Income Uncertainty and Precautionary Saving: Evidence from Household Rotating Panel Data

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Abstract

The aim of this paper is to analyse precautionary saving associated with income risk over the last two decades in Spain; some empirical evidence seems to point to the extension of temporary job contracts in those years as an important source of uncertainty for Spanish households. I use a rotating panel, the Spanish family expenditure survey, to model income dynamics and consumption growth. Following Banks, Blundell and Brugiavini (1999), I consider three components in the innovation to household income: idiosyncratic, (year-of-birth) cohort-specific and aggregate. I compute the conditional variance of these shocks, so as to include them as income risk terms in a consumption growth equation. I show how the rotating nature of my data (as compared to the repeated cross-sections available to Banks, Blundell and Brugiavini) can be exploited to identify the idiosyncratic component. The results provide evidence on the importance of precautionary motive for saving in response to income risk. Moreover, I find the cohort-specific (rather than aggregate) risk effect to be significant; this fact implies a failure of between-cohort insurance mechanisms.

1 Introduction

In this paper, I will analyse precautionary saving associated with income risk in Spain for the period 1985-1996. The first natural question is whether Spanish households are expected to have been exposed to (higher) income risks over the last two decades. Since the labour market reform of 1984, there has been a well known steady increase in the proportion of temporary employees;[1] this new group of workers is characterised by low firing costs and by fragile attachment to their employer. As a result, employment has become more variable over the business cycle and involuntary labour turnover has increased (see, for instance, Alba, 1991, and Bentolila and Dolado, 1994). García-Fontes and Hopenhayn (1995, 1996) provide empirical evidence of an increase in the variability of job creation and destruction flows in the Spanish economy, starting around 1985; these authors suggest that the level of labour rotation would have doubled. In short, once temporary employment regulation was significantly relaxed, aggregate employment increased, but has become highly volatile.[2]

Consequently, households are likely to have raised their precautionary demand for saving so as to gain insurance against future negative income contingencies. As an illustration, over the period 1985 to 1996, annual labour income, for the same sample of households used in this paper, grew by 2.8% on average, whereas non-durable goods consumption decreased by 0.3%. Moreover, Figure **??** shows that households' consumption has systematically grown less than their labour income (the only exception is 1993).[3]

[1]From 11% before the reform to 16% in 1987, and becoming stable around one third of all employees in the nineties (see Segura *et al.,* 1991).

[2]As well as a higher risk of becoming unemployed (with right to lower or no benefits), there is also evidence that workers on fixed term contracts receive lower wages than those on permanent contracts; see Bentolila and Dolado (1994).

Indeed, the sluggishness of private consumption in Spain after the recession of 1992-94[4] can also be understood along these lines, since the recovery of output was initially grounded on temporary job contracts (some of them replacing permanent jobs destroyed during the recession). Therefore, it is an important policy issue to know the extent to which an increase in income uncertainty could lead to a delay in the recovery of consumer spending.

As a theoretical starting point, this paper considers a standard model of consumption which allows for precautionary saving; that is, consumers want to borrow and save to smooth consumption over time and over states of nature. The importance of the precautionary-saving motive is estimated through the effect of income variability terms on consumption growth.

Firstly, I set up a dynamic model for income in which the variances of the innovations in this process are allowed to vary over time. Following Banks, Blundell and Brugiavini (1999), the innovation to household income will be decomposed into three terms: an idiosyncratic (household-specific) risk component, a cohort-specific risk component (affecting in the same manner to every household whose head belongs to the same year-of-birth cohort), and an aggregate risk component (common to all households in an economy).

Secondly, I compute the conditional variance of these shocks, so as to include them as income risk terms in the consumption growth equation. I use income from all labour sources (not just wages) thus capturing, to some extent, changes in unemployment risk as well as changes in earnings uncertainty.

[3]Note that these figures do not necessarily support a precautionary-saving motive. They could merely be explained by a progressive reduction of the non-durable goods expenditure share in the households budget.

[4]See, for instance, the *Annual Report* of the Bank of Spain (1996). In Figure **??**, a specially large gap can be appreciated in 1996

This analysis is carried out with the Spanish family expenditure survey. The rotating nature of this data constitutes a noteworthy feature. I have forty-eight quarterly waves from which a long time series synthetic panel for cohorts can be constructed; this allows me to capture the changing nature of income risk over long time series of expenditure and income, controlling for household unobserved heterogeneity, and consequently relying on the time evolution of risk terms to elicit precautionary saving effects. But, as a fundamental point of departure from Banks, Blundell and Brugiavini (1999), I can actually observe each individual for several consecutive periods; such a fact is exploited in this paper to identify the process for idiosyncratic shock.

Under full insurance, only risks common to all individuals should affect consumption; in other words, the individuals would be able to isolate the consumption distribution from shocks to the income distribution, through risk-sharing mechanisms. But there are good reasons to consider further separate components in the aggregate shock: overall risk will encompass shocks to the macro-economy and shocks specific to individuals in a group.[5] For instance, as those who started a job after the reform were more likely to do so under a temporary labour contract,[6] the income uncertainty associated to these contracts is expected to have a different incidence in different year-of-birth cohorts. Indeed, this distinction among aggregate, cohort-specific and idiosyncratic risks allows me to analyse the response of consumption to each component and, therefore, to study the ability of households of insuring against different sources of risk.

[5]As Banks, Blundell and Brugiavini (1999) clearly point out, there exists an observational equivalence between a common shock affecting individuals differently and a genuine individual shock; thus both of them are regarded as "idiosyncratic". The same applies for cohorts.

[6]Bentolila and Dolado (1994) quote evidence showing that temporary employment is prevalent among the youth.

Recent literature has emphasised that full insurance could be not only implemented through "formal" institutions (i.e., perfect capital markets, the Welfare State, etc.), but there could also exist a wide-range of "informal" insurance schemes open to individual, but unobservable to the econometrician; see Deaton and Paxson (1994). Therefore, it is important to assess, *a priori*, the size and importance of these idiosyncratic risks: these may be larger but they are also more insurable. For instance, at the household level, decisions are made jointly; thus, when one member faces with a higher employment uncertainty, other members' can optimally choose to join to the labour force or to work more, so that the household gets (partly) self-insured.[7] At the cohort level, pay-as-you-go state pension systems and *inter-vivos* transfers between extended family members of different generations could be thought of as informal insurance mechanisms.[8] My income measure includes all sources of non-asset income to the household, and social security receipts; so, contrary to the use of earnings of the head, earnings from all family members are incorporated, and, therefore, mechanisms that households have for pooling risk associated with individual components of income have been taken into account.[9]

Furthermore, if all three terms correctly measured uninsurable risk, their impact on consumption growth would be the same. Nevertheless, as indivi-

[7] Sánchez (1999) analyses how employment uncertainty of the "primary earner" (or husbands) affects the likelihood of "secondary earners" (or spouses) joining to the labour force; moreover, she uses the introduction and diffusion of temporary contracts as a exogenous source of variation in employment risk to get identification.

[8] Bentolila and Ichino (2000) show evidence supporting that extended family networks, whose ties seem to be quite strong in Spain and Italy (as compared to Germany, the UK and the US), provide an essential source of insurance against unemployment in those countries.

