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On the estimation of Engel curves for a micro-macro interface loop of two economic simulation models

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Abstract:

This paper provides a thorough report of the estimation process of Engle Curves in the context of a research project articulating microsimulation with macroeconomic modelling. We present the detailed results after setting up the stage of the broader project where households' behavior is to be represented by sets of elasticities by groups of cells. A first part describes the broader project in order to better assess the role of this estimation step. Once this is accomplished we present the model and data and then the results are presented and discussed.

The models estimated in this paper are Engel curves on a set of consumption bundles consistent with the macroeconomic model consumption module. The set of consumption items regroup 14 goods and services. This is a relatively large system with many durables, services and a few non-durables. We present many shortcomings that we had to bypass, thus justifying the present results which are theoretically set by Lewbel (2006), Leser (1963) and Working (1943).

We then present the model we have retained to estimate. We then derive the elasticities that are functions of the coefficients. We propose thereafter methods to estimate standard-errors for elasticities.

The estimation results are finally discussed and we sketch improvements for further research.

Synopsis: this paper presents the estimation of Engel curves on a 15 goods consumption over a cross section of seven consumption surveys.

JEL classification: C26, C29, D12.

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Introduction

This paper presents the complete results of Engel curves estimations in the context of a broader modelling effort that strongly articulates microsimulation with hybrid macroeconomic modelling. This means that the econometric estimates presented herein are a step in a broader modelling effort. This point is very important to keep in mind because it imposes many constraints that must absolutely be fulfilled to perform the given task.

The estimates conducted in this paper are grounded in the literature on consumption analysis, as presented in Deaton and Muellbauer (1980). We explain our pragmatic choices in order to arrive to the set of elasticities in the given nomenclature of consumption. The base data for this part of the research are the detailed budget survey tables at the household level in then available seven years of surveys. The tables were transformed into a set cross-section of cells by year for the computations. The elasticities were estimated in an equation by equation basis and adjusted for outliers and other anomalies. The retained results were used as behavioral parameters for the microsimulation step between the two macroeconomic modelling steps.

The paper is organized as follows. The first section presents the broader context of the research. The second section presents the methodology retained for estimation of the Engel curves. The third section presents the results. The fourth section discusses the results in the context of the recent French literature. We conclude in the last section and present prospects for further research.

1) The broader project's context: modelling distributional effects of climatic transition packages in France

We must present the big picture of the broader modelling effort where the Engel curve estimations take place. As claimed in the introduction, the econometric part is an early step in the whole modelling effort whose primary objective is to investigate the distributional consequences of raising the ambition of a national environmental strategy. Equity has proven to be a determining factor in the social acceptability of environmental reforms in France with the recent Yellow Vests movement.

The modelling project will thus compare two policy packages within the French Low-Carbon Strategy[1] (SNBC) whose level of ambition has been enhanced from a fourfold reduction of 2010 emissions to carbon neutrality in 2050. The forecast of distributive impacts at household level allows to identify the associations of socio-economic characteristics underlying vulnerability to mitigation policies and to investigate properly targeted compensating measures.

[1] https://www.ecologique-solidaire.gouv.fr/sites/default/files/Projet%20SNBC%20EN.pdf ; https://www.euractiv.com/section/energy-environment/news/france-is-a-good-student-with-bad-results-when-it-comes-to-climate-policy/

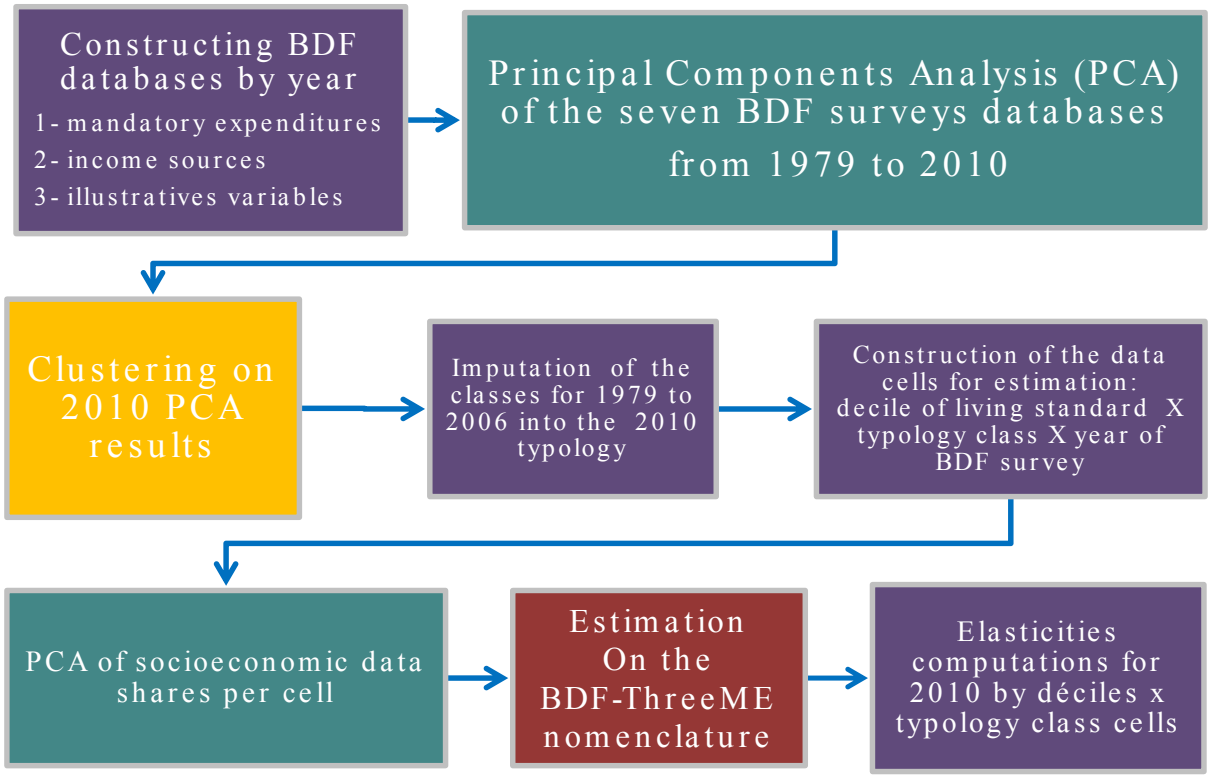
In this context, the modelling effort will evaluate packages of measures which include carbon taxation for households and firms, energy efficiency subsidies and thermal efficiency of social housing stock. The emphasis of the assessment bears on the interactions of several policies on households' budgets. For instance, a carbon tax will hit harder rural households dependent on cars, thereby limiting their capacity to invest (Berry, 2017; Combet et al., 2009; Douenne, 2020), hence a subsidy to switch thermal cars for electric vehicles could soften the burden.

The whole study thus investigates the extent to which policies in favor of low-carbon technologies compensate for the inequity of a carbon tax. The combination of price signals, income trends, technology incentives, growth and unemployment figures have indirect effects that are difficult to predict, given the many channels through which they propagate from the macroeconomic scale to the household level.

On several grounds, the whole research is innovative in the sense that it is the first 'macro-micro' study of the distributive impacts of the French energy transition. The major methodological contribution lies in the projection of a medium-term break in technology adoption by households within a coherent set of measures whose impacts are assessed by employing a set of inequality indicators in order to measure the effects of the increasingly ambitious transition on monetary poverty, income distribution, fuel poverty and on changes in available income and household budgets. The second major innovation lies in the fact that the impact of the studied measures is quantified both at the national level and disaggregated along several socio-economic dimensions in order to identify particularly vulnerable groups in the population.

The assessment of the redistributive impacts of the French Low-Carbon Strategy suppose a detailed representation of households behavior at both levels of analysis (wiz., micro and macro levels). In this perspective we made extensive use of the French family budget surveys (Budget des Familles, or BDF for short) that are conducted every five years since the first installment in 1979. The data have been extensively processed in order to conduct the first most important steps of our work. The processing chain is displayed in figure 1 below.

Figure 1: data processing chain



The figure sums up the different key steps of the data processing chain developed for the specific task of obtaining households elasticities through Engel curves estimations. The complete presentation of the whole process is described in the companion working paper detailing the PCAs and the clustering of households (Nadaud & al., 2020). For now, we concentrate on the estimation per se and refer to the processing step when needed. In fact this paper concentrates on the last two steps of figure 1, that is, estimation on the BDF-ThreeME nomenclature and computation of elasticities by cells.

2) Preparation of the data for estimation

One of the key steps for the whole project was to design a common nomenclature in order to find the best compromise for dialogue between the two macroeconomic models ThreeME and IMACLIM-S France. This step involved concertation between the two modelling teams at ADEME and Cired respectively on one hand. On the other hand, we carefully designed the best nomenclature apt to capture the most relevant common ground of the two models.

2.1) Defining a common nomenclature for two models

The estimates must be based on an expenditure nomenclature adapted to the dialogue between the macro and micro models which it is intended to link. On the one hand, this nomenclature must be as close as possible to the nomenclature of

the ThreeME model, from which the price changes subject to micro-simulation will be derived. On the other hand, it must aggregate expenditures by consumption functions that are sufficiently contrasted to allow us to deduce significant price and income elasticities.

After careful examination, we have selected fourteen product aggregates that encompass the COICOP classification of BDF 2010 and the national accounts classification of ThreeME. The final classification counts fourteen expenditure items that were reconstructed with the COICOP data for all the seven BDF survey years. The complete correspondence between COICOP and this fourteen-item nomenclature is given in the appendix.

