57%
City	257	1.47%

Source: Own calculations.
Note: Average values with respect to total expenditure for the households in each group.

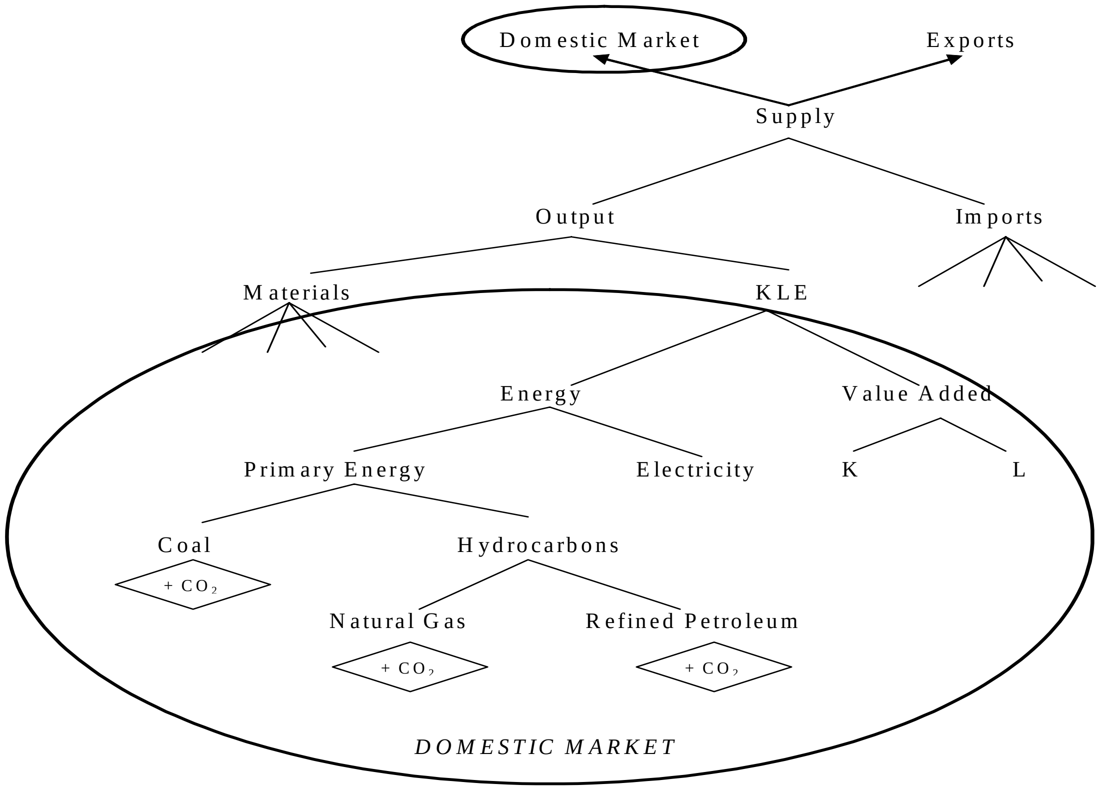
Table A.1. Sectors in the NAM-1995 and correspondence with the SIOT-1995

Sectors NAM-95	Description	Code SIOT 1995
AGRI	Agriculture, livestock and hunting, silviculture, fishing and aquiculture	SIOT 01, 02, 03
COAL	Extraction and agglomeration of anthracite, coal, lignite and peat	SIOT 04
CRUDE	Extraction of crude oil and natural gas. Extraction of uranium and thorium minerals	SIOT 05
MINER	Extraction of metallic, non-metallic nor energetic minerals	SIOT 06, 07
OIL	Coke, refined oil products and treatment of nuclear fuels	SIOT 08
ELEC	Electricity	SIOT 09
GAS	Natural gas	SIOT 10
FOOD	Food and drink	SIOT 12-15
MANUF	Other manufacturing industries	SIOT 11, 16-20, 31-38
CHEM	Chemical industry	SIOT 21-24
PROMIN	Manufacturing of other non-metallic minerals, recycling	SIOT 25-28, 39
METAL	Metallurgy, metallic products	SIOT 29, 30
CONSTR	Construction	SIOT 40
SERV1	Telecommunications, financial services, real estate, rent, computing, R+D, professional services, business associations.	SIOT 41-43, 50-58, 71
HOTEL-REST	Hotel and restaurant trade	SIOT 44
TRANSP	Transport services	SIOT 45-49
SERV2	Education, health, veterinary and social services, sanitation, leisure, culture, sports, public administrations	SIOT 59-70

Source: Drawn up by us for this study.

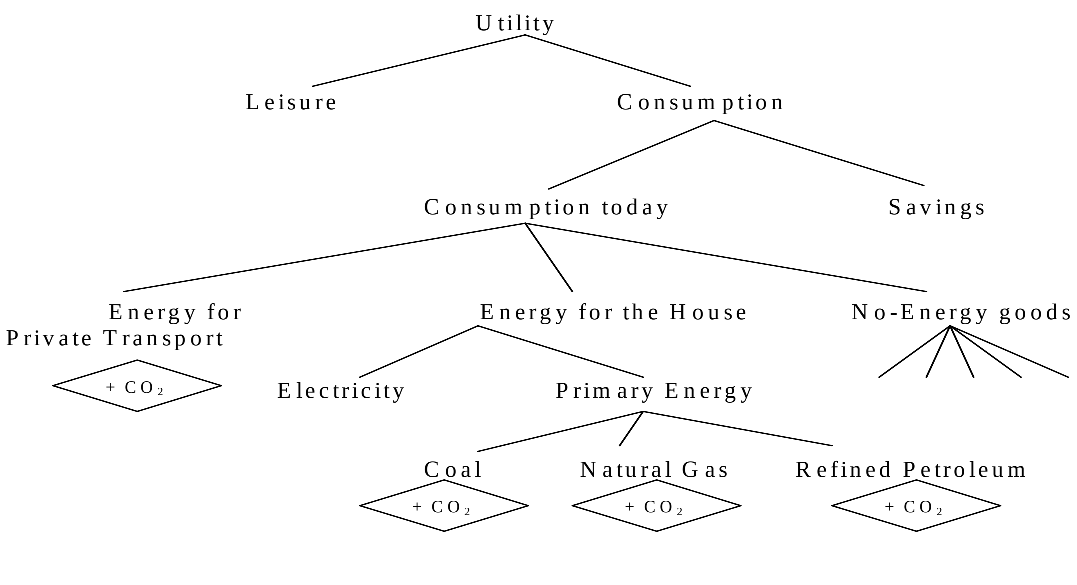
Note: The Symmetric Input Output Table (SIOT) codes represent the different areas of activity published in INE (2002a). Spanish oil production is not significative.

Figure A1. Chained production technology structure



Source: draw up for this study

Figure A2. Chained household consumption function structure



Source: draw up for this study