[9] Hayashi, Altonji and Kotlikoff (1996) test for family insurance, that is, households who are insured/insurers within the extended family (not insured by the outside world). They take advantage of the fact that the PSID includes as new households those set-up by emancipated members of a family already surveyed. I can only control for pooling among family members who are still living together.

duals are able to pool idiosyncratic risks in many ways, the estimated effect for the idiosyncratic component would be expected to be lower than the other two components, due merely to the fact that the first one is not reflecting true uncertainty.

The results obtained in this paper provide evidence on the importance of the precautionary motive for saving in response to income risks. Like Banks, Blundell and Brugiavini (1999) for United Kingdom, I find that the common component of risk does not appear to be significant, but instead the cohort-specific does. This fact suggests a failure of between cohort risk-pooling mechanisms akin to that found by Attanasio and Davis (1996). This result could be explained by the different uncertainty to which the older and younger members of the labour force were exposed, since they are more likely to be, respectively, permanent and temporary employees.

The rest of the paper is organised as follows. In section 2, I recall the standard life-cycle model of consumption. Section 3 shows how I model household income dynamics in order to get measures of the variability of income. In section 4, I describe my data set, commenting on some relevant features. In section 5, I first discuss some econometric issues concerning estimation and, then, I present and discuss the empirical results. Finally, some concluding remarks are contained in section 6.

2 Theoretical Framework

First of all, I will consider a model of consumption smoothing and precautionary saving as those discussed in Deaton (1992) and in Browning and Lusardi (1996). Let the decision problem faced by a household on how to allocate consumption over time be:[10]

[10] The household subindex has been omitted.

$$
\begin{aligned}
&\max_{\{C_{t+k}\}_{k=0}^{T-t}} E_t\left[\sum_{k=0}^{T-t}(1+\delta)^{-k}U\left(C_{t+k},D_{t+k}\right)\right]\\
&\text{subject to}\\
&A_{t+1+k}=(1+r_{t+k})\left(A_{t+k}+Y_{t+k}-C_{t+k}\right) \quad k=0,...,T-t\\
&A_{T+1}\geq 0
\end{aligned}
\tag{1}
$$

where $U(\bullet)$ is the within period utility (or "felicity function") and, for each period s, C_s is the household consumption and Y_s its total income, r_s denotes the real interest rate, A_s the non-human wealth at the beginning of period s and δ the subjective discount rate; moreover, D_s is a vector of "modifiers for utility" or "taste shifters" such as family composition, labour supply or health status, usually referred to as 'demographics'.

The optimal allocation of consumption verifies the standard Euler equation $E_t\left[\frac{1+r_t}{1+\delta}\frac{U_C(C_{t+1},D_{t+1})}{U_C(C_t,D_t)}\right]=1$, where $U_C(\bullet)$ denotes the first derivative of the utility function with respect to its first argument.

I will further assume that the felicity function is of the constant relative risk aversion (CRRA) form, namely, $U(C_t,D_t)=\frac{1}{1-\rho}\exp\left(\varphi' D_t\right)C_t^{1-\rho}$, where ρ is the relative risk aversion coefficient (therefore, $\rho>0$). As far as this paper is concerned, the most interesting feature of this functional form is that it allows to go beyond the certainty-equivalence model and, hence, to analyse the precautionary motive for saving.[11] Then, the Euler equation can be written as $\frac{1+r_t}{1+\delta}\exp\left(\varphi'\Delta D_t\right)\left(\frac{C_{t+1}}{C_t}\right)^{-\rho}=1+\xi_{t+1}$, with $E_t\left[\xi_{t+1}\right]=0$. After taking logarithms and making the usual Taylor approximation, the following equation is obtained:[12]

[11] As Deaton (1992) explains, convexity of the marginal utility implies that individuals will make a "*precautionary* demand for saving".

[12] This relationship would be exact under the assumption of either log-normality of ξ_{t+1} or joint log-normality of variables involved in the equation.

$$\Delta \ln (C_{t+1}) = \frac{1}{\rho} \ln (r_t - \delta) + \frac{1}{\rho} \varphi' \Delta D_{t+1} + \frac{1}{2\rho} \omega_{t+1}^2 + v_{t+1} \tag{2}$$

where $\omega_{t+1}^2 = Var_t \left[\xi_{t+1} \right]$, that is, a measure of the consumption shock conditional variance.

Equation (2) parsimoniously comprises the main determinants of consumer behaviour.[13] The first term accounts for the intertemporal substitution effect: an increase in the interest rate (opportunity cost of current consumption) implies a higher future consumption growth. The second term considers how different periods in the life-cycle are reflected in the consumption path through changes in circumstances which are implicit in demographic variables ΔD_{t+1}. Finally, the last term captures the precautionary saving motive: an increased value of the expected variance of future consumption shocks, ω_{t+1}^2, leads to a higher expected consumption growth, since current consumption is lowered in order to raise precautionary saving.

It is worth noting that ω_{t+1}^2 reflects uncertainty about future realisations of *each* exogenous uninsured variables. In other words, besides income risk, uncertainty about future demographics (number of family members, illness,...) could cause consumption shocks against which individuals would wish to insure by means of precautionary saving. Dynan (1996) estimates an equation similar to (2), including the conditional variance of consumption growth itself to capture all forms of risk. However, I will use the income's innovation conditional variance so as to concentrate on the precautionary-saving motive due to income uncertainty.

This notwithstanding, the variance term ω_{t+1}^2 in equation (2) cannot be simply replaced by the income shock conditional variance. The response of the consumption shock variance to unexpected income changes depends on

[13] See Browning and Lusardi (1996) for a detailed explanation.

the amount of financial wealth held by the household and on the magnitude of current income relative to future income. To clarify, even if future income becomes risky, some households would not need to save so as to guarantee their future consumption, if they hold enough liquid assets or if their future income is expected to be much higher than current income.

Accordingly, I will consider an equation such as:

$$\Delta \ln \left(C_{t+1}\right) = \tfrac{1}{\rho} \ln \left(r_t - \delta\right) + \tfrac{1}{\rho} \varphi' \Delta D_{t+1} + k \pi_t^2 \sigma_{t+1}^2 + v_{t+1} \tag{3}$$

where σ_{t+1}^2 is a measure of the income shock conditional variance and π_t is a scaling factor such that less wealthy individuals are more responsive to future income variance.

Following the approximate solutions derived by Blundell and Stoker (1999), the scaling factor can be written as $\pi_t = Y_t / E_t \left(A_{t+1}\right)$.[14] This could also be thought of as accounting for the impact of the wealth-income ratio target that drives buffer-stock saving behaviour in Carroll (1997). Assuming particular processes for income, Carroll shows that consumers with certain *prudence* and *impatience*[15] patterns have a desired wealth-income ratio. Bellow this target, prudence dominates and consumers will save; but above, impatience will lead households to dissave, i. e., to use up their wealth surplus.

Nevertheless, financial wealth (A_t) is often not available in micro datasets. For this reason, Banks, Blundell and Brugiavini (1999) replace it with C_t, and I will also use $\pi_t = Y_t / C_t$ as scaling factor.

[14] See also Banks, Blundell and Brugiavini (1999), Appendix A.