On the other hand we had to decide on some of the accounting conventions between ThreeME and BDF surveys, wiz, some items of the production oriented ThreeME nomenclature do not have equivalents in COICOP which is consumption oriented nomenclature. The ThreeME posts that have no equivalent in COICOP have been imputed to the greatest post in COICOP. Similarly, we decided to keep important consumption items in the households budgets that do are not taken into account in ThreeME because this latter model has only one households sector, it cannot take into account second hand vehicles purchases or rentals between households while those last two items represent roughly 50% of vehicles purchases and real housing rental expenditures.

The fourteen products nomenclature for estimation is given in table one below. The complete correspondence this shortened nomenclature and the full french COICOP 5 nomenclature from BDF 2010 is given in the annex 1 of this paper. We included some final remarks about the national accounting conventions for some items indicated in the table: that is, construction expenditures and used cars purchases. Both of these are accounted as investment in the national accounts but considered as consumption in our estimation procedures.

Table 1 Micro-macro common nomenclature for estimation

Item	Function	Expenditures description	Note
A01	Food	Agriculture products, fishery, food industry	-
A02	Home energy	Electricity	-
A03		Gas	-
A04		Other home energies	-
A05	Construction	Major works for home	Investment in National Accounts and consuption in ThreeME.
A06	New vehicles	New vehicles	-
A07	Personal vehicles energy	Gazoline and lubricants	-
A08	Transport services	Air & Rail transport services	-
A09		Road & Water transport services	-
A10	Leisure services	Leisure and communications	-
A11	Other services	Other services	-
A12	Other goods	Other consumption goods	-
A13	Housing rentals	Effective rents	-
A14	Used vehicles	Second-hand vehicles	Not accounted in national accounts.

Lecture by columns: A01-A14, nomenclature labels; function labels; expenditure description; modelling remarks.

The table lists fourteen consumption items for which we will estimate price and income elasticities with Engel curves estimates. We decided to include construction expenditures as a specific consumption item rather as an investment of the households because most of the refurbishment investments for the home are incremental of low to moderate amounts (Combet, 2013 ; Combet, Ghersi, Hourcade, Thubin 2010 ; Berry & alii, 2016). We thus found more relevant to keep this expenditures as consumption rather investment because they mostly enter in the household consumption budget choices for the most part and also it dispense us from designing an investment model to the consumption model. Notice also that the

policy implementation choices are incorporated into the microsimulation part presented in the other papers.

These fourteen expenditures posts imply expenditures and prices series. We are thus present in the following section the process of price series construction.

2.2) Price series

The estimation of Engel curves on the BDF bases aggregated into cells of decile groups x typology classes involves non-trivial price transformations. Indeed, if the step of constructing expenditure by cells, and consequently budget shares, is immediate, this is no longer the case for prices.

The price series of expenditure items for econometrics estimation are generally derived from macroeconomic price indices relating to elementary items at a lower level of aggregation. This makes it possible to introduce inter-household variability into the household data before cell aggregation. This is very important because price series which are practically invariant with expenditure observations lead to estimates which are at best imprecise, unstable most of the time, or even non-existent owing to almost perfect collinearity with the constant of the estimated equation.

The construction of price series involves two steps. The first step consists in constructing price series into the disaggregated BDF databases, wiz, specific to each household and at COICOP 5 level, by insertion of the corresponding price found in the detailed INSEE macroeconomic consumption expenditures price indices. We use the macroeconomic long run time series of household consumption in 360 items available online from INSEE in the household consumption section of national accounts[2]. We therefore construct for all the items of the previously defined nomenclature series of average price indices per household from level 5 components of each of the nomenclature items. These elementary indices are simply defined as the average of the INSEE elementary price indices weighted by the budget shares within the item under consideration. The second step is to calculate the average of the price indices on the BDF bases aggregated by year. This is simply the weighted average of the BDF household base price indices for each year.

At the end of this step, we obtain a complete database with correct prices the on fourteen items per decile by class for the seven BDF years, i.e. 280 observations per item. These price series have sufficient variability to guard against the risk of estimation failure, apart from a few exceptions[3]. The full detailed nomenclature is presented in annex 2 of the present paper. Indeed, several items in our 14-group nomenclature are composed of only one item in the elementary BDF bases. This is the case for electricity (A02), gas (A03), major housing works (A05), purchases of new

[2] https://www.insee.fr/fr/statistiques/4131372?sommaire=4131436

[3] These exceptions are relative to consumption items that are composed in a single product at COICOP 5 level. If there is insuffiecient prices. See also annex 2 of the paper.

vehicles (A06), fuels for personal vehicles (A07), rents (A13) and purchases of second-hand vehicles. For these items, we have only one macroeconomic price time series, so that it is impossible to introduce variability between households per year. Estimation is then all the more difficult as the single macroeconomic price series is not very contrasted over time. We shall see below how the results of our estimates reflect these difficulties.

3) Presentation of the estimated model

The next step is households behavior estimation discussed in this section. Therefore we present here the results of the estimation of the elasticities of household consumption over the period covered by all the BDF surveys from 1979 to 2010. The path followed is along the lines of Ghersi and Nadaud (2010) and Barbier et al (2016).

3.1) An Engel curve framework

We call cells the cross product of deciles and classes of the typology. Thus, for each year and in the selected nomenclature, we go from about 10,000 households to 40 cells of deciles x classes of the typology. For each of the fourteen consumption items retained, the expenditure data thus comprise 280 observations corresponding to the consumption of each of the 40 cells (decile x typology class) measured in the seven successive BDF surveys (1979 to 2010).

The estimated model is a simple Engel curve specification in budget share estimated on the set of 280 observations of deciles by classes per years. The equation for each item is as follows:

$$w_i = a_i + b_i t + c_i \ln\left(X/P\right) + d_i lnP_i + \sum_{k=1}^{5} \phi_{k,i} CP_k + e_i \qquad (1)$$

where :

w_i is the budget share for item i on total expenditures ;

t = 1979, …, 2010 the BDF survey years ;

X nominal expenditure for the cell ;

P the Stone deflateur for the cell : $P = \sum_{k=1}^{n} w_k \, lnP_k$;

P_i the price of item i for ce cell ;

CP_k component k of the socioeconomic variables weights' PCA ;

e_i regression residual for item i equation.

Note that in equation (1) of the Engel curves, estimated for the fourteen selected items (Table 1, above), we reintroduce some socio-economic variables

(components CP_k) obtained by a PCA separated from the percentage proportions of households by modality in each cell. This is a convenient way to reintroduce household heterogeneity that would otherwise be lost, at least in a standard specification, because of the data structure adopted for estimation. The details of this specific PCA are presented in annex 3 of the present paper.

The estimator used is an instrumental variable estimator that addresses the simultaneity bias that arises from the fact that the budget share comes into play on both side of the equation, leading with ordinary least squares to an asymptotically divergent estimator. Of course, in reality we are in a finite sample, but the larger the sample, the more divergent the results would be (Greene, 2010; Deaton and Muellbauer, 1980).

In any case, we use the classical procedure in empirical consumption econometrics, which consists in taking the real standard of living Y* as an instrument of the total nominal expenditure of the cell. We thus use as an instrument of total expenditure ln(X/P) the log of the real standard of living ln(Y*/P), in which Y* is defined by Y* = Y / average number of consumption units of the households in the cell according to the OECD equivalence scale, and with Y the average income of the households in the cell.

The equations are estimated one by one separately for each item. The final closure will be done in the numerical modelling stage. This is due to the fact that we were not able to estimate a demand system in the form of Engel curves with this nomenclature, even on data aggregated by cells. This is not in itself a hindrance, provided that macro looping is also ensured by guaranteeing that the breakdown of total nominal household expenditure does indeed add up to total consumption across all items.

3.2) Computation of elasticities

We present here the detailed calculations of the estimated elasticities on the fourteen consumption items of the common nomenclature IMACLIM-S France ThreeME.

The computations of elasticities from the coefficients draw heavily on the paper by Pawlowski and Breuer (2012) from which the following computations are derived with the results of Green and Alston (1990) for the popular LA-AIDS model.

Equation (1) above, relates the budget shares to the logarithms of real expenditure and the item price. In this specification, the coefficients are interpreted as budget share elasticities, and we wish to calculate the income and price elasticities of total expenditure.

In the case of equation (1), the elasticities are respectively for income:

$$e_{E_i X} = \frac{\partial E_i}{\partial X}\frac{X}{E_i} = 1 + \frac{c_i}{w_i}. \qquad (2)$$

And, for prices:

$$e_{E_iP_i} = \frac{\partial E_i}{\partial P_i}\ \frac{P_i}{E_i} = \frac{d_i}{w_i} - c_i. \qquad (3)$$

For either of each product, the simplified expression of the Engel curve is:

$$w_i = a_i + b_i \ln\left(X/P\right) + c_i lnP_i + e_i \qquad (4)$$

Equation where we voluntarily omit time *t* and the coefficients of the principal components without loss of generality. The coefficients are interpreted as semi-elasticities of the budget share to real expenditure (X/P) and to price (Deaton & Muellbauer, 1980). We therefore need to find the expressions of the price and income elasticities of expenditure for each item as functions of the regression coefficients on price and income.

