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Habits, Complementarities and Heterogenenity in Alcohol and Tobacco Demand: A Multivariate Dynamic Model

by

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HABITS, COMPLEMENTARITIES AND HETEROGENEITY IN ALCOHOL AND TOBACCO DEMAND: A MULTIVARIATE DYNAMIC MODEL

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Abstract

In this paper we test the existence of rational habit formation in a multivariate model for alcohol and tobacco consumption. The theoretical framework, based on a dynamic adjustment cost model with forward-looking behaviour, is enhanced to include the intertemporal interactions between the two goods. The analysis of the within-period preferences completes the intertemporal model, allowing to evaluate the static substitutability/complementarity relationships. The empirical strategy consists in a two step estimation procedure. In the first stage, the parameters of the demand system are obtained, while in a second stage Euler equations are estimated by a dynamic fixed-effects panel data model. Estimation results, based on a cohort dataset constructed from a series of cross-sections of the ISTAT Italian Household Budget Survey, reveal a significant complementarity relationship between alcohol and tobacco. The Euler system estimation does not reject the hypothesis of intertemporal dependence, providing support for a forward-looking behaviour in alcohol and tobacco consumption. Moreover, we find significant intertemporal interactions for tobacco adjustments, while alcohol consumption seems to follow only its own adjustment dynamics.

J.E.L. classification: D12, D91, C33

Keywords: alcohol and tobacco consumption, cohort data, adjustment cost model, intertemporal interactions, GMM.

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1. Introduction

Habit formation processes have received increasing attention from academics and policy makers in the recent years. For cigarette consumption, this concern is particularly relevant since economic and public health policies that have aimed at increasing prices have often been proved to be ineffective in reducing tobacco consumption (Jiménez-Martín and Labeaga 1994), revealing that habits and addiction, rather than economic factors, are the main determinants of smoking behaviour (Fanelli and Mazzocchi 2004). Moreover, in order to efficiently design public policies it may be not adequate to consider the use of addictive goods separately, but substitutability/complementarity relationships should be considered (Bask and Melkersson 2003, 2004; Pierani and Tiezzi 2005).

In the present paper our main interest is to model intertemporal alcohol and tobacco consumption behaviour in a extended framework, in which habit formation can also depend on the intertemporal interactions between the two goods. The analysis of intertemporal dynamics of alcohol and tobacco consumption is coupled with the estimation of the within-period preferences that allows us to evaluate the (static) substitutability/complementarity relationships.

The basic set-up of the framework presented in this paper is similar to that of Weissenberger (1986) and uses a dynamic adjustment cost model with forward-looking behaviour to investigate the consumption decisions of an optimizing agent. The disequilibrium model is specified by a conditional indirect utility function (Blundell e*t al.* 1994) to account for the significance of intertemporal dependence, in which the conditional influence of habits is extended to consider how habits affect preferences. The relevance of this theoretical framework in investigating the individual demand for addictive goods consists in the inclusion of the rational expectation hypothesis (REH) in a model of habit formation.

The theoretical framework adopted also allows to analyze intertemporal interactions among goods and is a straightforward generalization of Bask and Melkersson (2003, 2004) and Fanelli and Mazzocchi (2004) models. Unlike these works, that admit own or common habit forming between alcohol and tobacco, we model the possibility of obtaining asymmetric habit interactions between goods, including the previous specifications as special cases.

Our empirical strategy aims to addressed the problem of measurement error in estimating an intertemporal system of Euler equations that may arise from mismeasured heterogeneity, which is particularly severe when dealing with aggregate data (Heien and Durham 1991; Browning and Collado 2006). This suggest the relevance of using cohort data that controls for the effects of unobserved heterogeneity and still allows for dynamic specification as in aggregate data (Blundell *et al*. 1994; Jiménez-Martín *et al.* 1998; Labeaga 1999). Even though we do not identify heterogeneous preferences in the intertemporal framework, we indirectly recover their effects by the parameters of the demand system. In the within-period allocation process, the desired level of expenditure depends on a set of economic (prices and income), demographic and socio-economic variables, that have been these ones widely found to significantly affect consumption decisions.

A two step estimation procedure is followed in order to obtain the estimated parameters of an Almost Ideal (AI) demand system (Deaton and Muellbauer 1980), with demographic and socio-economic controls, and successively to estimate a second order cost of adjustment model for alcohol and tobacco (Fanelli and Mazzocchi 2004). In this study, we tackle both issues by estimating dynamic fixed-effects panel data models using appropriate Generalized Method of Moments (GMM) estimators that includes demographics and working status among the excluded set of instruments in order to addresses the attenuation bias.

The remainder of the paper is organized as follows. In Section 2, we define the theoretical framework to simultaneously account for habits, complementarities and heterogeneity in alcohol and tobacco demand. In Section 3, we describe the dataset, obtained by organizing in cohorts the household data taken from ISTAT Household Budget Survey for the period 1997-2003, and discuss estimation strategy and econometric identification. Section 4 presents the empirical results, while Section 5 offers some concluding remarks.

2. The Theoretical Model

Habits forming and multivariate intertemporal dependencies are determined by composite agent's behaviour, some of which are myopic reactions to past consumption levels and others rationally anticipate the expected future consequences of current actions (Alessie and Kapteyn 1991; Chaloupka 1991; Becker, Grossman and Murphy 1994; Baltagi and Griffin 2001). The issue of considering the future consequences of current consumption behaviour is commonly addressed in the context of an intertemporal utility maximization framework, following the rational addiction model proposed by Becker and Murphy (1988). This model assumes that agents choose an intertemporal consumption path to maximize expected utility and implies that consumption of addictive goods with negative health implications is still consistent with rational forward-looking behaviour. Suranovic *et al.* (1999) have proposed an economic theory for tobacco consumption that explicitly includes withdrawal effects in a rational addiction model by the adjustment cost approach. Re-interpreting adjacent complementarity in the Becker and Murphy model in term of withdrawal effects leads to have a negative impact on goods with habit formation if individuals with a past consumption stock attempts to reduce or to stop habitual consumption (Atkinson 1974).

In order to test rational habit formation in alcohol and tobacco consumption, in the present paper intertemporal consumption behaviour under uncertainty are obtained representing preferences by a conditional indirect utility function (Blundell *et al.* 1994). In particular, the within-period expenditure allocation is completely characterized by the indirect utility function $V(p,m)$, while intertemporal allocations are determined by the period-specific utility function $U = F[V(p,m)]$. Our approach in deriving habit consumption explicitly considers intertemporal dependencies in the demand of goods by means of the conditional indirect utility function:

$$U(p,z,m) = F[V(p,z,m),H] \qquad (1)$$

in which the conditional element H specifies how the influence of habits affects preferences. In (1) $V(\cdot)$ represents the indirect utility function that depends on prices (p), demographics (z) and total expenditure patterns (m), while $F(.)$ is a strictly increasing monotonic transformation such that U is a strictly concave function in m.

Model (1) has a conditional nature in that no attention is paid to the mechanism governing habit in the intratemporal allocation of expenditures. In fact, the presence of a dynamic dependence is included in the consumption function but not in the demand system, so that it is implicitly assumed that the chosen adjustment path does not influence the optimal level of the indirect utility function. In order to control for the empirical problem of "over-rationality" of agent's behaviour when rational addiction models are estimated on aggregate data (Auld and Grootendorst 2004; Baltagi and Geishecker 2006), demographic variables (z_1) are included to account for the heterogeneous patterns of the within-period expenditure allocation process. Thus, we can condition directly the desired level of demand and indirectly the parameters of the consumption function.

Coherently with the aim of the paper, we derive an estimable Euler equation system for alcohol and tobacco integrating the conditional framework with an adjustment cost model. The specification of $F(\cdot)$ follows closely the dynamic adjustment cost model with rational expectations behaviour proposed by Hansen and Sargent (1980) and then applied by Nickell (1984), Engsted and Haldrup (1994), Weissenberger (1986) and Fanelli (2002). More specifically, a quadratic cost of adjustment-disequilibrium framework for $F(.)$ is assumed. Let x_t^* be the target expenditure level for period *t* and assume that the consumer cannot instantaneously adjust his actual expenditure x_t to the target expenditure because convex utility costs are encountered by changing expenditure levels. In the context of alcohol and tobacco consumption, this is due to habit persistence and adjustment (or withdrawal) costs that may "lock-in" consumers to an unwanted pattern of behaviour, as suggested by Suranovic *et al*. (1999) and Jones (1999). The representative forward-looking consumer minimizes the expected value of a quadratic loss function:

$$F(t) = \lim_{T\to\infty} E_t \left\{ \sum_{\tau=0}^{T} \rho^{\tau} [(x_{t+\tau} - x_{t+\tau}^*)' \Omega_0 (x_{t+\tau} - x_{t+\tau}^*) + (x_{t+\tau} - x_{t+\tau-1})' \Omega_1 (x_{t+\tau} - x_{t+\tau-1})] \right\} \quad (2)$$

where $x_{t+\tau}$ is the expenditure vector to be determined, $x_{t+\tau}^*$ is the target expenditure vector for period $t+\tau$, ρ is the intertemporal discount factor, Ω_0 and Ω_1 are positive definite matrices of dimensions $n \times n$ and E_t is the conditional expectation operator at time *t*. The first quadratic form in (2) take into account the utility costs of not attaining the stochastic expenditure target x_t^*, while the second element evaluates the utility cost of adjusting the expenditure pattern of consumption.