[15] Consumers display *prudence* when the third derivative of their utility function with respect to consumption is non-negative ($U_{CCC} \geqslant 0$); see Kimball (1990).

As for *impatience*, it sets bounds to the wealth accumulation, yet its definition depends on the context. For example, see Carroll (1997) and the papers referenced there.

3 Modelling Income and Income Risk Dynamics

In this section, I show how disaggregated (i.e., aggregate, cohort and idiosyncratic) income risk measures can be computed from (rotating) panel data. I will use a general autoregressive/moving-average structure for income, in which the variances of the innovations in this process are allowed to vary over time.

I first set up a dynamic model for income in which the persistent or predictable components of income (including cross-section heterogeneity) are removed. Then, I model the conditional variance of the resulting income innovations, which will be used as risk terms in explaining consumption growth. Since this model requires lagged individual information, it will not be fully identified in the absence of a genuine panel.

3.1 A Dynamic Model of Income

Let Y_{ht} be the (log of) total income for household h at time t:

$$Y_{ht} = \beta' X_{ht} + \eta_h^* + \epsilon_{ht} \tag{4}$$

where η_h^* is an unobservable household effect and X_{ht} is a vector of exogenous control variables.

The error term is assumed to have three (pairwise orthogonal) components

$$\epsilon_{ht} = e_t + e_{ct} + e_{ht} \tag{5}$$

where e_t is the aggregate component (common to all individuals in an economy) of the error term, e_{ct} is the cohort-specific component (common to all individuals in a year-of-birth cohort) and e_{ht} is the idiosyncratic (household-specific) error term.

Allowing for a degree of persistence in the stochastic specification of income, I assume an ARMA process for each component of the error term, i. e.,

$$\begin{aligned}
\Phi(L)e_t &= \Theta(L)\varepsilon_t && (6)\\
\phi(L)e_{ct} &= \theta(L)\varepsilon_{ct} && (7)\\
\psi(L)e_{ht} &= \vartheta(L)\varepsilon_{ht} && (8)
\end{aligned}$$

where ε_t, ε_{ct} and ε_{ht} are white noise innovations.[16]

Since the aim of this paper is to study the effect of changes in risk on consumption, I do not want to use processes with constant variance. Instead, using time-dependent variances allows me to capture the time-changing nature of income risk; for instance, a permanent worker becoming unemployed will face, *ceteris paribus*, a higher income uncertainty.[17]

Then, to complete the dynamic specification of the model, the income innovations ε_t, ε_{ct} and ε_{ht} are assumed to be conditionally heteroskedastic, so that $E_t\left(\varepsilon^2_{t+1}\right) = \sigma^2_{t+1}$, $E_t\left(\varepsilon^2_{c(t+1)}\right) = \sigma^2_{c(t+1)}$ and $E_t\left(\varepsilon^2_{h(t+1)}\right) = \sigma^2_{h(t+1)}$. These "one-period ahead" expected variances of income innovations are the determinants of precautionary saving. Controlling for observable and unobservable characteristics which vary across individuals (X_{ht} and η^*_h, respectively, in 4) and stripping out persistent features of income in $(6)-(8)$ allows

[16] This specification encompasses that used by Banks, Blundell and Brugiavini (1999); they implicitly assume an ARMA (1,1) process for each income innovation. Moreover, in their model, the autoregressive coefficient is the same for the three processes, that is, $e_t = \alpha e_{t-1} + \varepsilon_t - \theta_1\varepsilon_{t-1}$, $e_{ct} = \alpha e_{c(t-1)} + \varepsilon_{ct} - \theta_2\varepsilon_{c(t-1)}$ and $e_{ht} = \alpha e_{h(t-1)} + \varepsilon_{ht} - \theta_3\varepsilon_{h(t-1)}$.

[17] Indeed, unemployment implies the highest uncertainty.

me to rely just on the time series evolution of risk terms to identify the effect of income risk on consumption growth.

3.2 Recovering Income Innovations

A separate income process is estimated for each cohort; as a consequence, all parameters are, by definition, allowed to be cohort-specific (common to all individuals in a cohort). I will also make the assumption that parameters are time invariant. After recovering the estimated income innovations, their conditional variances can be calculated so as to be included in the consumption equation.

Taking equations (4) and (5) together for a given cohort c, I have $Y_{ht} = (\beta^c)' X_{ht} + \eta_h^* + m_t^c + e_{ht}$, $\forall h \in c$, where $m_t^c = (e_t + e_{ct})$ and the superscript denotes that parameters are specific to cohort c. It is worth noticing that the cohort innovation (e_{ct}) and the aggregate innovation (e_t) cannot be separately distinguished, since both represent common effects across all households *within* a cohort; the parameter m_t^c reflects this (cohort-specific) time effect.

Moreover, let me assume a simple first-order autoregressive structure for the idiosyncratic innovation:

$$e_{ht} = \alpha^c e_{h(t-1)} + \varepsilon_{ht}, \quad \forall h \in c \tag{9}$$

Thus, after some rearrangements, the income equation can be expressed as:

$$Y_{ht} = \alpha^c Y_{h(t-1)} + (\beta^c)' X_{ht} - \alpha^c (\beta^c)' X_{h(t-1)} + \eta_h + \lambda_t^c + \varepsilon_{ht}, \quad \forall h \in c \tag{10}$$

where $\eta_h = (1-\alpha^c)\,\eta_h^*$ is a household-specific unobservable effect and $\lambda_t^c = m_t^c - \alpha^c m_{t-1}^c$ is a time-effect, simply captured by including time-dummies.

Once the parameters α^c and β^c have been estimated, the idiosyncratic innovations $\widehat{\varepsilon}_{ht}$ are recovered as the residuals in equation (10). Thus, the conditional variance of this income innovation can be calculated as: $E_t\left(\widehat{\varepsilon}^2_{h(t+1)}\right) = \widehat{\sigma}^2_{h(t+1)}$.

Likewise, it is straightforward to obtain each $\widehat{m}_t^c = (\widehat{e}_t + \widehat{e}_{ct})$ as the sum across households of the residuals in (4) for each cross section, that is,

$$\widehat{m}_t^c = \frac{1}{N_c}\sum_{h\in c}\left[Y_{ht} - \left(\widehat{\beta}^c\right)' X_{ht}\right]$$

where N_c is the number of households belonging to cohort c.[18] Then, I can decompose $\widehat{m}_t^c$ into aggregate (or macro level) and cohort income innovation. As the first one is common to all cohorts, it can be extracted as follows:

$$\widehat{e}_t = \frac{1}{\mathfrak{C}}\sum_{c=1}^{\mathfrak{C}}\widehat{m}_t^c$$

where $\mathfrak{C}$ is the number of cohorts. The time-series for $\widehat{e}_{ct}$ are obtained by subtracting $\widehat{e}_t$ from each $\widehat{m}_t^c$ series.