Consider the total expenditure :

$$X = \sum_{i=1}^{i=I} E_i,$$

from which the budget shares are calculated:

$$w_i = E_i/X = E_i / \sum_{i=1}^{i=I} E_i.$$

The income elasticity of expenditure for the given item i, is given by:

$$e_{E_iX} = \frac{\partial E_i}{\partial X} \times \frac{X}{E_i},$$

with the same for the price elasticity:

$$e_{E_iP_i} = \frac{\partial E_i}{\partial P_i} \times \frac{P_i}{E_i}.$$

The calculation trick consists mainly in using Engel's equation (1), noticing that $E_i = Xw_i$, so that:

$$E_i = Xw_i = Xa_i + Xb_i \ln\left(X/P\right) + Xc_i lnP_i,$$

that is :

$$E_i = Xw_i = Xa_i + Xb_i \ln X - Xb_i lnP + Xc_i lnP_i$$

This last expression is derived from the well-known properties of natural logarithms: ln(X/P) = lnX - lnP. A difficulty with equations (1) and (2) is that the Stone index P, is a function of individual prices P_i, which causes a simultaneity bias that renders the OLS estimator (1) inconsistent. The model must therefore be estimated using instrumental variables but, above all, this relationship between the expenditure deflator and elasticities must be taken into account. Consider the expression of the Stone index:

$$lnP = \sum_{i=1}^{i=I} w_i\, lnP_i \qquad (3)$$

Expression whose derivative for any individual price *i* is:

$$\frac{\partial lnP}{\partial P_i} = \frac{w_i}{P_i}$$

We can now calculate the expression of $\frac{\partial E_i}{\partial X}$ from equations (2) and (3'), i.e.:

$$\frac{\partial E_i}{\partial X} = a_i + b_i \ln X - b_i lnP + c_i lnP_i + \frac{Xb_i}{X}$$

Likewise, since we have $w_i = E_i/X$, it follows immediately that: $X/E_i = 1/w_i$.

This allows us to deduce the expression of the income elasticity of the expenditure of item i under consideration:

$$\frac{\partial E_i}{\partial X} = a_i + b_i \ln(\frac{X}{P}) + c_i lnP_i + b_i = w_i + b_i \quad (4)$$

So that it the income elasticity is:

$$e_{E_i X} = \frac{\partial E_i}{\partial X} \times \frac{X}{E_i} = (w_i + b_i) \times \left(\frac{1}{w_i}\right) = 1 + \frac{b_i}{w_i} \quad (5)$$

For the price elasticity of expenditure of product *i* under consideration, the calculation is similar although somewhat more complicated. Starting from the expression of the price elasticity, we find:

$$E_i = Xw_i = Xa_i + Xb_i \ln X - Xb_i lnP + Xc_i lnP_i,$$

expression for which we compute the partial derivative in relation to the price of product i under consideration, i.e.:

$$\frac{\partial E_i}{\partial P_i} = -Xb_i \frac{\partial lnP}{\partial P_i} + \frac{Xc_i}{P_i} \qquad (6)$$

Now, we recall the expression: $\frac{\partial lnP}{\partial P_i} = \frac{w_i}{P_i}$, which gives, by replacing in (6) :

$$\frac{\partial E_i}{\partial P_i} = -Xb_i \frac{w_i}{P_i} + \frac{Xc_i}{P_i}. \quad (6')$$

Let us now calculate the second member of the price elasticity expression, i.e., $\frac{P_i}{E_i} = \frac{P_i}{Xw_i}$, we have therefore, by replacing in the expression (6') :

$$e_{E_i P_i} = \frac{\partial E_i}{\partial P_i} \times \frac{P_i}{E_i} = (\frac{Xc_i}{P_i} - Xb_i \frac{w_i}{P_i}) \times (\frac{P_i}{Xw_i}),$$

$$e_{E_i P_i} = \frac{Xc_i}{P_i} \times \frac{P_i}{Xw_i} - \frac{Xw_i b_i}{Xw_i},$$

$$e_{E_i P_i} = \frac{c_i}{w_i} - b_i \quad (7)$$

This concludes the final calculation of the elasticities on the values sought, i.e. expressions (5) and (7). A the coefficients of interest terms, we have the income elasticity $e_{E_i X} = 1 + \frac{b_i}{w_i}$, and the price elasticity $e_{E_i P_i} = \frac{c_i}{w_i} - b_i$.

Notice that if Engel's equation (1) is more general and if we use another deflator than the Stone index given by equation (3), the expressions of the elasticities would be different.

4) The estimation procedure

The estimation procedure is conducted equation by equation independently because we knew beforehand from precedent experiences (Ghersi and Nadaud, 2010) that a full demand system, even simplified did not work, and this even on pseudopanel or cross section cells data.

The estimation procedure followed here is thus based on the Green and Alston (1990) instrumental variables procedure. Instrumental variables Greene (2010) is necessary because the dependent variables, wiz, the budget shares enter both side of the equation as endogenous and into the Stone index deflator of income.

Because of this endogeneity problem we did use the total expenditures as instrumented variables in the two step IV estimator of the package AER (Principles of Econometrics with R), developed by Colonescu (2016). The Stone deflated standard of living is used instead as an instrument for the first step of estimation. We also tested the one step OLS and WLS on with the same variables, results differ because it is a one step estimator and some coefficient show inconsistent signs. We thus retain the WLS IV estimates for the coefficients of the Engel Curves. Diverse corrections for various biases were applied without much change in the final estimates. Colinearity checks were applied with the Variance Inflation Factors (Colonescu, 2016), and the Besley, Kuh and Welsh (BKW) condition index test (Greene, 2010). When collinearity was found to high we adjuted the deterministic terms and the socioeconomic principal components variables by dropping or adding terms. One must notice that the terms CP_k component k of the socioeconomic variables weights' PCA are mutually uncorrelated between themselves but not from the other variables of each regression equation, wiz, deterministic terms, living standard and price index. We thus allowed some specification search room to accommodate the most parsimonious set of socioeconomic principal components and deterministic terms as a mean to limit the ill effect of multicolinearity.

Once we obtained satisfactory coefficients for each of the fourteen consumption items we computed the elasticities for the whole 280 decile---cluster-year cells. The standard-errors of the elasticities were computed by the delta method (Greene, 2010; Colonescu, 2016). We present in the following section the estimated elasticities.

5) The estimation results

The estimation step computes income and price elasticities from the coefficients estimates for the whole cross-section of 280 cells for the seven years-deciles-clusters of the typology. The final 40 last estimates correspond to the year 2010 that are

sought for use in the microsimulation module and the macroeconomic model of IMACLIM-S France.

5.1) Interpretation of computed elasticities

The final results are reported in table 2 below.

Table 2: elasticites estimates per decile of living standard in 2010

Expenditure	Élasticité	D01	D02	D03	D04	D05	D06	D07	D08	D09	D10	ENS
Food	Income	0,41	0,43	0,41	0,38	0,37	0,33	0,30	0,25	0,19	-0,09	0,30
	Price	-0,16	-0,16	-0,16	-0,17	-0,17	-0,17	-0,17	-0,18	-0,19	-0,27	-0,18
Electricity	Income	0,57	0,58	0,57	0,54	0,54	0,51	0,49	0,45	0,42	0,24	0,49
	Price	-0,56	-0,55	-0,57	-0,60	-0,60	-0,63	-0,66	-0,72	-0,75	-0,99	-0,66
Gas	Income	1,33	1,28	1,26	1,28	1,28	1,29	1,30	1,31	1,31	1,36	1,30
	Price	-0,19	-0,17	-0,16	-0,17	-0,17	-0,17	-0,18	-0,18	-0,19	-0,21	-0,18
Other fuels	Income	0,86	0,88	0,88	0,86	0,85	0,82	0,78	0,73	0,75	0,59	0,80
	Price	-0,43	-0,39	-0,38	-0,44	-0,48	-0,57	-0,69	-0,84	-0,78	-1,25	-0,62
Construction	Income	1,69	1,41	1,38	1,34	1,29	1,28	1,26	1,24	1,21	1,19	1,33
	Price	-0,55	-0,36	-0,34	-0,31	-0,28	-0,28	-0,26	-0,25	-0,24	-0,23	-0,31
New vehicles	Income	2,49	2,33	2,16	2,01	1,93	1,85	1,78	1,72	1,67	1,56	1,95
	Price	-2,15	-1,93	-1,68	-1,47	-1,36	-1,25	-1,15	-1,06	-0,99	-0,83	-1,39
Gasoline	Income	0,73	0,77	0,77	0,78	0,79	0,78	0,78	0,78	0,77	0,75	0,77
	Price	-0,33	-0,29	-0,29	-0,28	-0,27	-0,28	-0,28	-0,28	-0,29	-0,31	-0,29
Air & rail transports	Income	1,41	1,78	2,30	1,92	2,06	1,89	1,71	1,67	1,60	1,46	1,78
	Price	-0,21	-0,36	-0,58	-0,42	-0,48	-0,41	-0,33	-0,32	-0,28	-0,23	-0,36
Road & water transports	Income	1,48	1,64	1,71	1,71	1,72	1,73	1,74	1,77	1,72	1,69	1,69
	Price	-0,83	-1,11	-1,22	-1,22	-1,25	-1,27	-1,28	-1,32	-1,24	-1,20	-1,19
Leisure	Income	1,69	1,78	1,74	1,64	1,60	1,55	1,49	1,46	1,43	1,36	1,57

	Price	-0,35	-0,37	-0,36	-0,35	-0,34	-0,34	-0,33	-0,33	-0,33	-0,34	-0,34
Other services	Income	1,14	1,14	1,14	1,14	1,13	1,13	1,13	1,13	1,13	1,13	1,13
	Price	-0,43	-0,43	-0,43	-0,43	-0,43	-0,43	-0,43	-0,43	-0,43	-0,43	-0,43
Other products	Income	1,41	1,41	1,40	1,38	1,37	1,35	1,34	1,32	1,31	1,28	1,36
	Price	-0,58	-0,58	-0,57	-0,56	-0,55	-0,54	-0,53	-0,53	-0,52	-0,51	-0,55
Housing rentals	Income	0,56	0,55	0,52	0,50	0,48	0,45	0,42	0,38	0,33	0,18	0,44
	Price	-0,73	-0,75	-0,79	-0,84	-0,87	-0,92	-0,97	-1,04	-1,11	-1,38	-0,94
Used vehicles	Income	2,40	2,71	2,81	3,04	2,74	2,71	2,61	2,59	2,70	3,08	2,74
	Price	-0,69	-0,80	-0,83	-0,92	-0,80	-0,79	-0,76	-0,75	-0,79	-0,92	-0,80

All the items show acceptable profiles. At this stage, let us confine ourselves to noting the plausibility of the following profiles:

- Food: low price elasticity for all deciles, but a little more for the upper deciles;

- Electricity: constant price elasticities up to decile 5 and increasing in magnitude thereafter;

- Gas: constant profile over all deciles;

- Construction: strong price elasticities in absolute value for the lower deciles then decreasing for the higher deciles;

- New vehicles: high but decreasing price and income elasticities for high incomes;

- Fuels: constant profiles for all deciles;

- Air + rail transport services: decreasing price elasticities in absolute value;

- Water + road transport services: constant profile across all deciles;

- Leisure services: decreasing profile in absolute value for prices;

- Other services: constant profile across all deciles;

- Other products: slightly decreasing price profiles across deciles;

- Second-hand vehicles: high income elasticities and profiles increasing and then decreasing thereafter.