In order to identify intratemporal and intertemporal conditions for evaluating households behaviours in alcohol and tobacco consumption, we separately specify the utility function $F(\cdot)$ and the indirect utility representation $V(\cdot)$.

In the first stage of the decision process, the representative consumer decides the desired expenditure allocation across goods. Consumer preferences are formulated in terms of the Almost Ideal demand model of Deaton and Muellbauer (1980). To define the model, we start by specifying the indirect utility representation of the within-period preferences as:

$$V_{ht}(x_{ht}, p_t) = \frac{\ln m_{ht} - \ln a_t}{b_t} \tag{3}$$

where $a_t = a(p_t)$ and $b_t = b(p_t)$ are price indexes defined as:

$$\ln a(p_t) = \alpha_0 + \sum_j \alpha_j \ln p_{jt} + \frac{1}{2}\sum_j \sum_s \ln p_{st} \ln p_{jt}$$

$$b(p_t) = \sum_j \beta_j \ln p_{jt}$$

Applying Roy's identity to (3) we obtain the demand equations in term of budget shares:

$$w_{iht}^* = \alpha_i + \sum_j \gamma_j \ln p_{jt} + \beta_i \ln(m_{ht}/a_t) + \mu_{iht} \qquad i = 1,...,n \ , \ t = 1,...,T \tag{4}$$

where w_{iht}^* is the desired level for the *i*-th expenditure share, p_{jt} is the price of good *j* at time *t* and m_{ht} represents total expenditure at time *t*.

Next, we turn to the identification condition for intertemporal behaviour under uncertainty by deriving the Euler equation for this problem. The first order necessary conditions for the minimization of the quadratic loss function (2) consist of a system of Euler equations and transversality conditions to be respected. The Euler equations, derived by differentiating the expenditure in budget share form (w_{iht}), can be written in matrix form as:

$$\rho E_{iht} \Delta w_{iht+1} - \Delta w_{iht} + \Omega(w_{iht} - w_{iht}^{*}) = \underset{n\times 1}{0} \qquad (5)$$

where $\Delta w_{iht} = w_{iht} - w_{iht-1}$ and $\Omega = \Omega_1^{-1}\Omega_0$ is assumed to be a non-symmetric matrix. It is worth noting that the Euler equation does not hold in the usual form since the optimal dynamic pattern depends on the intratemporal allocation condition.

The essential feature of this model is the reinterpretation of the framework of Houthakker and Taylor (1966) based on the "psychological stocks of habits". In this context, the term concerning the difference between observed and desired level of expenditure allocation ($\Omega(w_{iht} - w_{iht}^{*})$) represents the extent to which observed expenditure exceed the target level derived by model (5), since addiction, social interaction and other determinants may affect individual behaviour. It is worth noting that the Euler model represents how the pattern of consumer's habit evolves over time and withdrawal effects, represented by the parameters of the future budget shares adjustments, are the cost supported by the consumer to adjust expenditure levels, that arise from being locked-in to an unwanted pattern of behaviour (Jones 1999).

Coherently to the class of models with rational expectations, the specification (5) assumes the parameter ρ to be constant over time (Engsted and Haldrup 1994). This identification condition leads to a too restrictive dynamics, only allowing to test the significance of intratemporal demand adjustment by the parameters of the Ω matrix, but excluding the possibility to formally test agent's intertemporal rationality in tobacco and alcohol consumption.

For this reason, the quadratic loss function (2) is extended to consider a second-order adjustment cost. The intertemporal optimizing function embodies the quadratic form $\Delta^2 w_{iht+j}{}' \Omega_2 \Delta^2 w_{iht+j}$, in which the matrix Ω_2 is not assumed to be diagonal. With respect to the consumption equation (5), second order adjustments, own and interrelated dynamics enhance the modelization of intertemporal agent's behaviours in alcohol and tobacco consumption. The model thus represents a generalization of the works of Bask and Melkersson (2004) and Fanelli and Mazzocchi (2004) that allows to test for own habit forming and common and asymmetric habit interactions.

First order conditions, derived following Kozicki and Tinsley (1999) or Fanelli (2006a, 2006b), are given by the following system of *n* second-order Euler equations:

$$\begin{aligned} &\rho^2 \Omega_2 \mathrm{E}_t \Delta^2 w_{iht+2} - \rho(\Omega_1 + 2\Omega_2) \mathrm{E}_t \Delta w_{iht+1} + (\Omega_1 + 2\rho\Omega_2)\Delta w_{iht} \\ &\quad + \Omega_2 \Delta^2 w_{iht} + \Omega_0 (w_{iht} - w^*_{iht}) = \underset{n\times 1}{0} \end{aligned} \tag{6}$$

and a set of transversality conditions (see Kozicky and Tinsley (1999)). The class of exact rational expectation models considered in this paper can consistently account for the μ_{ih} term in the equations of the demand system since it is assumed that the stochastic specification represents optimization errors in the allocation of budget shares (Hansen and Sargent 1991). The adding-up theoretical property of the demand system implies that these errors sum to zero.

Rearranging the terms of system (6), the Euler equation system can be written as:

$$\begin{aligned} \mathrm{E}_t \Delta w_{iht+2} &= \rho^{-1}\Gamma_1 \mathrm{E}_t \Delta w_{iht+1} - \rho^{-2}\Gamma_2 \Delta w_{iht} \\ &\quad - \rho^{-2}\Delta w_{iht-1} - \rho^{-2}\Gamma_0 (w_{iht} - \tilde{w}_{iht}) + \eta_{iht} \end{aligned} \tag{7}$$

where $\tilde{w}_{iht}$ is the deterministic part of the desired level of household's budget shares w^*_{iht}, while $\eta_{iht} = \rho^{-2}\Gamma_0\mu_{iht}$. The non symmetric matrices Γ_0, Γ_1 and Γ_2 summarize the parameters derived from equation (7). In particular, $\Gamma_0 = \Omega_2^{-1}\Omega_0$, $\Gamma_1 = [\Omega_2^{-1}\Omega_1 + (2+\rho)I_n]$ and $\Gamma_2 = [\Omega_2^{-1}\Omega_1 + 2\rho I_m]$.

Given the fixed value for ρ and the invertibility assumption of matrix Γ_2, the estimation of the dynamic adjustment model (7) can be obtained by estimating the within-period expenditure allocation and by including the estimated preferences parameters in the system of Euler equations. It is worth noting that the relevance of correctly estimating the desired budget share level in the static demand system become evident by checking the equation (7). In fact, the parameters of interest affect the dynamic adjustments of the consumption functions through the conditional information on the demand system and the error term μ_{is}. Secondly, by means of the within-period parameters, we can consistently estimate the substitutability/complementarity effects between alcohol and tobacco consumption.

Thus, in the next empirical section cohort data, that explicitly allow to consider socio-economic conditions and demographic characteristic of the households, are used to address the estimation of the model and to simultaneously test for the presence of complementarities, rational habit formation and dynamic interactions between alcohol and tobacco consumption.

3. Econometric issues and estimation procedures

In this paper we explicitly consider the extent of intertemporal dependencies as the empirical consequence of the existence of habits in alcohol and tobacco consumption. The Euler equations derived account for the persistence of agent's behaviours and allows us to give empirical answer to the issue of intertemporal rationality of consumer choice. These objectives are addressed by means of synthetic cohort data constructed from a series of repeated cross-sections of the Italian Household Budget Survey. The use of cohort data allows to capture information on consumer heterogeneity and to address the empirical issue of "over-rationality" in models estimated on aggregate time-series data (Auld and Grootendorst 2004; Baltagi and Geishecker 2006). The unobserved individual heterogeneity, in fact, generates a positive correlation with habit effects, so that habit effects are likely to be overestimated when aggregate data are used (Heien and Durham 1991). From an econometric point of view, consistent estimations of the dynamic system (7) are obtained by a two step procedure, following Fanelli and Mazzocchi (2004). The estimated parameters of the intratemporal preferences that determine the demand system (4) are taken as given in the interrelated Euler equations, leading to test for rational habits and intertemporal interactions by imposing restrictions directly on the unknown parameters of the matrices that define the dynamic adjustment structure.

3.1. Data and descriptive analysis

Given the lack of genuine panel data on household consumption expenditure in Italy, in order to pursue the main objectives of our analysis we use a time series of repeated cross-sections. In particular, the data are extracted from a series of seven independent cross-sections of the Household Budget Survey (HBS), conducted by the Italian Central Statistics Office (ISTAT) for the period 1997-2003. Each cross section contains disaggregated data on monthly expenditure and detailed information on socio-demographic characteristics for about 25000 households, sampled out by means of a stratified random scheme. The ISTAT Survey provide no price or quantity information and consumption of each good or service is measured as reported expenditure. The expenditure information is a mixture of diary (for frequently purchased goods) and retrospective (for durable and semi-durable goods) information. Household alcohol and tobacco expenditures, as all expenditures on commonly used non durable goods, are monitored for a one-week period and then expressed on a monthly basis.

Starting from these cross-sectional microdata, we then construct a pseudo-panel using cohort averages to estimate the model discussed in the previous Section. Household are grouped into cohorts on the basis of the year of birth of the household's head, following the typical approach adopted in life-cycle consumption models (Deaton 1985; Browning *et al.* 1985; Deaton and Paxson 2000). As showed in Table 1, we define eleven groups by a 5-year band, except for the first and last cohorts where the age brackets are extended due to the small cell size. The choice of the interval that defines a cohort is arbitrary and clearly there is a trade-off between the number of cells and cell size (Gardes *et al.* 2005). In particular, on the one hand, it is desirable to group homogeneous households by choosing narrow intervals, while, on the other hand, having large-size cells reduces the sampling noise of the resulting pseudo-panel.