Finally, the time series processes for $\widehat{e}_t$ and $\widehat{e}_{ct}$ can be estimated. Following the approach to prediction in dynamic models with time-dependent variances described in Ballie and Bollerslev (1992), I will use a two step procedure. First, I estimate the process for the conditional mean of $\widehat{e}_t$ and each

[18] Without loss of generality, I am assuming $E\left[\eta_h^*\right] = 0$ and $E\left[\varepsilon_{ht}\right] = 0$. Otherwise, the mean of η_h^* and ε_{ht} will be added to the mean of $\widehat{m}_t^c$, but the results will not be affected. On the other hand, the time series for $\widehat{m}_t^c$ could be alternatively obtained from the parameters $\widehat{\Lambda}_t^c = \widehat{m}_t^c - \alpha^c \widehat{m}_{t-1}^c$, by inverting this process with $\widehat{m}_1^c = \frac{1}{N_c}\sum_{h\in c}\left[Y_{h1} - \left(\widehat{\beta}^c\right)' X_{h1}\right]$ as its initial condition.

$\widehat{e}_{ct}$ (that is, $\Phi(L)\widehat{e}_t = \Theta(L)\varepsilon_t$ and $\phi^c(L)\widehat{e}_{ct} = \theta^c(L)\,\varepsilon_{ct},\ c = 1, \ldots, \mathfrak{C}$, respectively) under the assumption of a constant variance; thus, the white noise innovations $\widehat{\varepsilon}_t$ and $\widehat{\varepsilon}_{ct}$ can be computed. Then, their conditional variances $E_t\left(\widehat{\varepsilon}^2_{t+1}\right) = \widehat{\sigma}^2_{t+1}$, $E_t\left(\widehat{\varepsilon}^2_{c(t+1)}\right) = \widehat{\sigma}^2_{c(t+1)},\ c = 1, \ldots, \mathfrak{C}$, are calculated.

4 Data

The main data set used in this paper is the Spanish family expenditure survey (*Encuesta Continua de Presupuestos Familiares*, ECPF, hereafter). The ECPF is a rotating panel conducted by the National Institute of Statistics (INE) on a quarterly basis. About 3200 households are interviewed every quarter, with one eighth of the sample being renewed each quarter. This survey is highly suitable for my purpose, since it contains very detailed and comprehensive information both on variables in which I am interested (family expenditure and income) and on several control variables (household characteristics such as employment status, demographics, etc ...).

Contrary to the data available to Banks, Blundell and Brugiavini (1999), households are followed by the ECPF for several, at most eight, consecutive periods. Thus, I can take advantage of a true (although short and unbalanced) panel structure. This feature is crucial to identify a separate dynamic process for idiosyncratic innovations.[19]

In this paper, I use twelve consecutive years of the ECPF running from the first quarter of 1985 to the fourth quarter of 1996. The long period over which this data is available is also an important point. On the one hand, the identification of the consumption model would require long time series panel,

[19] Banks, Blundell and Brugiavini (1999) can observe each household just once, but instead the average behaviour of cohorts can be tracked throughout the sample period. Thus, a synthetic panel for cohorts can be constructed. Yet nothing can be said about idiosyncratic innovation dynamics unless further assumptions are made

so that common (macro) shocks were averaged out (see Deaton, 1992, and Browning and Lusardi, 1996). Secondly, time series information must suffice to remove persistence from the income series.

As regards my income definition, I use total household income earned by any member of the family, from any source with the exception of asset income. I do include unemployment benefits as a component of household income, since the participation variable accounts for much of observed income uncertainty (and, consequently, precautionary saving). As for consumption, I use household real expenditure on non-durable consumption goods.[20]

Likewise, I use the consumer retail price index (IPC), published by the INE, to deflate household expenditures, income and nominal interest rate. The nominal interest rate is a synthetic rate on deposits provided by Cuenca (1993).

Table 1: Cohort Definition, ECPF, 1985:1-1996:4

Cohort	Date of Birth	Age in sample Min.	Age in sample Max.	Observations each period Mean	Observations each period 1^{st} decile	Observations each period 9^{th} decile
1	1932-35	50	64	85	72	98
2	1936-39	46	60	69	56	83
3	1940-43	42	56	88	64	128
4	1944-47	38	52	95	76	120
5	1948-51	34	48	92	77	108
6	1952-55	30	44	104	90	121
7	1956-59	26	40	90	74	112

Summary statistics relating to the cohort definition used in this paper are shown in Table 1. I have selected seven cohorts in which the youngest

[20] I have included Food, Drinks and Tobacco (corresponding to Group 1 in the *Clasificación de los Gastos de Consumo* provided by INE), Clothing and Footwear (Group 2) and Energy and transport (Sub-groups 32, 62, 63 and 64)

individuals are 26 years old[21] in 1985 and nobody is older than 65 years old in 1996. Thus, each household head is observed at working ages throughout the sample period.[22] In the Data Appendix, additional details are given on how I obtain the final sample; other variables used in the estimation are described as well.

5 Econometric Issues and Results

5.1 Estimates for Income Innovations Conditional Variance

To get the predicted conditional variance of the income innovations, I first have to estimate the income equation (10). This constitutes a dynamic model with common factor restrictions on certain coefficients:

$$Y_{ht} = \pi_0^c Y_{h(t-1)} + (\pi_1^c)' X_{ht} + (\pi_2^c)' X_{h(t-1)} + \eta_h + \lambda_t^c + \varepsilon_{ht}, \quad \forall h \in c \tag{11}$$

with

$$\pi_0^c = \alpha^c; \quad \pi_1^c = \beta^c; \quad \pi_2^c = -\alpha^c \beta^c \tag{12}$$

As suggested by Chamberlain (1984), I initially carry out the estimation of the parameters in the reduced form (11), namely, $\widehat{\pi}_0^c$, $\widehat{\pi}_1^c$ and $\widehat{\pi}_2^c$ (without

[21] Originally, two additional cohorts were considered to be included, such that the youngest household head was aged 18 year in 1985. However, there existed too few households whose head was so young (at least for the first years of the sample period); so, they could not be included.

[22] This choice excludes from this study households headed by young and elderly people; however, both of them are likely to exhibit a precautionary saving behaviour. On the one hand, labour income uncertainty is expected to be higher at the earlier stages of the life-cycle. On the other hand, as people age, uncertainty arises from new sources such as medical expenses, the timing of death or assets returns. For an example, see Palumbo (1999).

imposing any restriction). From these results, I then estimate the parameters α^c and β^c using a minimum distance technique:

$$\begin{pmatrix} \widehat{\alpha}^c_{MDE} \\ \widehat{\beta}^c_{MDE} \end{pmatrix} = \arg\min_{\alpha^c,\beta^c} \begin{pmatrix} \widehat{\pi}^c_0 - \alpha^c \\ \widehat{\pi}^c_1 - \beta^c \\ \widehat{\pi}^c_2 - (-\alpha^c\beta^c) \end{pmatrix}' \widehat{V}^{-1} \begin{pmatrix} \widehat{\pi}^c_0 - \alpha^c \\ \widehat{\pi}^c_1 - \beta^c \\ \widehat{\pi}^c_2 - (-\alpha^c\beta^c) \end{pmatrix}$$

where $\widehat{V} = \widehat{Var}\left[\begin{pmatrix} \widehat{\pi}^c_0, & (\widehat{\pi}^c_1)', & (\widehat{\pi}^c_2)' \end{pmatrix}'\right]$.