The full elasticities per decile and cluster are presented in the complete tables per decile and class in annex 1.

This last section assesses the significance of the estimated elasticities, compares them with similar estimates available in the literature, and presents some additional calculations that allow us to anticipate certain micro-simulation results. We conclude it with a broader reflection on the difficulties raised by our exercise and the scope of its results.

5.2) Significance of results

Here we present some measures of the statistical significance of the item elasticities. For each estimate, standard deviations of the elasticities were calculated using the delta method, which approximates a function of the estimated coefficients. Table 3 reports both standard-errors and the Student's t of the means of each price and income elasticities over the whole fourteen expenditures items in 2010.

Table 3: significance of mean elasticities per consumption item

Expenditure	Income Elasticity	Student-t	Price Elasticity	Student-t
Food	0,30	5,10	-0,17	-3,20
Electricity	0,49	10,75	-0,67	-12,50
Gas	1,30	26,02	-0,16	-3,19
Other fuels	0,80	1,80	-0,62	-1,47
Construction	1,33	4,44	-0,26	-2,40
New vehicles	1,95	11,88	-1,39	-3,37
Gasoline	0,77	5,80	-0,27	-4,56
Air & rail transports	1,78	5,80	-0,35	-1,47
Road & water transports	1,69	4,13	-1,19	-1,39
Leisure	1,57	41,49	-0,20	-2,38
Other services	1,13	44,61	-0,22	-7,59
Other products	1,36	36,85	-0,39	-5,03
Housing rentals	0,44	1,81	-0,97	-1,94
Used vehicles	2,74	3,63	-0,71	-1,67

Significance levels : 10% = 1.65 ; 5% = 1.96, 1% = 2.58 ; orange highlighting : significant at 10%, red highlight : non-significant.

The majority of our elasticities are significant, many of them up to the 1% threshold indicated in the note to the table. Only the price elasticities for domestic fuels other than gas and for the two transport services are insignificant with Student's t below the 10% threshold. And only three additional elasticities are weakly significant at 10%: the price elasticity of second-hand vehicles, the income elasticity of domestic fuels other than gas and that of rents.

These last two items posed the greatest difficulties for us to estimate so that we had to make do with estimates per decile without distinction of economic vulnerability class. This leads to a fourfold reduction in our sample size, from 280 observations (deciles x classes x years) to 70 (deciles x years). The precision of our estimate, which evolves by construction as the square of the sample size, was thus divided by two. On the other hand, the estimate for the new vehicles item, also carried out at the level of the deciles without distinction of class because of results that are not admissible by keeping the classes, is on the other hand strong despite the reduction of the sample size. Its income and price elasticities (1.95 and -1.39) are both significant at 1% with a Student t-stat of 11.9 and -3.37 respectively.

Overall, income elasticities are generally more significant than price elasticities. This can be explained by the nature of the data on which we have based our estimates. Indeed, in budget surveys, expenditure is well observed but the real prices faced by households are hardly ever observed except for a few large purchases or pre-committed expenses. It should be remembered that we had to reconstruct prices for each item specific to each household from national price indices and that these national indices, although used at the finest possible level of nomenclature, reflect macroeconomic developments that are potentially far removed from the prices that households actually face.

5.3) Comparison with literature

This section is devoted to a comparison of the estimated elasticities with those of various previous studies. We do not claim to be exhaustive, but more reasonably to provide a useful overview for the reader. Wherever possible, we favor studies related to the energy field that are closely or remotely related to the overall issues of this study. Similarly, we favor recent studies (less than 10 years old) that are around the reference date of our estimates, i.e. around 2010. This overview is deliberately brief so that the reader can get a general idea of our results from this literature.

The focus on the energy literature makes it necessary to retain above all the references that propose estimates of household behavior using elasticities estimated on various types of data. The articles and studies from which the comparative results are drawn therefore use a variety of methods and data sources whose common

feature is the use of statistical methods to estimate household price and income elasticities.

The variety of sources we consulted precludes a single presentation in a summary table, for example. The articles consulted have widely varying motivations, objectives and methods. We mention only the broad outlines of their results.

First, we distinguish between generalist studies that deal with the totality of household consumption. We then distinguish energy-specific studies which generally distinguish household energy from fuel with a varying level of detail by household group.

In the first group of studies we find the article by Gardes (2014) which establishes the link between uses of time and household consumption on the basis of BDF 2001 and the 1999 use of time survey. The income and price elasticities for housing and transport are respectively 1.02 and -0.93 for housing, 1.02 and -0.47 for transport. If the income elasticities of this study are around 1.0, leisure appears to have low elasticities with 0.92 for income and -0.31 for prices, i.e. roughly the same elasticity as food: 0.77 and -0.35, while other goods are at 1.08 and -0.66. Complementarity over time explains why housing and transport have higher absolute price elasticities than food, especially in the case of housing: -0.93, twice as high for transport and three times as high for recreation. Also in this same group of studies, Gardes and Starzec (2014) look at income elasticities alone, again using data from the BDF 2001 and Time Use 1999 surveys. The income elasticities thus estimated as a function of the time incorporated in consumption are 0.92 for food, 0.74 for housing, 0.72 for clothing, 1.19 for transportation, 1.17 for recreation and 1.04 for other expenditures. The magnitudes of these elasticities appear to be more long-term based on the interpretation of single cross-sections without taking into account dynamic effects. Higher elasticities are found for the most time-consuming activities: recreation and transportation.

A second group of studies covers those concerned with energy demand in terms of behaviour, technologies and public regulatory policies. The literature on data specific to France is relatively limited. The paper by Damette et al (2018) proposes estimates of the sensitivity of household energy consumption to climate transition policies in order to quantify the incentive regime to change energy equipment. The data come from an ADEME survey on the TNS-Sofres panel. An equipment change model is estimated for four domestic energy sources. The estimated elasticities are respectively for income and price, 0.03 and -2.39 for wood, 0.03 and -1.33 for electricity, and 0.04 and -1.23 for gas. These elasticities are difficult to reconcile with the other results and seem both too low for income and very high for prices. However, they are interesting in that price elasticities are higher when considering equipment changes that take place over a longer time horizon. We note the important difference between the first study and the second, which underlines the importance of the method and the framework adopted in the final results.

In the second group of studies specific to energy, we find the fuel study by Calvet and Marical (2011), one of the most complete on French data to date. This study is closest to ours because of the similarity of the data sources since the authors use

data from successive BDF surveys from 1984 to 2006 to trace the evolution of the factors determining household fuel consumption. The methodology adopted differs in the definition of the data. Calvet and Marical constructed pseudo-panels of households while we constructed decile cells by typology class by summing successive BDF cuts from 1979 to 2011. The generation pseudo-panel model gives the following fuel price elasticities for three different specifications. For the price and expenditures specification -0.39; for price, expenditure and number of assets -0.57; for prices, expenditures, assets and age of the reference person -0.62. For the same pseudo panel, the elasticities by groups of deciles of standard of living are: -0.64 for D1-D3, -0.68 for D4-D7 and -0.65 for D8-D10. There is no significant effect of standard of living on the price elasticity of fuel consumption. The elasticities by location are -0.78 for rural and suburban and -0.74 for households in central and suburban cities, respectively. Here again, there is no significant effect of location. In fact the contrast is highly dependent on the specification. The pseudo panel by age group of the head of household gives similar results but much higher elasticities. In fact, according to the expenditure and price specification we obtain -0.59; for the expenditure, price and number of assets specification -0.69. The price elasticities by decile groups are for this same pseudo-panel by generating -0.83 for D1-D3, -0.84 for D4-D7 and -0.73 for D8-D10. Similarly, by locality we obtain -0.91 for rural and suburban dwellers against -0.93 for households in central cities and suburbs. The results vary much more between definitions of the pseudo-panel and the choice of explanatory variables than between groups of categories for which price elasticities are calculated.

An INSEE[4] working paper by Calvet and Marcus (2009) provides estimates for households in France using various methods and data types, distinguishing between fuels and domestic energy. Time series estimates allow to clearly specifying long and short term effects. The elasticities according to the horizon are therefore for household energy 1.72 for income and -0.06 for short-term price, compared to 0.42 and -0.19 for fuel; these same elasticities are for the long term 0.42 and -0.17 for household energy compared to 0.41 and -0.40 for fuel. The cross-sectional estimate based on BDF 2006 data gives the following price elasticities for some items: -0.43 for food, -0.70 for fuel and -2.53 for recreation. The same estimation with a reduced number of variables gives respectively: -0.36 for food, -0.98 for fuel and -3.12 for recreation. Here again, we see the importance of the specification in explaining the differences in results. Note the very large difference with the time-series estimate for fuel: -0.19 in the short term versus -0.40 in the long term versus -0.40 to -0.98 in cross-section according to the specification: a difference of 1 to 5 times between short term and long term and 1 to 2 times in cross-section according to the specification for elasticity with unknown horizon.