Table 1 – Cohort definition

Cohorts	Year of birth	Age in 1997	Number of households	Average cell size						
				1997	1998	1999	2000	2001	2002	2003
1	1967/1974	23-30	12097	80	92	106	137	160	204	230
2	1962/1966	31-35	15502	155	160	154	180	191	227	224
3	1957/1961	36-40	16678	188	180	178	195	197	221	231
4	1952/1956	41-45	17111	194	186	182	206	210	226	221
5	1947/1951	46-50	18156	210	202	198	214	211	237	241
6	1942/1946	51-55	16118	180	185	164	190	188	217	219
7	1937/1941	56-60	16708	190	177	174	202	193	228	229
8	1932/1936	61-65	15463	169	166	161	181	186	211	214
9	1927/1931	66-70	14702	167	161	156	177	174	191	200
10	1922/1926	71-75	11834	149	130	129	141	132	159	147
11	1914/1921	76-83	8985	119	111	97	103	100	109	110
Total	1914-1974	23-83	163354	164	159	154	175	177	203	206

We decide to exclude from the sample all the households whose head was born after 1974 and before 1914, limiting the attention to those with head aged 23-83 in 1997. The remaining 163354 household observations are then used to compute sample averages for each cohort and time period cell. In this respect, the large sample size enables us to define cells over monthly observations, without the need to gross up observations to the quarter or to the year. This increases the time dimension of the pseudo-panel and allows greater variability over time for the variables of interest in the analysis. A pseudo-panel sample containing 924 cell means, made up of eleven cohorts followed over 84 months (from January 1997 to December 2003), is thus obtained. The definition of five-years cohorts, together with the birth years and the size of each cell, are presented in Table 1. The average number of households in each cell is 176 and the size of all cells is sufficiently large to reduce the importance of measurement error (Deaton 1985; Verbeek and Nijman 1992, 1993) and remains stable over the survey years.

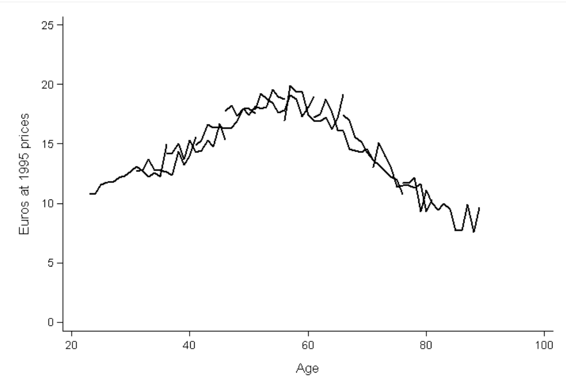
Prior to proceed to a formal analysis, we motivate descriptively the main purposes of the present study. Figure 1 plots the average alcohol and tobacco expenditure of each cohort against the age of household's head. Alcohol and tobacco consumption expenditures are expressed at 1995 constant prices, by deflating the original series by the retail price indexes of alcoholic beverages and tobacco published by ISTAT. In the figures, each connected line represents the consumption behaviour of a cohort over the years of observation. This representation permits some preliminary consideration about the presence of age and cohort effects (Kapteyn *et al.* 2003). The vertical difference between lines measures the cohort-time effect: differences between consumption levels of households observed at the same age but with different year of birth highlights the presence of generational (or cohort) effects. On the other hand, differences along the same line measure the age-time effects.

Figure 1.1 shows the life-cycle path of alcohol consumption, separately for all the households in the sample and for those with positive alcohol expenditure. As it can be noted, both the profiles are hump-shaped, with alcohol expenditures continuously rising over the first seven cohorts and peaking around age 60. The decline is not particularly sudden and average alcohol consumption remains quite high up to the oldest cohorts. Alcohol consumption appears to be higher among adjacent cohorts at the same age, suggesting the presence of positive cohort effects for almost all the cohorts. The age-effect is also significant: the young and middle-age cohorts display a notable growth in alcohol consumption as their age increases. Oldest cohorts, on the other hand, are characterized by a decline in alcohol expenditure, which is particularly evident from the eighth cohort onward.

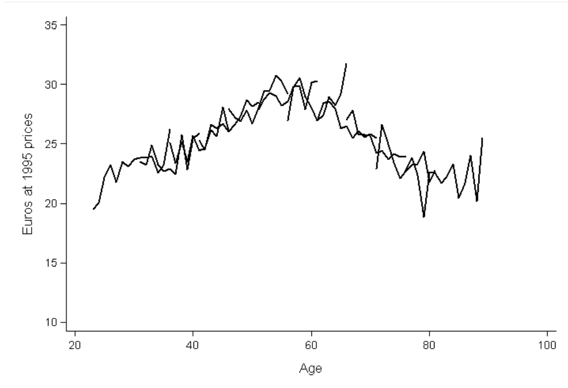
Figure 1 – Alcohol and tobacco expenditure by cohort and age

1) Alcohol

a) All households

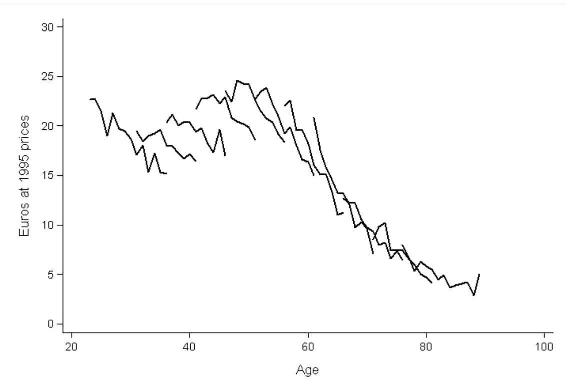


b) Consuming households

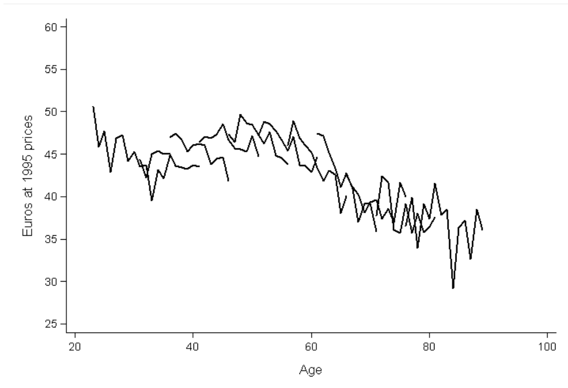


2) Tobacco

a) All households



b) Consuming households



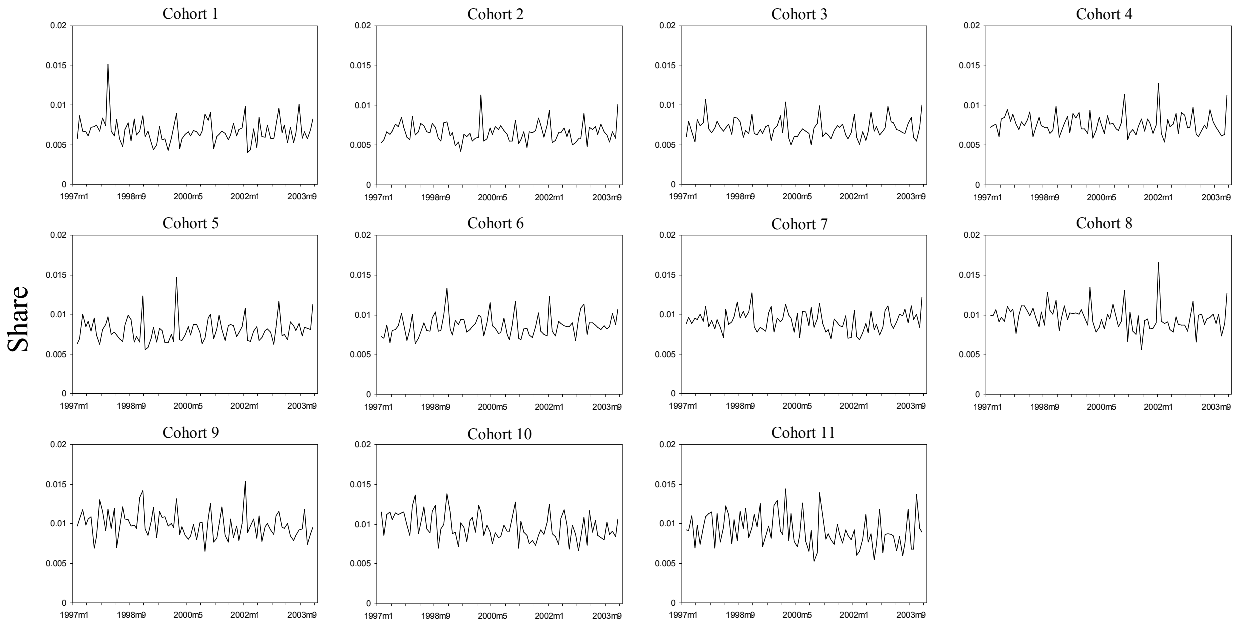
The pattern of tobacco consumption is represented in Figure 1.2. The life-cycle profile of tobacco expenditure is significantly different from that of alcohol. In this case, in fact, the level of tobacco consumption remains quite stable over the first five cohorts and then suddenly decreases in the last part of the life-cycle. Moreover, Figure 1.2.a shows the presence of positive cohort-time effects, with higher expenditures levels for successive cohorts observed at the same age. This pattern reveals a clear tendency of the youngest generations to reduce tobacco consumption. At the same time, an evident negative age-time effect can be picked out, reflecting the significant impact on smoking behaviour of age-related health problems.