Another issue I must also address is the seasonality of labour income in Spain. The Spanish pay system presents a particular institutional feature: many workers receive extra payments in the Summer (June or July) and in the Winter (December) of each year; that is, the same annual value can be paid through either twelve equal monthly payments or twelve unequal monthly payments which include these two extra payments. The payment scheme for a worker is determined by his/her job and can reasonably be taken as exogenous to workers' choices. Hence, the seasonal pattern of income varies randomly from one individual to another: i. e., the income equation includes a seasonal-individual random effect. This issue is discussed by Álvarez (1999).

Consider the income equation re-written as:

$$Y_{ht} = (\pi^c)' W_{ht} + u_{ht}, \quad \forall h \in c \tag{13}$$

where $\pi^c = \begin{bmatrix} \widehat{\pi}^c_0, & (\widehat{\pi}^c_1)', & (\widehat{\pi}^c_2)' \end{bmatrix}'$ and $W_{ht} = \begin{bmatrix} Y_{h(t-1)}, & X'_{ht}, & X'_{h(t-1)} \end{bmatrix}'$. The error component u_{ht} was given in (11) by $u_{ht} = \eta_h + \lambda^c_t + \varepsilon_{ht}$ (again, η_h is the household fixed effect and λ^c_t is the time effect). In this case, Generalised Method of Moments (GMM) estimators for π^c are available from the following moment conditions in the first-differenced equation: $E\left[W_h^{t-2}\Delta u_{ht}\right] = 0$,

$t=3,...,T$, with $W_h^{t-2}=\left(W'_{h1},W'_{h2},...,W'_{h(t-2)}\right)'$; see Arellano and Bond (1991) and Arellano and Honoré (1999).

But, taking into account the discussion two paragraphs above, I will have:

$$\begin{aligned} u_{ht} &= \eta_h+\sum_{s=1}^{4}\tau_{sh}d_{st}+\lambda_t^c+\varepsilon_{ht} \\ &= \sum_{s=1}^{4}\left(\eta_h+\tau_{sh}\right)d_{st}+\lambda_t^c+\varepsilon_{ht} \end{aligned} \tag{14}$$

where d_{st} are seasonal dummy variables and τ_{sh} are seasonal individual effects.

Hence, given this error structure, the previous moment conditions do not hold, since some lagged endogenous variables (included in W_h^{t-2}) are now correlated with $\Delta u_{ht}=\sum_{s=1}^{4}\tau_{sh}\left(d_{st}-d_{s(t-1)}\right)+\Delta\left(\lambda_t^c+\varepsilon_{ht}\right)$ through the first term (the seasonal-individual effects). Nevertheless, as Álvarez (1999) points out, those can be easily generalised by using seasonal differencing (so that such effects can actually be removed): $\Delta_4 u_{ht}=\sum_{s=1}^{4}\tau_{sh}\left(d_{st}-d_{s(t-4)}\right)+\Delta_4\left(\lambda_t^c+\varepsilon_{ht}\right)=\Delta_4\left(\lambda_t^c+\varepsilon_{ht}\right)$, because $\Delta_4 d_{ts}=\left(d_{st}-d_{s(t-4)}\right)=0,\quad \forall t,s$. Therefore, the following orthogonality conditions could be used to estimate the (unrestricted) parameters π^c:

$$E\left[W_h^{t-5}\Delta_4 u_{ht}\right]=0,\quad t=6,...,T$$

with $W_h^{t-5}=\left(W'_{h1},W'_{h2},...,W'_{h(t-5)}\right)'$; then, the parameters of interest α^c and β^c are recovered as explained before.[23] The estimation results of these parameters (for each cohort) are shown in the Figures and Tables Appendix, Table I and Table II.

[23] I have used the DPD98 program (written in Gauss by Arellano and Bond, 1998) with an extended procedure provided by Olympia Bover with which minimum distance estimation can be performed from DPD results.

With regard to the conditional variance of idiosyncratic income shock, $\widehat{\sigma}^2_{h(t+1)} = E_t\left(\widehat{\varepsilon}^2_{h(t+1)}\right)$, it has been estimated (Figures and Tables Appendix, Tables III and IV) allowing it to depend on:

1. The information set at time t (past observation of $\widehat{\varepsilon}_{h(t+1)}$, $\widehat{\varepsilon}^2_{h(t+1)}$ and other weakly exogenous variables: demographics, number of household members having an employment, labour status for household head, ...).

2. Control variables such as educational attendance, which accounts, to some extent, for permanent differences in idiosyncratic risk.

Lastly, Tables V through X in the Figures and Tables Appendix report the estimated ARMA processes for the conditional mean and ARCH processes for the conditional variance of the time series $\widehat{e}_{c(t+1)}$ and $\widehat{e}_{t+1}$. The main purpose of this estimation is to capture the time series dynamics, so as to get suitable forecasts of the conditional variances, $\widehat{\sigma}^2_{c(t+1)}$ and $\widehat{\sigma}^2_{(t+1)}$, to be included in the consumption growth equation. It should be noted that these estimates are purely based on time series, which emphasises the need for a long time series of income on each cohort.

5.2 Estimates for Consumption Growth Equation

Making use of the conditional variance of the income innovations estimated above, I finally move on to study the impact of precautionary saving on consumption growth. Thus, the estimated consumption growth equation will be:

$$\begin{aligned}\Delta \ln\left(C_{h(t+1)}\right) \quad = \quad & \tfrac{1}{\rho} r_t + \tfrac{1}{\rho}\varphi' \Delta D_{h(t+1)} \\ & + k_1 \pi^2_{ht}\sigma^2_{t+1} + k_2 \pi^2_{ht}\sigma^2_{c(t+1)} + k_3 \pi^2_{ht}\sigma^2_{h(t+1)} \\ & + \left(v_h + v_{h(t+1)}\right) \qquad (15)\end{aligned}$$

where the error component $\left(v_h + v_{h(t+1)}\right)$ includes a household-specific effect, v_h, and the expectational error. However, the presence of measurement errors in consumption will add some extra terms to the disturbances; provided that the measurement errors are serially uncorrelated, the error term $v_{h(t+1)}$ will have a MA(1) structure.

It follows that a GMM estimator for the parameters in (15) is defined by the moment conditions:

$$E\left[\begin{pmatrix} Z_h^{t-2} \\ \widetilde{Z}_h^t \end{pmatrix} \Delta v_{ht}\right] = 0, \quad t = 3, ..., T$$

with $Z_h^{t-2} = \left(Z'_{h1}, Z'_{h2}, ..., Z'_{h(t-2)}\right)'$, $\widetilde{Z}_h^t = \left(\widetilde{Z}'_{h1}, \widetilde{Z}'_{h2}, ..., \widetilde{Z}'_{ht}\right)'$ and where Z_{ht} is a vector of endogenous variables in the model and $\widetilde{Z}_{ht}$ is a vector of exogenous variables. Moreover, I have used optimally reweighted instruments taking into account of the autocorrelation in v_{ht}.

The results are reported in Table 2. As it can be seen, I treat demographic variables as exogenous[24] whereas employment variables, the interest rate, income, consumption and conditional variances are, obviously, regarded as endogenous.