The paper presented by Calvet and Marcus (2009) provides estimates using cross-sectional data (BDF 2006) relate to the price elasticity of fuel consumption according to specific categories. Households using their personal vehicle for commuting have a fuel price elasticity of -0.80; the rural/urban distinction for these same households gives respectively -0.68 for rural and -0.85 for urban; on the other hand, households

[4] Institut National de la Statistique et des Etudes Economiques : the french statistical office.

that do not use their personal vehicle for commuting have an elasticity of -1.51; finally, modest households (D1-D3) have a fuel price elasticity of -1.04 against -0.93 for the better-off (D8-D10).

The article by Lampin et al (2013) estimates the price and income elasticities of household fuel consumption and their interactions with the price of housing over long time series. Using the same specification as Calvet and Marcus (2009), the authors find 0.78 in the short run for income and prices and -0.20 and 1.21 and -0.26 in the long run. When they add the effect of old house prices on their specification, the elasticities change to 0.90 and -0.19 in the short run, 0.99 and 0.20 in the long run.

We close this brief literature review by discussing the most up to date study by Thomas Douenne on carbon taxation in France (Douenne, 2018). This study attempts to estimate a complete QAIDS-type demand system (Douenne, 2018, Calvet and Marical, 2011, Calvet and Marcus, 2009, Garde, 2014). The author has matched the 2008 national transport and travel survey (ENTD, 2008) to better reflect the expenditure of 2010 BDF households whose trips are very unrepresentative of actual trips. This pairing made it possible to calculate kilometers travelled and therefore fuel and vehicle use expenditure closer to reality. The elasticities finally estimated are presented per decile and per locality of residence of households. The expenditure-weighted average for all deciles and localities combined in BDF 2010 gives -0.17 for household energy and -0.45 for fuels. The following table reproduces the same calculation of decile-weighted elasticities at the national level.

Table 4: Price elasticities by deciles from Douenne (2018)

Expenditure/Decile	D01	D02	D03	D04	D05	D06	D07	D08	D09	D10
Domestic energy	-0.29	-0.31	-0.28	-0.25	-0.24	-0.20	-0.16	-0.12	-0.05	0.02
Gasoline	-0.55	-0.54	-0.52	-0.51	-0.50	-0.48	-0.46	-0.43	-0.40	-0.30

Source : Douenne, (2018), note IPP n° 34, computations by Cired.

The results can be directly compared with the table that summarizes our decile elasticities. At the end of this section, we can only note the wide variety of elasticity estimates and the difficulty of comparing the results of studies with always slightly different perimeters. This observation reinforces our initial choice to produce demand econometrics specific to the needs of our study.

6) Discussion of estimation results

This last section recalls and comments on the difficulties encountered in achieving our results. We hope that it allows us to measure the extent of the work carried out and its scope. The difficulties we encountered are mainly threefold. The first is the availability of data. The second difficulty is related to nomenclatures, in other words,

to the organization and harmonization of data. The third order relates to empirical methods and estimation constraints.

The empirical framework of this research is innovative in that we articulate three distinct fields of empirical research: factorial analysis of multidimensional data (PCA and typology), standard econometrics (estimates of the price and income elasticities of 2010 BDF households) and finally modelling by numerical simulation in a framework that is itself very specific since it involves a dialogue between two hybrid macroeconomic/energy models - ADEME's ThreeME model and a declination of Cired's IMACLIM-S France model, IMACLIM-3ME - and a micro-economic database where micro-simulation takes place. Thus stated, this empirical framework is unprecedented, so it is natural to encounter some difficulties in implementing a harmonized treatment chain.

The availability of data was not the slightest obstacle, but proved to be simpler than initially envisioned. The difficulties encountered take two main forms. The first is the availability of data from INSEE's family budget surveys. It was initially envisaged to use data from BDF 2015 but this was not available at the beginning of the study, so we had to use data from 1979 to 2010. The other problematic data sources are more related to housing and energy. These are the PHEBUS data, the Housing and Transport data through the ENTD and Housing 2016 surveys. These sources are very different from BDF, so we had to give up full matching, which proved too complex to carry out. We chose simpler reweighting treatments by rescaling in the microsimulation module that interfaces between the BDF, PHEBUS, ENTD and Housing databases. This is the preparatory phase of the data that will then be sent to the IMACLIM model to produce the simulations of the redistributive effects of the SNBC measurement clusters. This satisfactory and simpler method has the merit of transparency, but above all it has allowed us to produce a marginal calibration reweighting script that works perfectly and in which we can include an indefinite number of variables for rescaling the weights.

The second difficulty relates to the nomenclatures in which the results will be produced. This is a non-trivial problem which must be subject to sometimes very delicate trade-offs. Indeed, the starting point is the COICOP consumption nomenclature in which INSEE's BDF data are disseminated. While this is immediately accessible and very familiar to any expert in the field of consumption, in order to ensure the best possible dialogue between the databases where micro-simulation takes place and the ThreeME and IMACLIM-3ME models, it is advisable to find a fairly accurate common nomenclature. We were able to define such a base after a detailed examination of our 2010 COICOP nomenclatures harmonized in the ThreeME base in which we present the econometric estimates. It was necessary to add to this nomenclature an item that is absent from the macroeconomic models: used vehicle sales between households. In addition to this, the calculations of energy consumption in the 2010 BDFE database inherited from Simona De Lauretis' thesis (De Lauretis, 2017) are also included. Several round trips and numerous adjustments that would take too long to detail were necessary to arrive at the data used for the estimate.

In the meantime, we may add that factorial analysis in its broadest sense, i.e. the PCA and typology steps, are relatively disconnected from the other steps: this is why they were the first steps of the study launched while the data and simulation scripts were being prepared. The main difficulty of the statistical stage was the preparation of the empirical data for estimation since this estimation had to be conducted in a common BDF-IMACLIM-ThreeME nomenclature. Estimates were therefore made according to this nomenclature. We had initially envisaged an EASI demand system, but this proved impossible for practical and empirical reasons. The estimation script has been removed from the R packages and this formalism is of an unclear economic interpretation but more importantly very far away from the representations of household consumption in IMACLIM and ThreeME models. Assuming that it would have been possible to estimate such a demand system on our data, the results would have been very difficult to use in the simulation models, leading to unnecessary complications. We therefore decided to use the simpler and clearer formalism of the Engel curves on the data of the nomenclature presented above. We were not able to estimate it in system but we ensure the overall loop in the 'macro-micro' simulation step, which guarantees an overall consistency in the representation of consumption behaviors.

7) Conclusion and perspectives

The present paper presented the estimation of Engel curves in the framework of a broader modelling effort articulating two macroeconomic models with a microsimulation module developed to assess the redistributive impacts of the French Low Carbon Strategy package of measures on standard of living deciles.

This work mobilized substantial efforts for data harmonization before estimation. The crucial steps were to define a common nomenclature of consumption in order to capture key phenomena in both models and the computation of a pseudopanel database for estimation.

Once these step conducted the estimation was done with a weighted IV estimator on an equation by equation basis because system estimation was not feasible with the data.

Elasticities were computed for each good and price at the year 2010 and then handed to the microsimulation and macroeconomic modules for simulation of the redistributive impacts.

The project opens many possible improvements that could be performed in the following years. First, we can add the last year of the BDF survey, 2015 which could be the easiest step. Second, we could refine our databases and redo the estimates. Third we can also search for system estimation and Fourth improve the results with full database matching with the other surveys in order to obtain more accurate figures for some key variables that are not well measures in the BDF surveys.

This paper has a companion paper presenting the whole process of PCA and typology that was used to construct the pseudopanels.

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Annex 1: detailed estimation results.

The table on the following page reproduces the estimated values of the elasticities for each of the 40 cells and 14 items of the selected nomenclature, calculated from the expressions of the elasticities presented in the previous Annex.

For fuels other than gas, new vehicles and rents, the estimation with class distinction produced aberrant results, due in particular to the typology of the classes, which tends to discriminate between fuel oil non-consumers (majority in classes 1 and 2, very urban), households not paying rent (owners over-represented in classes 3 and 4) and households unlikely to purchase new vehicles (class 2 of pensioners isolated poor tenants in large cities). We produced an estimate per decile without distinction of class (3 grey columns in the table).

Table 3 : Detailed estimation results by class of typology decile in 2010

Décile	Classe	Poids ménages	Alimentation		Électricité		Gaz		Combustibles		Construction		Véhicules neufs		Carburants		Transp. air & rail		Transp. route & eau		Loisirs		Autres services		Autres produits		Loyers		Véhicules d'occasion	
			Revenu	Prix	Revenu	Prix	Revenu	Prix	Revenu	Prix	Revenu	Prix	Revenu	Prix	Revenu	Prix	Revenu	Prix	Revenu	Prix	Revenu	Prix	Revenu	Prix	Revenu	Prix	Revenu	Prix	Revenu	Prix
1	1	730 389	0.28	-0.17	0.46	-0.70	1.35	-0.21	0.86	-0.43	1.86	-0.67	2.49	-2.15	0.69	-0.37	1.31	-0.17	1.39	-0.68	1.58	-0.34	1.15	-0.43	1.39	-0.56	0.56	-0.73	1.93	-0.54
1	2	916 785	0.42	-0.16	0.57	-0.57	1.29	-0.17	0.86	-0.43	2.07	-0.82	2.49	-2.15	0.69	-0.37	1.38	-0.19	1.45	-0.78	1.80	-0.37	1.15	-0.43	1.44	-0.59	0.56	-0.73	1.99	-0.55
1	3	449 982	0.45	-0.16	0.61	-0.51	1.46	-0.26	0.86	-0.43	1.26	-0.26	2.49	-2.15	0.82	-0.24	1.44	-0.22	1.54	-0.94	1.52	-0.33	1.13	-0.43	1.37	-0.55	0.56	-0.73	3.23	-0.97
1	4	678 380	0.51	-0.16	0.67	-0.43	1.27	-0.17	0.86	-0.43	1.27	-0.26	2.49	-2.15	0.77	-0.29	1.56	-0.27	1.57	-0.98	1.79	-0.37	1.12	-0.43	1.43	-0.59	0.56	-0.73	2.91	-0.86
2	1	674 630	0.28	-0.17	0.44	-0.72	1.32	-0.19	0.88	-0.39	1.55	-0.45	2.33	-1.93	0.78	-0.28	1.45	-0.22	1.50	-0.87	1.54	-0.33	1.15	-0.43	1.36	-0.55	0.55	-0.75	1.96	-0.55
2	2	746 170	0.45	-0.16	0.59	-0.54	1.25	-0.16	0.88	-0.39	1.56	-0.45	2.33	-1.93	0.71	-0.35	1.55	-0.27	1.63	-1.10	1.86	-0.38	1.14	-0.43	1.44	-0.60	0.55	-0.75	2.35	-0.67
2	3	514	0.3	-0.1	0.5	-0.5	1.3	-0.2	0.8	-0.3	1.3	-0.3	2.3	-1.9	0.8	-0.2	1.5	-0.2	1.6	-1.0	1.5	-0.3	1.1	-0.4	1.3	-0.5	0.5	-0.7	2.1	-0.6