The life-cycle patterns of alcohol and tobacco expenditures for the sub-samples of consuming households are not significantly different from those relative to the entire sample. Apart from being obviously higher, consumption levels remain quite stable among cohorts over the life-cycle. One feature that is worth underlining is that, for the older cohorts containing alcohol drinkers or smokers, expenditures displays much more variation than for the other cohorts. This can be partly explained by death attrition, since the cell size of older cohorts of smoking or alcohol drinking households is considerably smaller than the cell size of young or mid-age cohorts of consuming households (Jiménez-Martín *et al.* 1998).

The information on life-cycle patterns can be complemented by the analysis of the dynamics of alcohol and tobacco consumption and participation rate over the survey period. Figures 2 and 3 show the rate of participation and the budget share or alcohol and tobacco for each of the eleven cohorts over the 84 months of our sample. Inspection of the graphs highlights the existence of significant differences in the within-cohort patterns of tobacco and alcohol consumption, coherently with the previously discussed differences in the life-cycle profiles. The budget share devoted to alcohol (Figure 2.a), in fact, remains stable over the years covered by the survey for all the cohorts. However, the dynamics of alcohol expenditures is characterized by a substantial seasonality, with the budget shares peaking in the last month of every year due to the larger amount of wine and spirits bought during December seasonal holydays. The across-cohort pattern reveals that the share devoted to alcohol by young and mid-age cohorts is lower than that

Figure 2 – Alcohol consumption: per household budget share and participation rate by cohort

a) Budget share



b) Participation rate

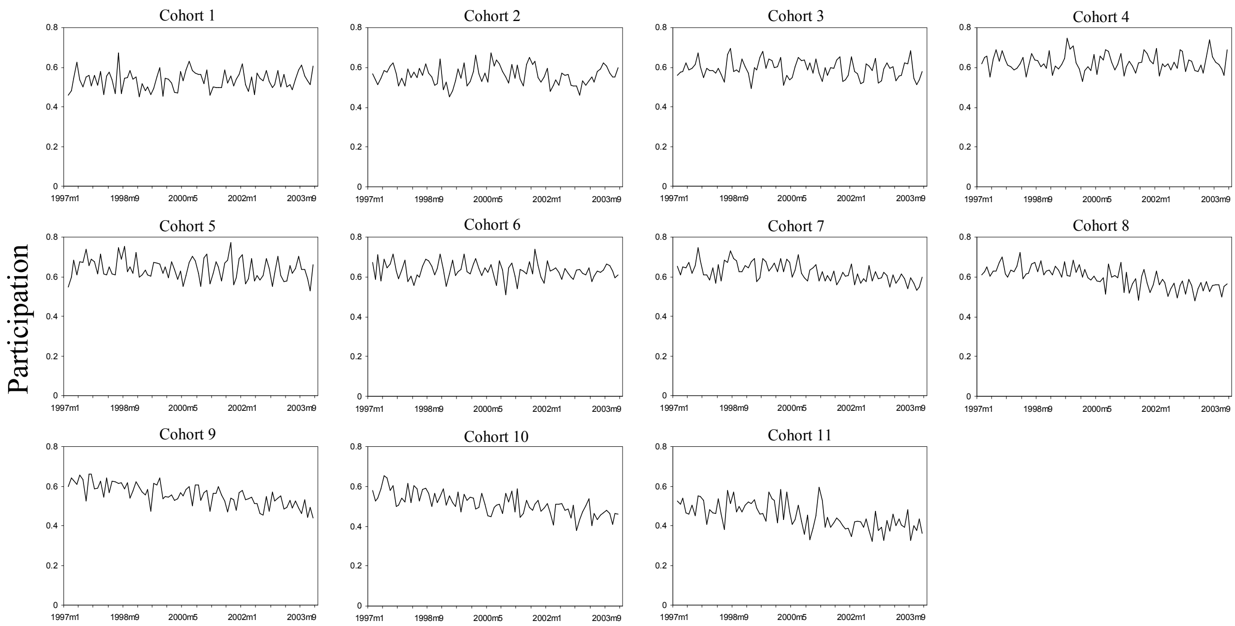
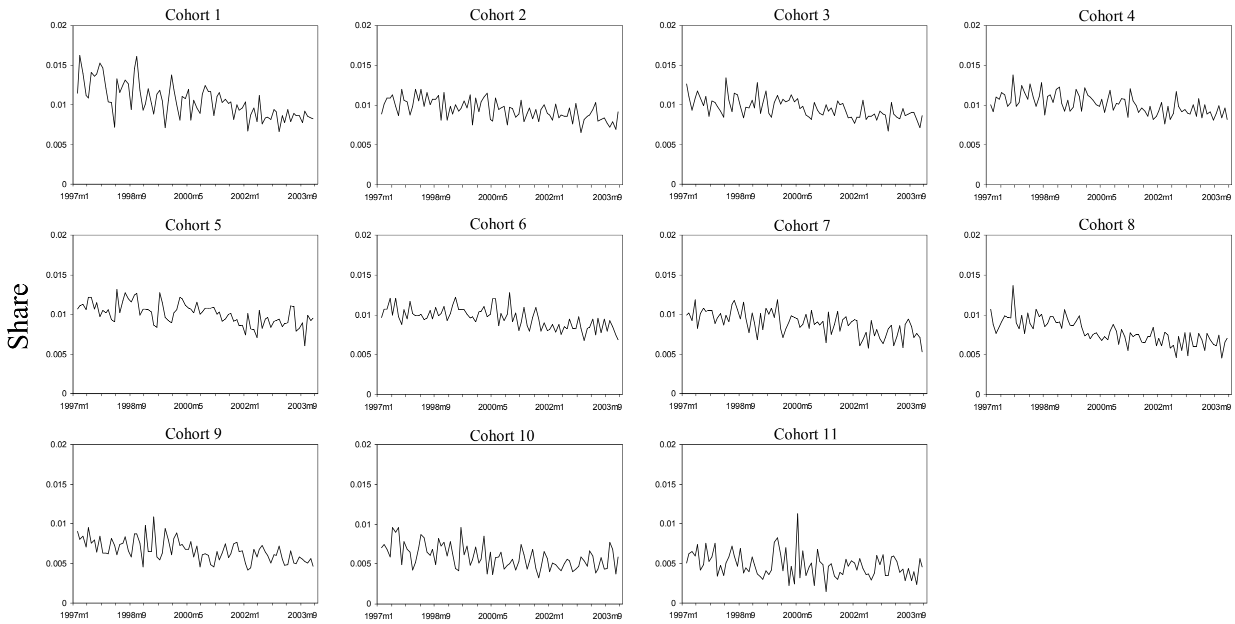
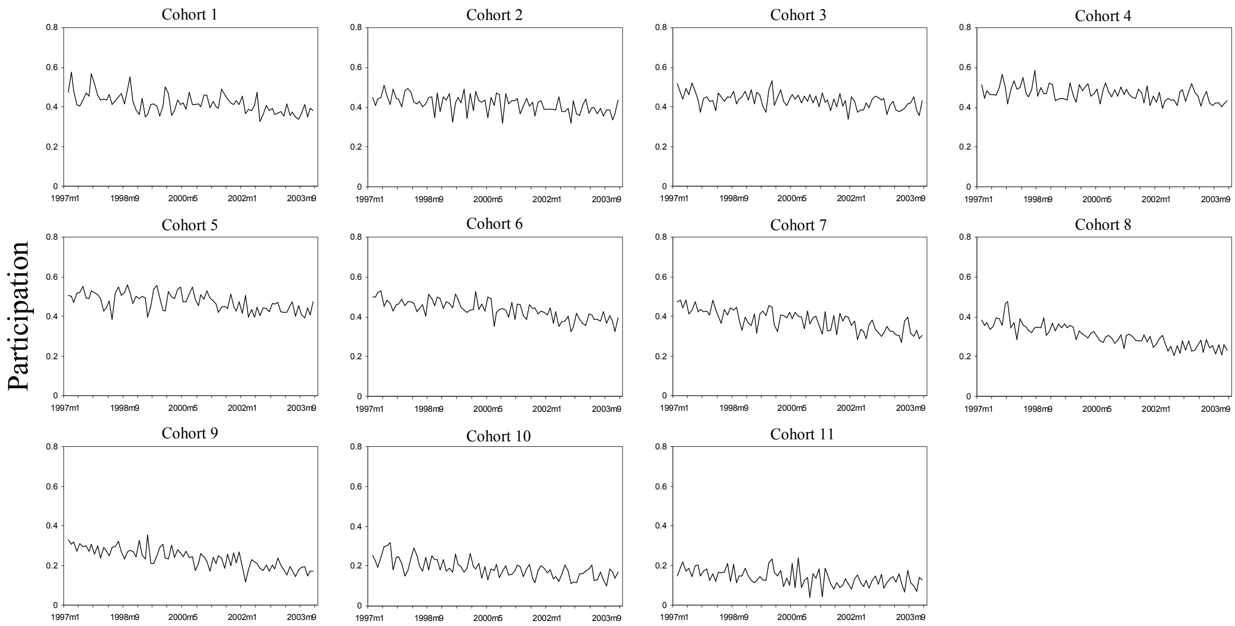


Figure 3 – Tobacco consumption: per household budget share and participation rate by cohort

a) Budget share



b) Participation rate



of old cohorts. Concerning the changes in participation rate over the sample period (Figure 2.b), the graphs suggest that older cohorts participate less to alcohol consumption and that for households in cohorts 8-11 (whose head is at least 61 in the first year of the sample and is therefore observed at the retirement age) there is a decline of in the rate of participation. Alcohol participation is stable over time for the remaining cohorts and is not affected by the same seasonal fluctuations of expenditure share, suggesting that there is not an increase of consuming households in December. The pattern of tobacco share and participation (Figures 3.a and 3.b) is characterized by a sharp decline both across and within-cohort. The rates of participation are high and slightly decreasing over time for young cohorts and they rapidly decline from the seventh cohort onward, passing from an average value of 0.5 in the first cohort to 0.15 in the eleventh. Part of the decline in participation rates in older cohorts can be due to the higher probability of death for smokers in the last part of the life-cycle (Jiménez-Martín *et al.* 1998). The dynamics of the budget share follows very closely the pattern of the rate of participation. Budget shares continuously decrease both across cohorts and over time, falling below 0.5 percent in the last cohort. Differently from alcohol consumption, no indication of seasonal fluctuations can be picked out.