In the first column, I report, as a baseline, a conventional consumption growth equation, that is, without including the risk terms in the right hand side. Several results are worth noting. First, the estimated coefficient for real interest rate (i.e., the elasticity of intertemporal substitution) is positive and significantly different from zero. Likewise, I find important effects of some demographic variables: the estimated response to an increased number of household members is significantly positive. These results remain unchanged

[24] Statistical tests cannot reject the demographics dated at t and $t-1$ as valid instruments.

Table 2: Estimates for the Consumption Growth Equation

	(1)	(2)	(3)	(4)
r_t	0.420	0.429	0.420	0.424
	(0.084)	(0.084)	(0.084)	(0.083)
Age of head	0.1^{-4}	-0.002	-0.003	-0.004
	(0.016)	(0.016)	(0.016)	(0.016)
Δ#children	-0.003	-0.002	-0.002	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Δ#members	0.109	0.110	0.114	0.114
	(0.037)	(0.037)	(0.037)	(0.037)
Δ#elderly	-0.031	-0.035	-0.040	-0.042
	(0.078)	(0.078)	(0.078)	(0.077)
Δ#employed	0.049	0.042	0.027	0.017
	(0.051)	(0.052)	(0.051)	(0.052)
$\pi^2_{ht}\sigma^2_{h(t+1)}$	–	-0.1^{-3}	-0.1^{-3}	-0.1^{-3}
		(0.1^{-3})	(0.1^{-3})	(0.1^{-3})
$\pi^2_{ht}\sigma^2_{c(t+1)}$	–	–	0.221	0.730
			(0.097)	(0.361)
$\pi^2_{ht}\sigma^2_{t+1}$	–	0.209	–	-0.528
		(0.092)		(0.371)
Sargan Test	45.102	48.252	50.905	52.285
d.f.	40	44	44	46

Notes:

1) See the Data Appendix regarding the variables displayed in this Table.

2) Numbers in parentheses are standard errors.

3) The set of instruments includes: age and age squared of the household head and household head's wife, Number of total members, children, and elderly in the household dated at t, $t-1$, $t-2$, $t-3$ and $t-4$; real interest rate, number of employees, labour status of household head and his wife, household income, consumption and conditional variances (in the columns where they appear) dated at $t-2$, $t-3$ and $t-4$.

when conditional variances are introduced as explanatory variables into the consumption equation.

In columns (2) and (3), besides the idiosyncratic risk term, I have included a common-risk term: the aggregate risk term σ^2_{t+1} in (2) (common to all households) and the cohort-specific risk term $\sigma^2_{c(t+1)}$ (common to all households whose head belongs at the same cohort) in (3). Similar conclusions can be reached from both columns: the idiosyncratic component is not significant, whereas the common-risk components are positive and significantly different from zero; the latter confirms the importance of a precautionary motive for saving. It is also worth noting that the theoretical model for consumption, see equation (2), predicts that the coefficient for risk term should be one half of the coefficient for interest rate; the estimated coefficients in columns (2) and (3) seem to verify this property. On the other hand, the non-significance of the idiosyncratic term suggests that much of what I am counting as idiosyncratic risk in $\sigma^2_{h(t+1)}$ does not pose true (i. e., uninsurable) risk; as I have already commented in the Introduction, households can get insured against idiosyncratic risks through many different schemes unobservable to the econometrician.

Finally, the three risk components have been included in column (4). In this case, it is just the coefficient for the variance of cohort component which is significantly different from zero (and positive).[25] Furthermore, the coefficient estimated in Table 2, column (4), implies that a 1% increase in the variance of cohort component would lead consumption growth to increase by 2.8%[26] in order that households protect themselves from uncertainty associated with such income variability. Hence, these results indicate that "between groups" insurance mechanisms at the cohort level have not worked out to limit the differential impact of these risks across households.

[25] Notice that the cohort-specific shock has to be regarded as including some macroeconomic shocks (common to all households in an economy), which have different impacts on individuals in different generations.

[26] This elasticity is a bit lower for estimates in column (3): 0.8%.

6 Conclusions

In this paper, I have used micro-data from a rotating panel, the Spanish family expenditure survey, to analyse precautionary saving associated with income risk. This entails modelling household income dynamics. Following Banks, Blundell and Brugiavini (1999), I consider three components in the innovation to household income: idiosyncratic, (year-of-birth) cohort-specific and aggregate. I compute the conditional variances of these shocks, so as to include them as income risk terms in a consumption growth equation. I have showed how the rotating nature of my data (as compared to the repeated cross-sections available to Banks, Blundell and Brugiavini) can be exploited to identify the idiosyncratic component.

The empirical work reported in the previous section provides evidence on the significance of the precautionary motive for saving; nevertheless, I find that different components of income risk impact on consumption growth in different ways. As a matter of fact, consumption growth does not appear to be affected by idiosyncratic risks; this is not surprising since there exists a number of "informal" insurance schemes available to the households but unobservable to the econometrician. Furthermore, I find the cohort-specific (rather than aggregate) risk effect to be significant; hence, it can be concluded that (at least for the sample period used in this paper) there has existed a failure of between-groups insurance mechanisms. These results are similar to those obtained by Banks, Blundell and Brugiavini (1999) for United Kingdom and also agree with Attanasio and Davis (1996), who found a "spectacular" failure of between cohort risk-pooling in their study on wage inequality and consumption for United States. According to my estimations, a 1% increase in the variance of cohort component would imply that households raise their precautionary saving by 2.8% in order to protect themselves from uncertainty associated with such income variability.

As I mentioned in the Introduction, the steady spreading of temporary employment in Spain could have been an important source of income uncertainty. Furthermore, the different incidence of fixed-term contracts amongst cohorts can explain the different income risks to which they were exposed. Then, the failure of insurance between agents at the cohort level makes the precautionary motive for saving an increasingly important self-insurance mechanism.

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A Data Appendix

The final sample of the households has been constructed by imposing the following requirements on the original data set:

- Households having permanent guests at any interview period are dropped, since I could be dealing with some kind of rooms-for-rent business which does not fit to my purpose in this paper.
- Every household member must have fully answered the survey. When a household member does not answer the survey, his/her income and expenditure are attributed by the INE according to his/her known characteristics (age, attained education, ...); I have decided to keep only households whose information is actually reported by themselves.
- The household head must be a married male.
- The household head must have been born between 1932 and 1959 (i. e., he belongs to any cohort in Table 1).
- The household must have answered the survey for, at least, 6 consecutive periods. This allows me to use lagged variables as instruments in the seasonally differenced panel data estimates.

The following variables, used in the estimates, are easily available from ECPF records:

- Age and age squared of the household head.
- Age and age squared of the household head's wife.
- Number of household members.

- Number of females in the household.
- Number of children: calculated as those household members aged 17 or less.
- Number of members older than 65 years old.
- Number of household members having an employment, either as wage earners or as self-employed.
- Dummy variables for the labour market status of the household head: part-time employed, unemployed, and out of the labour force (dummy for fully employed[27] is omitted in estimates).
- Dummy variables for the household head's educational attendance: illiterate or no schooling, secondary schooling, and university and postgraduate studies (dummy for primary schooling is omitted in estimates).

[27] Concerning employees, an individual working less than one third of the legal shift is regarded as partly employed and, otherwise, as fully employed.