		691	9	6	5	9	3	0	8	9	4	1	3	3	2	4	3	6	1	5	2	3	4	3	5	4	5	5	7	1
2	4	843135	0.55	-0.17	0.70	-0.40	1.22	-0.14	0.88	-0.39	1.22	-0.24	2.33	-1.93	0.78	-0.27	2.38	-0.62	1.79	-1.37	2.04	-0.41	1.12	-0.44	1.46	-0.61	0.55	-0.75	3.96	-1.23
3	1	755579	0.26	-0.18	0.40	-0.78	1.30	-0.18	0.88	-0.38	1.61	-0.49	2.16	-1.68	0.79	-0.27	1.49	-0.24	1.54	-0.93	1.54	-0.33	1.16	-0.43	1.36	-0.55	0.52	-0.79	1.92	-0.53
3	2	741728	0.46	-0.16	0.61	-0.52	1.21	-0.13	0.88	-0.38	1.41	-0.35	2.16	-1.68	0.69	-0.37	1.75	-0.35	1.74	-1.28	1.92	-0.39	1.14	-0.43	1.43	-0.59	0.52	-0.79	2.23	-0.63
3	3	492969	0.41	-0.16	0.56	-0.57	1.33	-0.20	0.88	-0.38	1.29	-0.28	2.16	-1.68	0.83	-0.23	1.68	-0.32	1.75	-1.30	1.51	-0.33	1.14	-0.43	1.35	-0.54	0.52	-0.79	2.43	-0.69
3	4	791100	0.52	-0.16	0.69	-0.41	1.22	-0.14	0.88	-0.38	1.19	-0.23	2.16	-1.68	0.80	-0.26	3.95	-1.30	1.81	-1.39	1.91	-0.39	1.11	-0.44	1.44	-0.59	0.52	-0.79	4.44	-1.40
4	1	801944	0.23	-0.18	0.39	-0.79	1.30	-0.18	0.86	-0.44	1.55	-0.44	2.01	-1.47	0.78	-0.28	1.48	-0.23	1.54	-0.93	1.52	-0.33	1.16	-0.43	1.35	-0.54	0.50	-0.84	1.94	-0.54
4	2	541890	0.42	-0.16	0.58	-0.55	1.22	-0.14	0.86	-0.44	1.34	-0.31	2.01	-1.47	0.68	-0.38	1.70	-0.32	1.75	-1.30	1.77	-0.36	1.13	-0.43	1.41	-0.57	0.50	-0.84	2.46	-0.70
4	3	664224	0.37	-0.16	0.55	-0.59	1.36	-0.21	0.86	-0.44	1.25	-0.25	2.01	-1.47	0.84	-0.22	1.70	-0.33	1.70	-1.20	1.47	-0.33	1.14	-0.43	1.34	-0.54	0.50	-0.84	2.60	-0.75
4	4	769865	0.50	-0.1	0.67	-0.4	1.23	-0.1	0.86	-0.4	1.19	-0.2	2.01	-1.4	0.79	-0.2	2.73	-0.7	1.87	-1.5	1.80	-0.3	1.12	-0.4	1.42	-0.5	0.50	-0.8	4.97	-1.6

				6		4		4		4		3		7		7		6		0		7		4		8		4		0
5	1	863231	0.23	-0.18	0.40	-0.78	1.32	-0.19	0.85	-0.48	1.42	-0.36	1.93	-1.36	0.80	-0.26	1.50	-0.24	1.56	-0.97	1.49	-0.33	1.15	-0.43	1.34	-0.54	0.48	-0.87	2.05	-0.57
5	2	404432	0.39	-0.16	0.57	-0.56	1.22	-0.14	0.85	-0.48	1.30	-0.28	1.93	-1.36	0.67	-0.40	1.66	-0.31	1.69	-1.18	1.73	-0.36	1.13	-0.43	1.40	-0.57	0.48	-0.87	2.68	-0.78
5	3	729299	0.38	-0.16	0.56	-0.58	1.32	-0.19	0.85	-0.48	1.24	-0.25	1.93	-1.36	0.84	-0.22	1.77	-0.35	1.73	-1.26	1.47	-0.33	1.14	-0.43	1.33	-0.53	0.48	-0.87	2.42	-0.69
5	4	779257	0.50	-0.16	0.67	-0.44	1.21	-0.14	0.85	-0.48	1.19	-0.23	1.93	-1.36	0.79	-0.26	3.15	-0.95	1.92	-1.58	1.77	-0.36	1.12	-0.44	1.40	-0.57	0.48	-0.87	3.82	-1.18
6	1	844214	0.19	-0.19	0.37	-0.82	1.31	-0.19	0.82	-0.57	1.41	-0.35	1.85	-1.25	0.78	-0.27	1.48	-0.23	1.54	-0.94	1.48	-0.33	1.15	-0.43	1.34	-0.54	0.45	-0.92	2.01	-0.56
6	2	344876	0.35	-0.16	0.53	-0.61	1.21	-0.14	0.82	-0.57	1.32	-0.29	1.85	-1.25	0.60	-0.48	1.59	-0.28	1.72	-1.25	1.69	-0.35	1.13	-0.43	1.38	-0.56	0.45	-0.92	2.45	-0.70
6	3	935787	0.36	-0.16	0.54	-0.60	1.34	-0.20	0.82	-0.57	1.23	-0.24	1.85	-1.25	0.84	-0.22	1.71	-0.33	1.80	-1.39	1.45	-0.33	1.14	-0.43	1.32	-0.53	0.45	-0.92	2.56	-0.74
6	4	656682	0.47	-0.16	0.66	-0.45	1.22	-0.14	0.82	-0.57	1.18	-0.22	1.85	-1.25	0.79	-0.27	2.83	-0.81	1.88	-1.52	1.70	-0.35	1.11	-0.44	1.39	-0.56	0.45	-0.92	3.95	-1.22
7	1	789988	0.20	-0.1	0.36	-0.8	1.34	-0.2	0.78	-0.6	1.34	-0.3	1.78	-1.1	0.78	-0.2	1.48	-0.2	1.62	-1.0	1.46	-0.3	1.15	-0.4	1.33	-0.5	0.42	-0.9	2.36	-0.6

				9		3		0		9		1		5		8		4		8		3		3		3		7		7
7	2	307429	0.31	-0.177	0.51	-0.633	1.22	-0.144	0.78	-0.699	1.29	-0.288	1.78	-1.155	0.60	-0.477	1.55	-0.266	1.68	-1.177	1.63	-0.334	1.13	-0.433	1.37	-0.555	0.42	-0.977	2.55	-0.733
7	3	1057103	0.31	-0.177	0.50	-0.655	1.33	-0.199	0.78	-0.699	1.23	-0.255	1.78	-1.155	0.83	-0.233	1.66	-0.311	1.78	-1.355	1.43	-0.333	1.14	-0.433	1.31	-0.533	0.42	-0.977	2.44	-0.700
7	4	624436	0.41	-0.166	0.62	-0.499	1.22	-0.144	0.78	-0.699	1.17	-0.222	1.78	-1.155	0.77	-0.288	2.17	-0.533	1.85	-1.477	1.59	-0.334	1.11	-0.444	1.36	-0.555	0.42	-0.977	3.24	-0.977
8	1	757790	0.11	-0.211	0.28	-0.944	1.36	-0.211	0.73	-0.844	1.33	-0.300	1.72	-1.066	0.76	-0.300	1.42	-0.211	1.61	-1.066	1.42	-0.333	1.15	-0.433	1.32	-0.533	0.38	-1.044	2.38	-0.688
8	2	195065	0.22	-0.188	0.48	-0.688	1.23	-0.144	0.73	-0.844	1.24	-0.255	1.72	-1.066	0.66	-0.411	1.56	-0.277	1.62	-1.077	1.54	-0.333	1.12	-0.433	1.35	-0.544	0.38	-1.044	2.39	-0.688
8	3	1189286	0.27	-0.188	0.47	-0.699	1.35	-0.200	0.73	-0.844	1.22	-0.244	1.72	-1.066	0.82	-0.244	1.59	-0.288	1.81	-1.399	1.40	-0.333	1.14	-0.433	1.30	-0.522	0.38	-1.044	2.66	-0.777
8	4	635243	0.40	-0.166	0.61	-0.511	1.20	-0.133	0.73	-0.844	1.18	-0.222	1.72	-1.066	0.75	-0.311	2.16	-0.522	1.92	-1.599	1.59	-0.344	1.11	-0.444	1.35	-0.544	0.38	-1.044	2.78	-0.811
9	1	705865	0.03	-0.244	0.22	-1.011	1.38	-0.222	0.75	-0.788	1.28	-0.277	1.67	-0.999	0.76	-0.300	1.41	-0.211	1.63	-1.099	1.39	-0.333	1.14	-0.433	1.30	-0.522	0.33	-1.111	2.55	-0.733
9	2	249439	0.14	-0.2	0.43	-0.7	1.23	-0.1	0.75	-0.7	1.22	-0.2	1.67	-0.9	0.63	-0.4	1.52	-0.2	1.66	-1.1	1.48	-0.3	1.12	-0.4	1.32	-0.5	0.33	-1.1	2.47	-0.7