The descriptive analysis of alcohol and tobacco dynamics is completed by the analysis of the budget share patterns for the sub-sample of consuming households presented in Figure A.1 in the Appendix. The analysis of the graphs reveals that the trend is basically the same pointed out for the entire sample. As previously discussed, the only difference is the higher variation over time for the two last cohorts, connected with the smaller cell size.

3.2. Specifying and estimating intratemporal preferences

The demand system (4) is flexible enough to allow consumer preferences to depend on individual (or household) characteristics. Therefore the parameters of the model can be thought as functions of demographics z_{it} and they can be rewritten as polynomials in z to make demographic effects explicit. In particular, we assume that they shift the intercept as:

$$\alpha_i = \alpha_i(z_{ht}) = \alpha_{i0} + \sum_k \delta_{ik} z_{kht} \tag{8}$$

Substituting (8) in model (4), we obtain:

$$w^*_{iht} = \alpha_{i0} + \sum_j \gamma_{ij} \ln p_{jt} + \beta_i \ln(m_{ht}/a_t) + \sum_k \delta_{ik} z_{kht} + \mu_{iht} \tag{9}$$

If the exact non-linear price index $a(p_t)$ is approximated by the Stone price index ($\ln P^*_t = \sum_j w_{jt} \ln p_{jt}$), system (9) is linear in the preference parameters and is derived under the assumption of intertemporal separability. In addition, to assure the consistency of the AI model to demand theory, the following parameter restrictions must hold:

$$\sum_i \alpha_{i0} = 1,\ \sum_i \gamma_{ij} = 0, \quad \sum_i \beta_i = 0, \quad \sum_i \delta_{ik} = 0 \tag{10}$$

$$\sum_j \gamma_{ij} = 0 \tag{11}$$

$$\gamma_{ij} = \gamma_{ji} \qquad \forall i, j \tag{12}$$

where (10) implies adding-up, (11) implies zero-degree homogeneity and (12) imposes Slutsky symmetry. Given the adding-up constraints, the demand system is singular by construction and one equation must be dropped from the system.

As discussed in Section 1, household data from the series of independent cross-sections of the HBS are grouped on the basis of the year of birth of the household's head to form a pseudo-panel with repeated observations on $N(=11)$ cohorts over $T(=84)$ periods. The grouping of household (i,t) into cells (C,t) over the sample period gives rise to the aggregated model:

$$\tilde{w}^{*}_{iCt} = \alpha_{i0} + \sum_{j} \gamma_{ij} \ln p_{jt} + \beta_i \ln(\tilde{x}_{Ct}/a_t) + \sum_{k} \delta_{ik} \tilde{z}_{kCt} + \tilde{\theta}_{Ct} + \tilde{\mu}_{iCt} \quad (13)$$

where $\tilde{w}^{*}_{iCt}$, $\tilde{x}_{Ct}$ and $\tilde{z}_{kCt}$ are averages of all the observed household-specific variables in cohort C at time t and $\tilde{\theta}_{Ct}$ denotes cohort fixed effects.

When dealing with cohort data, either in a static or a dynamic context, it should be considered that all the cohort variables are error ridden measurements of the true cohort population values. The main problem in estimating the demand system (13) with cohort data is that the cohort fixed effects $\tilde{\theta}_{Ct}$ is unobserved and is likely to be correlated with the explanatory variables of the demand system. This issue, as pointed out by Verbeek (1992), becomes particularly significant when the average cohort size and/or the time-series dimension are small. Deaton (1985) proposes an estimator that controls for the error-in-variables, which is consistent under fairly weak assumptions and ensures convergence of pseudo-panel estimates. However, Verbeek and Nijman (1992) showed that the bias that occurs in the standard fixed effects estimator when the individual effects and the explanatory variables in the model are correlated will tend to be negligible when both the cohort size and the number of available periods are sufficiently large. In particular, a cell size of about 100 individuals is proved to be sufficient to ignore the cohort nature of the data and to treat pseudo-panels as genuine panels. Thus, in our case, given that the cells defined are made up of more than 100 individuals for all the cohorts (with the only exception of cells relative to cohort 1 for the first months of 1997), the within-group estimator allow us to consistently retrieve the parameters of the static demand system (13).

The use of synthetic panels, however, does not completely eliminate concerns about non-random attrition, since we still have to rely on the assumption that the population from which the sample is drawn is homogeneous over time (Attanasio and Weber 1995). In order to check the presence of non-random attrition, following Jiménez-Martín *et al.* (1998), we have compared the demographic composition and the total expenditure levels of each cohort over time and found no significant differences. This indicates that attrition is not systematically related with the demographic structure of the households and should not be correlated with any unobservable characteristics that affect household consumption behaviour.

Another significant econometric issue in cohort-data analysis is that the aggregation of household observations introduces a systematic heteroscedasticity (Gardes *et al.* 2005) due to differences in cell sizes across cohorts and over time. In order to circumvent this problem, following the approach initially proposed by Deaton (1985) and then commonly adopted in empirical studies (Jiménez-Martín *et al.* 1998), we weight each observation by an heteroscedasticity factor ω_t that is proportional to the square root of the cell size. In particular, the weights are scaled to sum to the total number of observations $N \cdot T$, so that $\omega_t \equiv (N \cdot T)\sqrt{n_t} \Big/ \sum_t \sqrt{n_t}$.

3.3. Econometric specification of the system of Euler equations

The system of Euler equations defining alcohol and tobacco intertemporal consumption patterns is reformulated to be adapted to cohort data, so that heterogeneous households profiles can be considered. Household heterogeneity, included in the demand system by z_k, allows to control for changes in socio-economic condition and demographic structure of the household and reduce dynamic misspecifications.

In order to simplify notation, the dimension i of system (7) is omitted. The model is written for cohort means by using the expected value of the equations, conditional on cohort C and time period t. Thus:

$$E_t \Delta w_{Ct+2} = \rho^{-1}\Gamma_1 E_t \Delta w_{Ct+1} - \rho^{-2}\Gamma_2 \Delta w_{Ct} + \rho^{-2}\Delta w_{Ct-1} + \rho^{-2}\Gamma_0 (w_{Ct} - \tilde{w}_{Ct}) + \varepsilon_{Ct} \qquad (14)$$

where ε_{ct} is the cohort average of innovations. From a statistical point of view, the Euler equations system (14) generates a dynamic fixed-effect panel data model and implies the assumption of a rational expectations forecast error ε_{Ct} for testing rational habit formation.

The theoretical restrictions on the dynamics of the Euler equation expectation errors (14) are given by $E\varepsilon_{Ct+1} = 0$ and $E\varepsilon_{Ct+2} = 0$, so that we can decompose $\Delta w_{Ct+2} = E_t \Delta w_{Ct+2} + \varepsilon_{Ct+2}$, obtaining an estimable specification by lagging model (14) by two time periods:

$$\Delta w_{Ct} = \rho^{-1}\Gamma_1 \Delta w_{Ct-1} - \rho^{-2}\Gamma_2 \Delta w_{Ct-2} - \rho^{-2}\Delta w_{Ct-3} - \rho^{-2}\Gamma_0 (w_{Ct-2} - \tilde{w}_{Ct-2}) + \varepsilon^*_{Ct} \qquad (15)$$

where ε^*_{Ct} is the cohort average of innovations measured as $\varepsilon^*_{Ct} = \varepsilon_{Ct} - \rho^{-1}\Phi_1 \varepsilon_{Ct-1} + \eta_{Ct-2}$.

This definition of ε^*_{Ct} makes the Euler equation residuals follow an MA(2) process, so that ε^*_{Ct} will be correlated with most of the choice variables in the first-step regression, *i.e.* relative prices, and lagged budget share at time $t-1$ and $t-2$. As shown in Browning and Collado (2006), time aggregation could induce serial correlation and the error term can be correlated to the past values of prices and expenditures. It is worth noting that, even if in general the condition to consistently estimate the Euler system is that the chosen instruments are orthogonal to the residuals of the equations, in cohort data the autocorrelation of the error term ε^*_{Ct} that detects habit forming is controlled by the cohort fixed effect. However, residual autocorrelation may reflect the variation in heterogeneity (Browning and Collado 2006). In the intertemporal model (15) we cannot directly recover the heterogeneity of demographics and socio-economic status of the cohorts. However, the identification problem can be solved by using an appropriate set of instruments that includes demographics and working status variables.