B Figures and Tables Appendix

Figure I: Growth Rate for Consumption and Labour Income, 1985-96

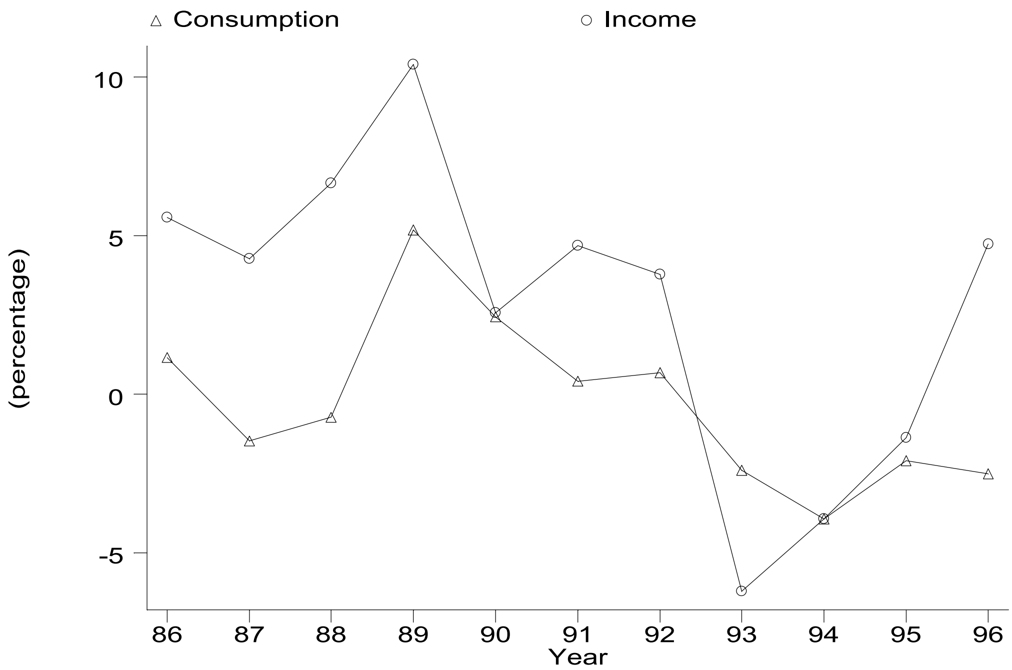

Table I: Estimates for the Income Equation

	coh. 1	coh. 2	coh. 3	coh. 4
$Y_{h(t-1)}$	0.019	0.195	0.263	0.374
	(0.019)	(0.045)	(0.124)	(0.091)
#members	0.017	0.045	−0.046	−0.069
	(0.048)	(0.090)	(0.113)	(0.104)
#females	0.061	0.009	−0.090	−0.030
	(0.057)	(0.094)	(0.102)	(0.097)
#children	−0.015	−0.019	0.011	−0.003
	(0.005)	(0.009)	(0.004)	(0.004)
#elderly	0.178	0.264	0.155	0.217
	(0.065)	(0.177)	(0.155)	(0.155)
#employed	0.383	0.301	0.641	0.500
	(0.115)	(0.206)	(0.216)	(0.204)
head part-time emp.	0.127	−1.392	−0.283	0.045
	(0.089)	(1.175)	(0.164)	(0.216)
head unemployed	0.276	0.039	−0.269	−0.058
	(0.140)	(0.246)	(0.182)	(0.148)
head inactive	0.332	0.059	0.174	0.444
	(0.109)	(0.314)	(0.234)	(0.550)

Note: Numbers in parentheses are standard errors.

Table II: Estimates for the Income Equation (cont.)

	coh. 5	coh. 6	coh. 7
$Y_{h(t-1)}$	0.675	0.057	0.001
	(0.103)	(0.033)	(0.013)
#members	0.067	0.027	-0.013
	(0.096)	(0.090)	(0.053)
#females	0.038	0.042	0.114
	(0.054)	(0.103)	(0.085)
#children	-0.001	$3 10^{-5}$	-0.001
	(0.004)	(0.002)	(0.002)
#elderly	0.153	0.343	-0.099
	(0.234)	(0.203)	(0.474)
#employed	0.351	0.069	0.417
	(0.109)	(0.196)	(0.107)
head part-time	0.399	-0.101	-0.244
	(0.311)	(0.298)	(0.072)
head unemployed	0.034	-0.398	-0.044
	(0.149)	(0.157)	(0.094)
head inactive	0.877	-0.019	0.035
	(0.906)	(1.871)	(0.179)

Note: Numbers in parentheses are standard errors.

Table III: Estimates for the Conditional Variance of the Idiosyncratic Component

	coh. 1	coh. 2	coh. 3	coh. 4
Constant	28.575	4.873	6.086	−0.655
	(19.066)	(20.750)	(15.558)	(12.547)
$\varepsilon^2_{h(t-1)}$	0.016	−0.023	0.016	0.117
	(0.049)	(0.019)	(0.015)	(0.042)
$\varepsilon_{h(t-1)}$	−0.314	0.356	−0.434	−1.548
	(1.082)	(0.280)	(0.179)	(0.529)
age of head	−1.090	−0.564	−0.431	−0.469
	(0.662)	(0.778)	(0.643)	(0.619)
(age of head)^2	0.009	0.005	0.005	0.005
	(0.006)	(0.007)	(0.007)	(0.007)
age of wife	−0.033	0.204	−0.118	0.313
	(0.167)	(0.160)	(0.163)	(0.186)
(age of wife)^2	0.001	−0.002	0.001	−0.004
	(0.002)	(0.002)	(0.002)	(0.002)
#members	−0.103	−0.030	0.145	0.029
	(0.077)	(0.069)	(0.065)	(0.070)
#employed$_{t-1}$	0.000	−0.041	0.065	0.281
	(0.105)	(0.094)	(0.100)	(0.093)
head illiterate	0.276	0.527	0.289	0.283
	(0.191)	(0.218)	(0.218)	(0.219)
head sec. sch.	−0.377	−0.306	−0.116	0.442
	(0.314)	(0.292)	(0.275)	(0.195)
head university	0.360	−0.062	0.238	0.234
	(0.283)	(0.323)	(0.319)	(0.268)
(head part-time)$_{t-1}$	−0.328	3.425	0.694	−0.034
	(0.577)	(0.683)	(0.702)	(0.757)
(head unemployed)$_{t-1}$	0.467	0.343	1.400	1.206
	(0.274)	(0.378)	(0.452)	(0.226)
(head inactive)$_{t-1}$	0.116	−0.041	0.415	0.758
	(0.220)	(0.266)	(0.256)	(0.484)

Notes:

1) The dependent variable is $\log(\varepsilon^2_{ht})$. The set of explanatory variables also includes seasonal dummies (not reported).

2) Numbers in parentheses are standard errors.