				0		4		4		8		4		9		4		5		3		3		3		3		1		1
9	3	1 139 896	0.25	-0.18	0.47	-0.69	1.35	-0.20	0.75	-0.78	1.20	-0.23	1.67	-0.99	0.82	-0.24	1.60	-0.29	1.81	-1.40	1.39	-0.33	1.13	-0.43	1.30	-0.52	0.33	-1.11	2.94	-0.87
9	4	683 337	0.29	-0.17	0.56	-0.57	1.21	-0.14	0.75	-0.78	1.18	-0.22	1.67	-0.99	0.74	-0.32	1.80	-0.37	1.68	-1.17	1.52	-0.33	1.11	-0.44	1.33	-0.53	0.33	-1.11	2.56	-0.74
10	1	691 933	-0.43	-0.39	-0.14	-1.49	1.48	-0.27	0.59	-1.25	1.21	-0.23	1.56	-0.83	0.73	-0.33	1.34	-0.18	1.59	-1.02	1.32	-0.34	1.14	-0.43	1.27	-0.51	0.18	-1.38	3.75	-1.15
10	2	247 684	-0.35	-0.36	0.24	-0.98	1.24	-0.15	0.59	-1.25	1.18	-0.22	1.56	-0.83	0.63	-0.44	1.43	-0.22	1.51	-0.88	1.39	-0.33	1.11	-0.44	1.29	-0.52	0.18	-1.38	2.31	-0.65
10	3	1 258 963	0.07	-0.22	0.34	-0.86	1.38	-0.22	0.59	-1.25	1.18	-0.22	1.56	-0.83	0.79	-0.27	1.46	-0.23	1.81	-1.40	1.34	-0.34	1.13	-0.43	1.28	-0.51	0.18	-1.38	3.22	-0.97
10	4	582 020	0.10	-0.21	0.48	-0.68	1.21	-0.14	0.59	-1.25	1.16	-0.22	1.56	-0.83	0.72	-0.34	1.64	-0.30	1.64	-1.12	1.43	-0.33	1.11	-0.44	1.30	-0.52	0.18	-1.38	2.32	-0.66

Lecture : les ménages du décile 1, classe 1, ont pour élasticités revenu et prix des produits agricoles 0,28 et -0.18 ; de l'électricité, 0,46 et -0.70 ; etc. Les élasticités grisées ont été estimées sans distinction de classe (voir ci-dessus).

Annex 2: Table of correspondence between COICOP 5 to ADEME 01 nomenclature

COICOP5	Coicop1	Micro	Libellé
c01111	c01	**A01**	Rice in all its forms and rice products
c01112	c01	**A01**	Bread and other bakery and pastry products (including biscuits, cakes)
c01113	c01	**A01**	Pasta in all its forms and pasta-based dishes
c01114	c01	**A01**	Preparations such as pastry dough, industrial cake, pie, quiche, pizza
c01115	c01	**A01**	Other cereals and cereal products (including flour, semolina, breakfast cereals)
c01121	c01	**A01**	Fresh or frozen beef and veal
c01122	c01	**A01**	Fresh or frozen pork meat
c01123	c01	**A01**	Fresh or frozen sheep or goat meat
c01124	c01	**A01**	Fresh or frozen poultry meat
c01125	c01	**A01**	Fresh or frozen salted or smoked cured meat
c01126	c01	**A01**	Canned meat, meat processing products, prepared meat dishes
c01127	c01	**A01**	Other fresh or frozen edible meat (horse, rabbit, game), including animals on leg
c01130	c01	**A01**	Fresh fish or WOI (without other indication)
c01131	c01	**A01**	Frozen or deep-frozen fish (excluding breaded or cooked fish)
c01132	c01	**A01**	Fresh or frozen seafood (including cooked, cooked not included)
c01133	c01	**A01**	Frozen salted, smoked and dried fish and seafood, including frozen fish and seafood
c01134	c01	**A01**	Canned fish and seafood or products of fish and seafood processing, prepared dishes
c01141	c01	**A01**	Whole milk
c01142	c01	**A01**	Semi-skimmed milk, skimmed
c01143	c01	**A01**	Canned milk

c01144	c01	**A01**	Yoghurts, cottage cheese and small swiss cheese and soy sauce
c01145	c01	**A01**	Cheese and curd
c01146	c01	**A01**	Other dairy products (milk-based desserts, fresh cream, flavoured milk)
c01147	c01	**A01**	Eggs
c01151	c01	**A01**	Butter
c01152	c01	**A01**	Margarine and other vegetable fats
c01153	c01	**A01**	Edible olive oils
c01154	c01	**A01**	Peanut, sunflower, corn, rapeseed and peanut edible oils
c01155	c01	**A01**	Lard and other fats of animal origin
c01161	c01	**A01**	Fresh citrus fruits
c01162	c01	**A01**	Fresh bananas
c01163	c01	**A01**	Apples
c01164	c01	**A01**	Pears
c01165	c01	**A01**	Fresh stone fruit
c01166	c01	**A01**	Fresh berries
c01167	c01	**A01**	Other fruits, fresh tropical fruits
c01168	c01	**A01**	Dried fruits
c01169	c01	**A01**	Fruits with sirrup or frozen fruits
c01171	c01	**A01**	Fresh leafy and stalked vegetables, herbs (fresh)
c01172	c01	**A01**	Fresh cabbage
c01173	c01	**A01**	Fresh vegetables grown for their fruit
c01174	c01	**A01**	Fresh food roots and fresh mushrooms
c01175	c01	**A01**	Dried vegetables
c01176	c01	**A01**	Uncooked frozen vegetables
c01177	c01	**A01**	Vegetables and vegetable-based dishes, canned and potato-free

c01178	c01	A01	Vegetables and vegetable-based dishes, fresh and frozen (except potato-based)
c01179	c01	A01	Potatoes, other tubers, potato products and tubers
c01181	c01	A01	Sugar
c01182	c01	A01	Jams, marmalade, compote, jellies, fruit purees and pastes, honey
c01183	c01	A01	Chocolate
c01184	c01	A01	Sweets, candies and other confections
c01185	c01	A01	Ice cream, sorbets and frozen desserts
c01186	c01	A01	Other sugar products
c01191	c01	A01	Sauces and condiments
c01192	c01	A01	Salt and dried spices
c01193	c01	A01	Yeast, dessert preparations, soups
c01194	c01	A01	Other food products
c01195	c01	A01	Food basket
c01211	c01	A01	Coffe
c01212	c01	A01	Tea and herbal teas
c01213	c01	A01	Cocoa and chocolate powder
c01221	c01	A01	Mineral waters
c01222	c01	A01	Gazeous beverages
c01223	c01	A01	Fruit and vegetable juices, syrups, flavoured drinks
c01224	c01	A01	Vegetable Juice
c01311	c01	A01	Other food expenses: ceremonies, stays away from home, person living away from home at least one day a week
c01312	c01	A01	Other food expenses: gifts from the household
c02111	c02	A01	Spirits and liqueurs
c02121	c02	A01	Wines and ciders
c02122	c02	A01	Other aperitifs based on wine, champagne and other

			sparkling wines, sake and others
c02131	c02	**A01**	Beer and beer-based drinks
c02211	c02	**A01**	Cigarettes
c02212	c02	**A01**	Cigars and cigarillos
c02213	c02	**A01**	Tobacco in other forms and related products
c02411	c02	**A01**	Other expenditure on alcoholic beverages, tobacco and drugs: gifts offered
c09321	c09	**A01**	Horticulture
c09331	c09	**A01**	Pets, pet food, pet products and accessories
c09341	c09	**A01**	Feed for other animals
c04500	**c04**	A02	Electricity + gas bill (not separable)
c04511	**c04**	A02	Electricity bill
c04521	**c04**	A03	Gas bill
c04522	**c04**	A04	Purchases of butane, propane
c04531	**c04**	A04	Liquid fuels for the main residence: fuel oil, heating oil, petroleum
c04541	**c04**	A04	Solid fuel primary residence
c04551	**c04**	A04	District heating
c04552	**c04**	A04	Ice
c13411	c13	A05	Major maintenance and equipment work on the main residence
c13421	c13	A05	Major maintenance and equipment work on the secondary residence or AL
c07111	c07	A06	New car purchases
c07121	c07	A06	Purchases of new and used motorcycles
c07131	c07	A06	Purchases of new and used bicycles
c07141	c07	A06	Purchases of other new and used vehicles
c07221	c07	A07	Fuels, electricity, oils, lubricants...
c07311	c07	A08	Local passenger transport services (metro tram) and long-distance SNCF railway services including