The GMM estimation procedure employed implies a set of orthogonal conditions that reflect the presence of MA(2) residuals in the Euler system. Given the population moments, the orthogonality conditions can be written as:

$$\mathrm{E}\left[g(y_{Ct},\psi)\right]=0 \tag{16}$$

where y_{Ct} is a $p\times 1$ vector of observed variables for the cohorts at time *t*; ψ is a $q\times 1$ vector of unknown parameters to be estimated. Let *T* denotes the sample size for each cohort; the sample moments of $g(\cdot)$ can be then written as:

$$g_T(\psi)=\frac{1}{T}\sum_{t=1}^{T}g(y_t,\psi) \tag{17}$$

The GMM estimator determines an estimate that matches the sample moments $g_t(\psi)$ and the population moments given by (16). To solve this problem, Hansen (1982) suggests to define a distance function:

$$J_T(\psi)=\left[g_T(\psi)\right]' W_T\left[g_T(\psi)\right] \tag{18}$$

where W_T is a symmetric and positive definite weighting matrix. The GMM estimator is the value $\hat{\psi}$ that minimizes the $J_T(\psi)$ function. From this results, a consistent estimator of the variance-covariance matrix of $\hat{\psi}$ is:

$$Var(\widehat{\psi})=\frac{1}{T}(G_T)'W_T(G_T) \tag{19}$$

where $G_T=\partial g_T(\hat{\psi})/\partial\hat{\psi}$. In this paper, an optimal GMM estimator is obtained by choosing a weighting matrix W_T that allows to weight the covariance matrix of the estimator for period heteroscedasticity. Moreover, the additional assumption that the endogenous variables have a constant correlation with the cohort effects allows to identify the autocorrelation of the stochastic term. A GMM estimation in two-step is employed, as in Hansen and Singleton (1982). First, a sub-optimal weighting matrix is chosen to minimize $J_T(\psi)$ and hence a consistent estimator for $\hat{\psi}$ is obtained. The consistent estimator obtained in the first stage is then included in the definition of W_T, so that $J_T(\psi)$ is minimized. The over-identifying restrictions can be tested by means of the $J_T(\hat{\psi}) = \left[g_T(\hat{\psi})\right]' W_T \left[g_T(\hat{\psi})\right]$ statistic, which is distributed as a χ^2 with $q-p$ degrees of freedom.

In order to estimate the Euler equations (15), we model the set of orthogonality conditions (17) by using three or more lagged instruments (belonging to the information set at time $t-3$) for endogeneous variables, while demographic and socio-economic variables, together with seasonal and cohort dummies, are included to control for unobserved heterogeneity.

Finally, as it is generally difficult to estimate the intertemporal discount factor within this class of forward-looking model (Gregory *et al.* 1993; Engsted and Haldrup 1994, 1999), we follow the common practice of presetting it. Most studies find that variations in ρ do not significantly affect estimates of the other parameters. In particular, Engsted and Haldrup (1994) suggest that it is reasonable, with quarterly data, to prefix ρ within the range 0.95–0.99, while Johansen and Swensen (1999) propose grid search techniques in the estimation procedure. For fixed values of the intertemporal discount factor ρ, the system of Euler equations (15) is linear in parameters.

4. Estimation Results

The estimation of model (15) is based on a pseudo panel of $T = 84$ monthly observations of alcohol and tobacco expenditures for $T = 11$ cohorts of Italian households, observed over the period 1997(1)-2003(12). The system is estimated for two expenditure share equations, namely Alcohol (w_{1Ct}) and Tobacco (w_{2Ct}), while a third expenditure category ("Other Non Durables"), grouping all the remaining non-durable expenditures, is used as a numeraire and is excluded due to the implicit singularity entailed by the adding-up constraints (10). As highlighted in Section 1, data on monthly alcohol and tobacco expenditures by cohorts are obtained as cell averages of the household-level observations taken from the BHS. The survey does not provide any information on prices. The price series used to estimate the model will then correspond to the monthly Consumer Price Index (CPI) for alcoholic beverages (p_{1t}), tobacco (p_{2t}) and non-durable goods and services (p_{3t}). All price series are normalized to have sample mean equal to one.

The first step of the estimation procedure highlighted in the previous section consists in the estimation of the demand system (13) to retrieve the parameters of the within-period preferences. In order to estimate the parameters of the expenditure share system, we adopt a generalized method of moments (GMM) estimator. GMM estimation is used to account for the endogeneity of real total expenditure arising from potential measurement errors (Altonji and Siow 1987; Gardes *et al.* 2005) and from the fact that x_{ct} represents, by construction, the denominator of budget shares w_{iCt}.

In the estimation, the demand system (13) is re-parameterized in an equivalent but somewhat convenient way, by using prices relative to the numeraire equation, as in Ng (1995). We then obtain:

$$\tilde{w}^*_{iCt} = \alpha_{i0} + \sum_{j}^{n-1} \gamma_{ij} \ln \frac{p_{jt}}{p_{nt}} + \gamma^h_i \ln p_{nt} + \beta_i \ln(\tilde{m}_{Ct} / P^*_t) + \sum_k \delta_i \tilde{z}_{kCt} + \tilde{\theta}_{Ct} + \tilde{\mu}_{iCt} \quad (16)$$

where $\gamma^h_i = \sum_j^n \gamma_{ij}$ and p_{nt} is the price of the numeraire good ("Other Non-Durables"). The advantage of this formulation is that the homogeneity condition (12) corresponds to restriction $\gamma^h_i = 0$.

The existence of differentiated behavioural patterns across demographic groups is taken into account by introducing specific demographic controls. The socio-demographic variables considered, included in model (16) as intercept shifters, are described in Table A.1 in the Appendix and are intended to encompass the effects on expenditure allocation exerted by the household structure (*Nchild013*, *Nadults*, *Percmale* and *Single*) and socio-economic status (*Loweduc* and *Unemployed*).

Model (16) is estimated on a pseudo panel constructed by taking cohort averages computed on the whole sample of households. Given the low smoking participation rates for the oldest cohorts already highlighted in Section 1, there is a clear trade-off between cell size and sample selection. In particular, when the sub-sample of alcohol and tobacco consuming households is considered, the cell dimension becomes so small to prevent consistent parameter estimates to be obtained. In order to check the sensitivity of the estimates of the demand system to non participation and sample selection, we also estimate the model on the sub-sample of smokers (dropping those households with zero alcohol expenditure) and on the sub-sample of households with at least a positive expenditure on either alcohol or tobacco consumptions (dropping households with zero expenditure on both alcohol and tobacco). Comparing the results obtained, it is worth remarking that we find minor differences in the estimated parameters and elasticities. This confirms the evidences discussed in the descriptive analysis (Figures 3.a, 4.a and A.1), where no significant differences can be pointed out in the patterns of alcohol and tobacco expenditure comparing the whole sample to the sub-sample of consuming households.

Concerning theoretical restrictions, the homogeneity condition can be tested for each of the estimated equations as well as for the system as a whole. Given formulation (16) it is straightforward to test homogeneity by checking the significance of parameters γ_i^h. Results of the Wald test shows that γ_i^h is not significantly different from zero in each of the two non-singular equations, providing support for the validity of the homogeneity condition and allowing to estimate the restricted version of system (16) with $\gamma_i^h = 0$. The Wald test statistics are equal to 0.0233 (*p-value* = 0.8788) and 2.2879 (*p-value* = 0.1304) for alcohol and tobacco equations, respectively. Given homogeneity, the symmetry restriction, which implies the additional cross-equation constraint (12), is tested by means of a LR test. The test clearly indicates that symmetry and homogeneity is not supported by the data ($LR(\chi^2_{(3)}) = 95.67$, *p-value* = 0.000), as commonly found in empirical demand studies. However, in order to assure the consistency of consumer choice, we proceed by *a priori* imposing symmetry of price effects during the estimation.

The estimated parameters of the homogeneity and symmetry-restricted model and the list of instruments used to account for total expenditure endogeneity are presented in Table 2. Analyzing the results obtained, there is a clear indication of the importance of socio-demographic variables in the within-period allocation of expenditures. This evidence supports the relevance of using cohort data, as they retain the same advantages

Table 2 – GMM estimates of the static Almost ideal Demand System

	1) Alcohol (w_1)	*2) Tobacco (w_2)*
Constant	0.0303***	0.0412***
	(0.0055)	(0.0055)
$log(p_{ALC})$	-0.0064***	0.0049**
	(0.0022)	(0.0022)
$log(p_{TOB})$	-0.0090***	0.0049**
	(0.0019)	(0.0022)
$log(y/P)$	-0.0031***	-0.0062***
	(0.0007)	(0.0007)
Nchild013	0.0006	0.0014**
	(0.0006)	(0.0006)
Nadults	0.0007*	0.0027***
	(0.0004)	(0.0004)
Percmale	0.0082***	0.0048**
	(0.0023)	(0.0020)
Single	-0.0062***	-0.0024
	(0.0017)	(0.0017)
Loweduc	-0.0011	0.0031***
	(0.0011)	(0.0011)
Unemployed	0.0058*	0.0141***
	(0.0034)	(0.0035)
Adjusted R-squared	0.5222	0.7541
Significance of cohort fixed-effects	51.01	156.8
	[0.000]	[0.000]
J-Statistic	44.532 [0.2502]	

Notes: standard errors are reported in parentheses below estimates. P-values of the cohort-fixed effects tests and J test are reported is square brackets.
Seasonal (monthly) shifts in the intercept are included in the estimation, but are not reported here.
****, ** and * denote significance at the 1%, 5% and 10% levels, respectively.*
Instruments: seasonal dummies, cohort dummies, Nchild013, Nadults, Percmale, Single, Loweduc, Unemployed, alcohol ad tobacco prices, three lags of total expenditure and interactions of total expenditure with seasonal dummies and demographics.