Table IV: Estimates for the Conditional Variance of the Idiosyncratic Component (cont.)

	coh. 5	coh. 6	coh. 7
Constant	4.596	16.251	6.233
	(11.149)	(8.884)	(8.852)
$\varepsilon^2_{h(t-1)}$	−0.037	0.013	0.070
	(0.020)	(0.018)	(0.027)
$\varepsilon_{h(t-1)}$	0.710	−0.205	−1.361
	(0.321)	(0.222)	(0.273)
age of head	−0.411	−1.040	−0.396
	(0.530)	(0.519)	(0.536)
(age of head)^2	0.006	0.013	0.006
	(0.006)	(0.007)	(0.008)
age of wife	−0.103	−0.049	−0.274
	(0.178)	(0.198)	(0.281)
(age of head)^2	0.001	0.001	0.004
	(0.002)	(0.003)	(0.004)
#members	0.051	0.035	0.009
	(0.069)	(0.076)	(0.087)
#employed$_{t-1}$	−0.060	−0.132	−0.112
	(0.108)	(0.118)	(0.144)
head illiterate	0.345	0.030	−0.270
	(0.254)	(0.227)	(0.419)
head sec. sch.	0.139	−0.089	−0.163
	(0.194)	(0.160)	(0.171)
head university	0.260	−0.154	−0.043
	(0.190)	(0.194)	(0.252)
head (part-time emp)$_{t-1}$	1.510	1.367	0.159
	(0.412)	(0.595)	(0.816)
head unemployed$_{t-1}$	0.568	1.326	0.691
	(0.289)	(0.266)	(0.308)
head inactive$_{t-1}$	0.615	1.432	0.383
	(0.489)	(0.663)	(0.969)

Notes:

1) The dependent variable is $\log(\varepsilon^2_{ht})$. The set of explanatory variables also includes seasonal dummies (not reported).

2) Numbers in parentheses are standard errors.

Table V: Process for the Conditional Mean. Aggregate Component Series

Aggregate Component $(1-\phi_1 L)(1-\gamma_1 L^4)e_t = \mu + (1-\theta_1 L)(1-\delta_1 L^4)\varepsilon_t$		
	Parameter	Standard Error
ϕ_1	0.699	0.171
θ_1	0.123	0.249
γ_1	0.840	0.121
δ_1	0.261	0.201
μ	0.601	0.560

Table VI: Processes for the Conditional Mean. Cohort-Specific Component Series

	Cohort 1	
	$(1-\phi_1 L)(1-\gamma_1 L^4)e_{ct} = \mu + (1-\theta_1 L)(1-\delta_1 L^4)\varepsilon_{ct}$	
	Parameter	Standard Error
ϕ_1	0.879	0.143
θ_1	0.609	0.219
γ_1	0.206	2.487
δ_1	0.143	2.488
μ	-0.023	0.066
	Cohort 2	
	$(1-\phi_1 L-\phi_2 L^2)e_{ct} = \mu + (1-\delta_1 L^4)\varepsilon_{ct}$	
	Parameter	Standard Error
ϕ_1	0.490	0.142
ϕ_2	-0.273	0.143
δ_1	0.438	0.137
μ	-0.038	0.015
	Cohort 3	
	$(1-\phi_1 L)(1-\gamma_1 L^4)e_{ct} = \mu + (1-\delta_1 L^4)\varepsilon_{ct}$	
	Parameter	Standard Error
ϕ_1	0.289	0.116
γ_1	-0.344	0.122
δ_1	-0.935	0.020
μ	0.058	0.035
	Cohort 4	
	$(1-\phi_1 L)(1-\gamma_1 L^4)e_{ct} = \mu + (1-\theta_1 L)\varepsilon_{ct}$	
	Parameter	Standard Error
ϕ_1	0.782	0.227
θ_1	0.507	0.305
γ_1	-0.103	0.165
μ	0.066	0.065

Table VII: Processes for the Conditional Mean. Cohort-Specific Component Series (cont.)

	Cohort 5	
	$(1-\phi_1 L-\phi_3 L^3-\phi_4 L^4)e_{ct}=\mu+\varepsilon_{ct}$	
	Parameter	Standard Error
ϕ_1	0.518	0.147
ϕ_3	-0.515	0.144
ϕ_4	0.314	0.137
μ	-0.130	0.042
	Cohort 6	
	$(1-\phi_1 L)e_{ct}=\mu+(1-\theta_1 L)(1-\delta_1 L^4)\varepsilon_{ct}$	
	Parameter	Standard Error
ϕ_1	0.938	0.089
θ_1	0.749	0.163
δ_1	0.010	0.174
μ	0.018	0.024
	Cohort 7	
	$(1-\phi_1 L)(1-\gamma_1 L^4)e_{ct}=\mu+(1-\theta_1 L)(1-\delta_1 L^4)\varepsilon_{ct}$	
	Parameter	Standard Error
ϕ_1	0.751	0.057
θ_1	0.963	0.081
γ_1	0.308	0.125
δ_1	0.974	0.029
μ	-0.016	0.002

Table VIII: Process for the Conditional Variance. Aggregate Component Series

Aggregate Component $(1-\phi_1 L-\phi_6 L^6)\log(\varepsilon_t^2)=\mu+\upsilon_t$		
	Parameter	Standard Error
ϕ_1	0.171	0.143
ϕ_6	-0.337	0.153
μ	-8.057	1.541

Table IX: Processes for the Conditional Variance. Cohort-Specific Component Series

	Cohort 1	
	$(1-\phi_1 L)\log(\varepsilon_{ct}^2)=\mu+\upsilon_{ct}$	
	Parameter	Standard Error
ϕ_1	-0.374	0.150
μ	-16.205	4.287

	Cohort 2	
	$(1-\phi_1 L-\phi_4 L^4-\phi_5 L^5)\log(\varepsilon_{ct}^2)=\mu+\upsilon_{ct}$	
	Parameter	Standard Error
ϕ_1	0.133	0.149
ϕ_4	0.355	0.140
ϕ_5	-0.201	0.149
μ	-3.470	1.092

	Cohort 3	
	$(1-\phi_1 L)(1-\gamma_1 L^4)\log(\varepsilon_{ct}^2)=\mu+\upsilon_{ct}$	
	Parameter	Standard Error
ϕ_1	-0.291	0.143
γ_1	-0.322	0.144
μ	-9.083	1.470

	Cohort 4	
	$(1-\phi_1 L-\phi_2 L^2-\phi_3 L^3)\log(\varepsilon_{ct}^2)=\mu+\upsilon_{ct}$	
	Parameter	Standard Error
ϕ_1	0.126	0.147
ϕ_2	0.149	0.146
ϕ_3	-0.301	0.148
μ	-5.720	1.339

Table X: Processes for the Conditional Variance. Cohort-Specific Component Series (cont.)

Cohort 5		
$(1-\phi_1 L)(1-\gamma_1 L^4)\log(\varepsilon_{ct}^2) = \mu + \upsilon_{ct}$		
	Parameter	Standard Error
ϕ_1	0.319	0.141
γ_1	0.262	0.144
μ	−3.028	0.943
Cohort 6		
$(1-\phi_5 L^5)\log(\varepsilon_{ct}^2) = \mu + \upsilon_{ct}$		
	Parameter	Standard Error
ϕ_5	0.269	0.144
μ	−3.397	0.771
Cohort 7		
$(1-\phi_1 L)(1-\gamma_1 L^4)\log(\varepsilon_{ct}^2) = \mu + \upsilon_{ct}$		
	Parameter	Standard Error
ϕ_1	0.038	0.154
γ_1	0.332	0.138
μ	−3.712	1.006