			associated services
c07331	c07	A08	Passenger transport services by air (including transport of luggage and vehicles)
c07351	c07	A08	Combined passenger transport services (navigo, train+bus tickets)
c07321	c07	A09	Passenger transport services by road including school busses
c07341	c07	A09	Transport services by sea and inland waterways (including transport of luggage and vehicles)
c07361	c07	A09	Other transportation services including moving
c09411	c09	A10	Sports and recreation services (sports shows, recreation participation, equipment rentals, recreation courses and fees, video game subscriptions, etc.))
c09421	c09	A10	Cinemas, theatres, concert halls
c09422	c09	A10	Museums, zoological gardens and the like
c09423	c09	A10	Television and broadcasting services (rental, licence fee, subscription)
c09424	c09	A10	Other recreational services (entertainers, photographers, animal services)
c09431	c09	A10	Games of chance (lottery, pinball...)
c09611	c09	A10	Package tours, weekends, excursions...yc school trip
c09711	c09	A10	Other leisure expenses: stays away from home, people living away from home at least one day a week
c09712	c09	A10	Other recreational expenses: gift given (to another household)
c11111	c11	A10	Restaurants
c11112	c11	A10	Coffee bars and similar (buffets, refreshment bars, tea rooms, fast food...)
c11121	c11	A10	Canteens
c11131	c11	A10	Other catering expenses: out-of-home stays, people living away from home at least one day a week
c11132	c11	A10	Other catering expenses: gift offered (to another household)

c11211	c11	A10	Hosting services
c03141	c03	A11	Cleaning, repair and rental of clothing
c03221	c03	A11	Shoe repair and rental
c04321	c04	A11	Maintenance services and small repairs in the housing unit
c04411	c04	A11	Garbage removal
c04421	c04	A11	Sanitation
c04431	c04	A11	Water bills main residence, other dwelling, outbuilding, land
c04441	c04	A11	Collective charges relating to housing (paid separately from rent or credit)
c04611	c04	A11	Other housing expenses: gift offered (to another household)
c05131	c05	A11	Furniture repair
c05331	c05	A11	Repair and maintenance of household appliances
c05621	c05	A11	Domestic services (cleaning, childcare, gardening...)
c05622	c05	A11	Other maintenance services for the dwelling (laundry, renting appliances, disinsectisation..., duplicate key)
c06211	c06	A11	Medical Services
c06221	c06	A11	Dentist, orthodontics
c06231	c06	A11	Medical Analytical Laboratory and Radiology Office Services
c06232	c06	A11	Services of medical auxiliaries (nurse, physiotherapist, laboratory...)
c06233	c06	A11	Extra-hospital services (ambulance, equipment hire)
c06311	c06	A11	Hospital services and care
c06411	c06	A11	Other health expenditures: people living away from home at least one day a week
c06412	c06	A11	Other health expenses: gift offered (to another household)
c07231	c07	A11	Repairs, troubleshooting, overhauls, washing,

			maintenance and technical control
c07241	c07	A11	Rental of premises, parking charges
c07242	c07	A11	Other services related to the use of personal vehicles (tolls, school car, car hire)
c07411	c07	A11	Other transportation expenses: ceremony, out-of-home stays, people living away from home at least one day a week
c07412	c07	A11	Other transportation expenses: gift offered (to another household)
c08141	c08	A11	Other communications and postal services expenses: gifts offered
c08111	c08	A11	Postal Services
c08131	c08	A11	Telephone, telegraph and facsimile services, internet, telephone refills
c09151	c09	A11	Repair of audio-visual, photographic and computer equipment and accessories
c09231	c09	A11	Repair and maintenance of durable goods for recreation, sport and culture
c10111	c10	A11	Kindergarten and primary education (schooling and literacy courses)
c10121	c10	A11	Secondary education (schooling and enrolment in secondary level courses)
c10141	c10	A11	Education not corresponding to any particular level (private tuition, correspondence courses)
c10131	c10	A11	Higher education and registration fees for competitive entrance exams to the grandes écoles
c10152	c10	A11	Other education expenses: gift (to another household)
c10151	c10	A11	Other educational expenses: persons living away from home at least one day a week
c12111	c12	A11	Hairdressing salons and body aesthetics (including spa treatments, tattoos, piercings)
c12411	c12	A11	Social welfare services (childminder, crèche, old people's home)

c12511	c12	A11	Life insurance, death
c12521	c12	A11	Housing insurances
c12531	c12	A11	Health insurances
c12541	c12	A11	Transport insurances
c12551	c12	A11	Other insurances
c12611	c12	A11	Financial Services
c12711	c12	A11	Other services (undertakers, legal services, cloakrooms, locker rooms, instructions, graphologists, delivery charges excluding meals, photocopies, small ads)
c03111	c03	A12	Fabrics for clothing
c03121	c03	A12	Men's clothing
c03122	c03	A12	Women's clothing
c03123	c03	A12	Children's clothing (3 to 13 years old)
c03131	c03	A12	Clothing accessories and haberdashery
c03211	c03	A12	Men's footwear
c03212	c03	A12	Women's shoes
c03213	c03	A12	Children's shoes (3 to 13 years old)
c03311	c03	A12	Other clothing expenses: ceremony, out-of-home stays, people living away from home at least one day a week
c03312	c03	A12	Other clothing expenses: gift given (to another household)
c04311	c04	A12	Products for routine housing maintenance and repairs (excluding major works)
c05110	c05	A12	Computer furniture
c05111	c05	A12	Bedroom furniture (bed, wardrobe, chest of drawers, bedside table, children's desks, bed base) excluding mattress.
c05112	c05	A12	Living room furniture (sideboard, sideboard, bookcase...)
c05113	c05	A12	Kitchen and bathroom furniture including built-in and non-built in units, stools, kitchen tables and chairs
c05114	c05	A12	Tables, seats, chairs outside kitchen and bathroom

c05115	c05	A12	Garden furniture (swing, table, armchair, garden shed, portico...) and camping furniture (table, seat, bed)
c05116	c05	A12	Other furniture, furniture accessories (including lighting, decoration, children's equipment), furniture installation
c05121	c05	A12	Carpets and other floor coverings (linoleum, carpets...), laying and repair of these articles
c05211	c05	A12	Bedding items (mattress, futon, pillow, duvet, blanket, sheet, draw sheet...)
c05212	c05	A12	Other textile household articles (upholstery fabric, curtains, household linen, toilet linen, other textiles) including repairs
c05311	c05	A12	Refrigerators, freezers and refrigerator-freezers, , wine cellar
c05312	c05	A12	Washing machine, dryer and dishwasher
c05313	c05	A12	Large Cooking Appliances
c05314	c05	A12	Heating and air-conditioning equipment
c05315	c05	A12	Cleaning devices
c05316	c05	A12	Sewing and knitting machine
c05317	c05	A12	Other Major Household Appliances
c05321	c05	A12	Small household appliances
c05411	c05	A12	Glass and crystalware, crockery, earthenware, stoneware, household or toilet articles...
c05412	c05	A12	Cutlery and silverware
c05413	c05	A12	Kitchen utensils and other household items
c05414	c05	A12	Repair and maintenance of glassware, crockery and other kitchen utensils
c05511	c05	A12	Large do-it-yourself tools
c05512	c05	A12	Large gardening tools
c05513	c05	A12	Repair of large tooling
c05521	c05	A12	Small tools and miscellaneous do-it-yourself accessories including small electrical equipment (extension cords, light bulbs, batteries, etc.).

c05522	c05	A12	Small tools and miscellaneous gardening tools and accessories, outdoor landscaping materials
c05523	c05	A12	Repair of small tools
c05611	c05	A12	Cleaning and maintenance products
c05612	c05	A12	Other household products (paper and plastic articles, brushes, miscellaneous products)
c05711	c05	A12	Other equipment expenses: people living away from home at least one day a week
c05712	c05	A12	Other equipment expenses: gift offered (to another household)
c06111	c06	A12	Pharmaceuticals for ingestion and treatment, food supplements, vitamins and minerals
c06112	c06	A12	Other pharmaceutical products
c06113	c06	A12	Therapeutic devices and materials (glasses, prostheses, etc.)
c07211	c07	A12	Spare parts and accessories (except those installed by a professional)
c08121	c08	A12	Purchase and repair of telephones, fax machines and accessories
c09111	c09	A12	Sound recording and reproducing receiving apparatus
c09112	c09	A12	TVs, home cinema, VCRs and DVD players for living rooms and laptops
c09121	c09	A12	Photographic and cinematographic equipment (including accessories)
c09122	c09	A12	Optical instruments
c09131	c09	A12	Microcomputers, computer hardware and accessories, consumables
c09141	c09	A12	Blank or recorded image and sound carriers
c09211	c09	A12	Musical instruments (excluding small instruments and accessories)
c09221	c09	A12	Musical instruments and accessories
c09222	c09	A12	Large equipment for indoor leisure activities

c09311	c09	A12	Toys and hobbies, including video games
c09312	c09	A12	Sports, camping and outdoor recreation equipment (fishing, hunting, special utensils and clothing, camping equipment)
c09511	c09	A12	Books including e-books
c09521	c09	A12	Newspapers and periodicals including subscriptions
c09531	c09	A12	Miscellaneous printed matter (postcards, business cards, posters, calendars, road maps, stickers...)
c09541	c09	A12	Stationery and drawing materials (including printer toner)
c12121	c12	A12	Electrical appliances for personal care
c12122	c12	A12	Other personal care items and products
c12311	c12	A12	Articles of jewellery and clocks and watches (including their repair)
c12321	c12	A12	Travel items containing personal effects
c12322	c12	A12	Other Personal Effects
c12331	c12	A12	Other goods and services: personal effects given as gifts
c04111	c04	A13	Tenants' rents and charges main residence
c04121	c04	A13	Rents and charges from tenants other residences
c12712	c12	A13	Deposit for housing accommodation
c07112	**c07**	**A14**	Purchasing used cars

Reading: COICOP level 5 code, COICOP level 1 code, ADEME nomenclature, full label of expenditure at COICOP5 level.

Annex 3: The PCA of the pseudo panel cells.

[detail of the phi(k) PCA in the regression equation here.]