of aggregate data for dynamic specifications and still allow to control for the effects of unobserved heterogeneity at the individual level (Jiménez-Martín *et al.* 1998; Labeaga 1999). In particular, alcohol demand is found to be positively related to the percentage of male members within the household, indicating that alcoholic beverages are mainly consumed by men. Moreover, single adult households, after controlling for household size, are characterized by the lowest expenditure levels. The effect of socio-economic status is less relevant; only the variable *Unemployed* is significant at the 10% level and exerts a positive effect on alcohol consumption. In the tobacco expenditure equation, on the other hand, the socio-economic status of the household's head is an important determinant of tobacco demand. The positive signs of *Loweduc* and *Unemployed*, in particular, suggest that consumption levels and smoking probability are higher for households with lower educational attainments and belonging to lower social classes, which are likely to be less aware of the health consequences of smoking. These evidences are similar to those found by Jones (1995) and Yen (2005) in microeconomic analyses of tobacco consumption. Household composition modify tobacco expenditure pattern, with expenditure levels rising as the number of adult members and the percentage of males increases. Contrary to other studies, the presence of children does not act to modify the attitudes towards smoking and drinking of the parents and does not reduce consumption level, but it rather seems to increase tobacco consumption level.

Turning to the analysis of price and income effects, Table 3 presents the estimated uncompensated (Marshallian) price elasticities and income elasticities for the homogeneity and symmetry-constrained demand system. Alcoholic beverages are found to be highly price sensitive, with an average elasticity equal to -1.72. The estimated income elasticity is statistical significant and equal to 0.65, a value which fully coherent with those estimated by Selvanathan (2006) in a comparative study of alcohol consumption patterns in eight industrialized countries. Alcoholic beverages emerge as a "necessary" good; this can be explained by considering that the main component of household alcohol expenditure in Italy is wine, which is mainly consumed during meals and is therefore strictly related to household food habits.

Table 3 – Uncompensated price elasticities and income elasticities

Commodity	*Alcohol*	*Tobacco*	*Other goods*	*Expenditure*
Alcohol	-1.7183***	-1.0044***	1.7285***	0.6502***
	(0.1236)	(0.1109)	(0.1524)	(0.0813)
Tobacco	-0.9089***	-0.4983	0.4191**	0.3662***
	(0.1524)	(0.2823)	(0.1934)	(0.0731)

Notes: standard errors are computed by the delta method and are reported in parentheses below estimates.
****, ** and * denote significance at the 1%, 5% and 10% levels, respectively.*

Concerning tobacco, the low estimated income elasticity (equal to 0.3662) is close to those found in previous empirical studies (see Gallet and List (2003) who report, in a meta-analysis of cigarette elasticities, a mean income elasticity equal to 0.42 across 86 empirical studies) and indicates that consumption is not particularly responsive to income changes. Moreover, the Marshallian own-price elasticity is non-significant showing that Italian consumers have not reacted to price changes during the period of analysis. This result is in line with the findings of Labeaga (1999), Jones and Labeaga (2003) and Fanelli and Mazzocchi (2004) and suggest that habits and addiction, rather than traditional economic factors, are the main determinants driving tobacco demand.

Finally, we obtain significant cross-price effects reflecting strong complementarity between alcohol and tobacco consumption. The two estimated cross-price elasticity are both negative and highly significant, consistently with the evidences reported by a growing mass of empirical literature (Jones 1989; Decker and Schwartz 2000; Duffy 2003; Bask and Melkersson 2004; Pierani and Tiezzi 2005). In particular, given the imposition of the symmetry constraint, both the elasticities are close to one in absolute value (-1.0044 and -0.9089), as in the studies of Jiménez-Martín and Labeaga (1994) and Fanelli and Mazzocchi (2004).

The results of the demand system provides the estimated intratemporal preference parameters to be included in the Euler equations (15). The empirical analysis of rational habit forming behaviours on alcohol and tobacco consumptions is carried out by estimating the parameter matrices Γ_0, Γ_1 and Γ_2 in (15) recovering $\tilde{w}_{Ct}$ from the first-step estimation. As previously discussed in Section 3, the intertemporal discount factor ρ has been prefixed at 0.9933, consistently with a yearly real discount rate of 8%, so that Euler equations (15) are linear in parameters. In order to check the sensitivity of the estimation results to the choice of the prefixed discount factor, we have estimated Euler equations (15) using a grid of values for ρ. Coherently with previous empirical studies (Gregory *et al.* 1993; Engsted and Haldrup 1994), the results of the model have been found to remain unaffected to changes in ρ.

A test for intertemporal separability in own consumption and for the absence of forward-looking behaviour can be directly carried out on the parameters concerning own forward-looking adjustment, *i.e.* $\Gamma_{1ii} = 0$ and $\Gamma_{2ii} = 0$. Thus, the intertemporal rational habit behaviour of consumers is explicitly assessed by analyzing the significance of the parameters of the Euler equations (15). Moreover, the extended parameterization of (15) account for correlation among the intertemporal consumption patterns of the two goods at different periods. As stressed in Pacula (1997), to test intertemporal interaction effects it is necessary to represent the cumulative influence of past consumption of both goods. By specifying Γ_1 and Γ_2 as non-diagonal matrices, cross-adjustment costs arise and the expenditure pattern of each good will also depend on the dynamics of the other. A test for intertemporal interactions can be therefore performed by checking the statistical significance of the Γ_{1ij} and Γ_{2ij} parameters.

Table 4 – Euler equations estimates

Alcohol Euler Equation:

$$\Delta w_{1Ct} = \rho^{-1}(\Gamma_{1_{11}}\Delta w_{1Ct-1} + \Gamma_{1_{12}}\Delta w_{2Ct-1}) - \rho^{-2}(\Gamma_{2_{11}}\Delta w_{1Ct-2} + \Gamma_{2_{12}}\Delta w_{2Ct-2}) - \rho^{-2}\Delta w_{1Ct-3}$$
$$-\rho^{-2}[\Gamma_{0_{11}}(w_{1Ct-2} - \hat{w}^*_{1Ct-2}) + \Gamma_{0_{12}}(w_{2Ct-2} - \hat{w}^*_{2Ct-2})] + \varepsilon^*_{1ct}$$

Tobacco Euler Equation:

$$\Delta w_{2Ct} = \rho^{-1}(\Gamma_{1_{21}}\Delta w_{1Ct-1} + \Gamma_{1_{22}}\Delta w_{2Ct-1}) - \rho^{-2}(\Gamma_{2_{21}}\Delta w_{1Ct-2} + \Gamma_{2_{22}}\Delta w_{2Ct-2}) - \rho^{-2}\Delta w_{2Ct-3}$$
$$-\rho^{-2}[\Gamma_{0_{21}}(w_{1Ct-2} - \hat{w}^*_{1Ct-2}) + \Gamma_{0_{22}}(w_{2Ct-2} - \hat{w}^*_{2Ct-2})] + \varepsilon^*_{2Ct}$$

	1) Alcohol (w_1)		*2) Tobacco* (w_2)
$\Gamma_{1_{11}}$ (0.3922)	-0.8932*** (0.2493)	$\Gamma_{1_{21}}$ (0.3873)	0.4057** (0.1765)
$\Gamma_{2_{11}}$ (0.6734)	-0.0497** (0.0211)	$\Gamma_{2_{21}}$ (0.7232)	0.0122 (0.0409)
$\Gamma_{1_{12}}$ (0.0401)	0.0456 (0.2013)	$\Gamma_{1_{22}}$ (0.0561)	-0.6973*** (0.1764)
$\Gamma_{2_{12}}$ (0.4648)	0.0186 (0.0471)	$\Gamma_{2_{22}}$ (0.5373)	-0.0044 (0.0440)
$\Gamma_{0_{11}}$ (0.0408)	-0.4814** (0.2038)	$\Gamma_{0_{21}}$ (0.0602)	0.6530*** (0.2504)
$\Gamma_{0_{12}}$ (0.1055)	0.3833** (0.1654)	$\Gamma_{0_{22}}$ (0.1294)	-0.5916*** (0.2024)
λ	0.99333 (*fixed*)	λ	0.99333 (*fixed*)
J-Statistic	9.1623 [0.6069]		21.394 [0.1300]
Adjusted R-squared	0.5687		0.3500
S. E. of regression	0.0014		0.0015
Significance of cohort fixed-effects	167.473 [0.000]		112.768 [0.000]

Notes: standard errors are reported in parentheses below estimates.. P-values of the cohort-fixed effects tests and J test are reported is square brackets.

The R^2 of the first stage regressions are reported in round brackets below the parameter names.
Seasonal (monthly) shifts in the intercept are included in the estimation, but are not reported here.
****, ** and * denote significance at the 1%, 5% and 10% levels, respectively.*
Instruments:

Alcohol equation: Δw_{1Ct-3}, Δw_{2Ct-3}, Δw_{1Ct-4}, Δw_{2Ct-4}, $(w_{1Ct-3} - \hat{w}^*_{1Ct-3})$, $(w_{2Ct-3} - \hat{w}^*_{2Ct-3})$, $(w_{1Ct-4} - \hat{w}^*_{1Ct-4})$, $(w_{2Ct-4} - \hat{w}^*_{2Ct-4})$, $\log(p_{1t-3})$, $\log(p_{2t-3})$, $\log(p_{3t-3})$, $\log(p_{2t-4})$, $\log(p_{3t-4})$, *Single, Nadults, Unemploye,. seasonal dummie, cohort dummies.*

Tobacco equation: Δw_{1Ct-3}, Δw_{2Ct-3}, Δw_{1Ct-4}, Δw_{2Ct-4}, Δw_{1Ct-5}, Δw_{2Ct-5}, Δw_{1Ct-6}, Δw_{2Ct-6}, $(w_{1Ct-3} - \hat{w}^*_{1Ct-3})$, $(w_{2Ct-3} - \hat{w}^*_{2Ct-3})$, $\log(p_{1t-3})$, $\log(p_{2t-3})$, $\log(p_{3t-3})$, $\log(p_{1t-4})$, $\log(p_{2t-4})$, $\log(p_{3t-4})$, *Percmale, Loweduc, Nadults, Unemployed, seasonal dummies, cohort dummies.*

The GMM estimates of model (15) are presented in Table 4. In order to keep the estimation procedure simple, alcohol and tobacco equations are estimate separately. This approach can be justified by the fact that no cross-equation restriction is imposed on the intertemporal adjustment structure, allowing for asymmetric interactions, and intratemporal interdependences are recovered through the cross-price effects of the first-step demand system estimation.

The condition of orthogonality to obtain consistent estimators is satisfied using a vector of instruments for $t-3$ and earlier periods. A different dynamic between the two goods is maintained in the empirical estimation using a different set of instruments that represent a combination of budget share differences, log prices and demographic and socio-economic indicators. The instruments chosen are reported at the bottom of Table 4 and are found to perform well. By adding earlier lags as instrumental variables, while the estimated parameters of the intertemporal adjustments remain stable, the *J*-statistics almost never rejects the overidentifying restrictions in both alcohol and tobacco equations. It is worth noting that exists an heterogeneous impact of demographics and working and social status variables on intertemporal adjustment of two goods. Significant instruments for two equations are in both *Nadults* and *Unemployed* in the first stage of the GMM estimation. However, while *Percmale* and *Loweduc* variables significantly impact on the pattern of tobacco consumption, the intertemporal estimations of alcohol are improved instrumenting for *Single*.

In order to check the relevance of the instrumental variables considered, the partial correlation between the lagged endogenous variables and the instruments measured in the first-stage regression are reported. The values of the R^2 range from 0.60 to 0.05, showing some information lack only in the instrumentation of the Δw_{2Ct-1} variable in both the equations.

To emphasize the importance of the estimation procedure, the significance of the cohort fixed-effects in alcohol and tobacco consumption is tested by means of a Wald test. It is important to remark that almost all the cohort parameters are statistically significant in both for alcohol and tobacco. The value of the tests reported in Table 4 are $\chi^2 = 167.473$ ($p\text{-}value = 0.000$) and $\chi^2 = 112.768$ ($p\text{-}value = 0.000$), respectively.

In the alcohol consumption equation the parameters of the intratemporal disequilibria for alcohol and tobacco are significantly correlated to the dynamic adjustments of the alcohol equation and the intertemporal adjustment parameters of alcohol take the expected sign. Thus, a positive shock in the allocation of the budget share for alcohol directly generates a positive impact that it is reabsorbed by own second order adjustment pattern. It is worth noting that in the alcohol equation, the dynamic adjustments of tobacco, which provide a measure of the intertemporal interactions between the two goods, are not statistically significant.

For tobacco equation the results show a different path for the intertemporal adjustments. In this case dynamic interactions are not rejected. Tobacco adjust not only to its own past disequilibria, but also to disequilibria in alcohol expenditure, showing that rational habit forming in tobacco consumption also depends on the adjustment of alcohol budget share.

Finally, these empirical evidences show the existence of asymmetry in the intertemporal adjustment between drinkers and smokers when a shock determines an intratemporal allocation change. In particular, we find significant intertemporal interactions for tobacco adjustments, while alcohol consumption seems to follow only its own adjustment dynamics. Smokers show a persistence to adjust the future pattern of expenditure conditioning from the intertemporal smoking behaviours, while drinkers are more sensitive throughout the periods but connected with own dynamic adjustment. These results on intertemporal consumption patterns are consistent with the findings of Pierani and Tiezzi (2005), who highlight the existence of asymmetric intertemporal interactions connected with differences in social norms regarding drinking and smoking behaviours. Moreover, together with the complementarity relationships found in the intratemporal allocation**,** relevant and asymmetric intertemporal rational habit relationships characterize alcohol and tobacco consumption patterns.

5. Concluding remarks

A large body of empirical studies, which test the rational model of habit forming in alcohol and tobacco consumption, use an aggregate measure of consumption, so that heterogeneous agent's behaviour are collapsed on a representative agent. The advantage of using aggregate data can be partly supported in terms of allowing for consistent dynamic specifications. However, this justification cannot be now more sustained for two grounds. Firstly, for the growing availability of true panels or pseudo-panels. Secondly, for the strong impact of demographic and socio-economic characteristics on expenditure decisions.

Thus, in this paper a rational habit forming model for alcohol and tobacco, based on a dynamic adjustment cost model with forward-looking behaviour, is enhanced to include the intertemporal interactions between the two goods and to account for the presence of household heterogeneity. This theoretical framework, that distinguishes intertemporal from intratemporal expenditure allocation, allows the within-period complementarities between alcohol and tobacco to be evaluated in the context of an intertemporal optimization model.

In order to empirically test the aforementioned rational habit model, appropriate pseudo-panel data methods have been employed to account for the heterogeneous household consumption patterns. Our results reveal that habits and complementarity effects between alcohol and tobacco assume the expected size when demographic and working and social status characteristics are included in the rational habit model. Significant cross price elasticities in the estimation of demand system confirm, as expected and as widely found in the literature, that the two goods are complements. This result provides a relevant information for policy-maker since measures that reduce the effective consumption of one of two goods have positive externalities on the other, suggesting the appropriateness of synergic health policies. The Euler system estimation does not reject the hypothesis of intertemporal dependence of alcohol and tobacco and their intertemporal interactions. While the intertemporal dependence provides support for a forward-looking behaviour in both of goods, persistence and interaction effects show a different behaviour for alcohol and tobacco in the optimizing pattern of consumption. In particular, we find more persistence and significant intertemporal interactions for tobacco equation, while alcohol consumption seems to follow only its own adjustment dynamics.

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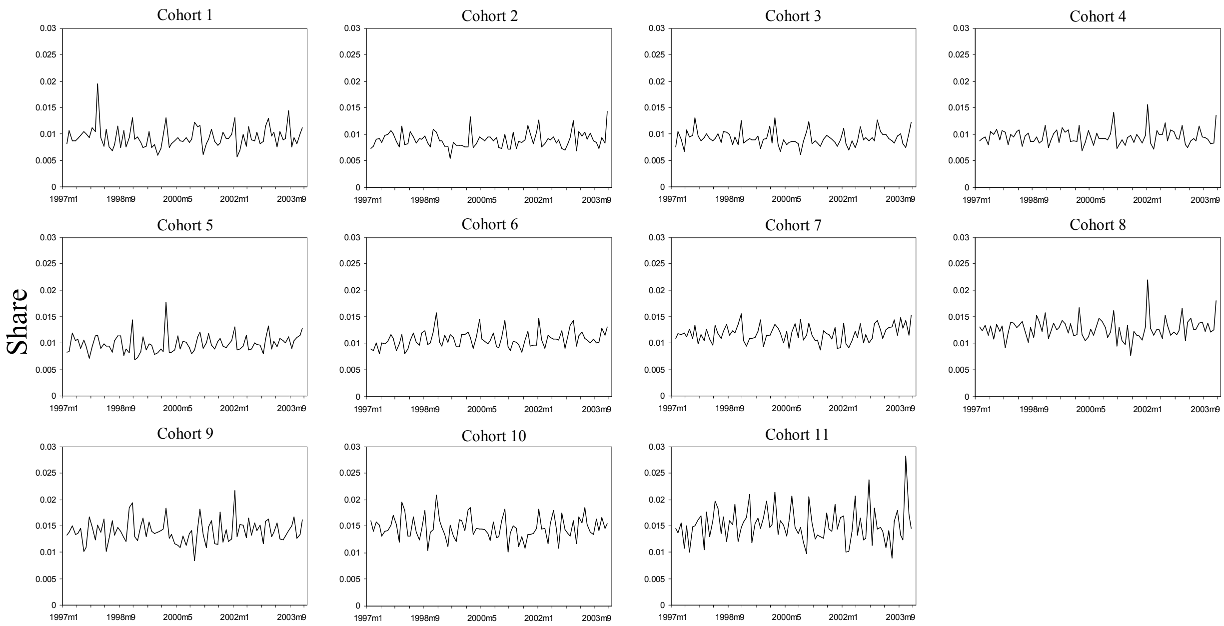
Appendix: Descriptive Tables

Table A.1 - Demographic and seasonal controls

Variable	Definition
NCHILD013	Number of children aged 0-13 within the household.
NADULTS	Number of adult members within the household.
PERMALE	Percentage of adult male members in the household.
SINGLE	Dummy variable equal to one for a single adult household without children, zero otherwise.
LOWEDUC	Dummy variable equal to one if the household's head has primary or non education, zero otherwise.
UNEMPLOYED	Dummy variable equal to one if the household's head is unemployed, zero otherwise.
DM2-DM12	Monthly dummies

Figure A.1 - Per consuming household budget share by cohort

a) Alcohol



b) Tobacco