



Munich Personal RePEc Archive

Precautionary Saving: a review of the theory and the evidence

Lugilde, Alba and Bande, Roberto and Riveiro, Dolores

GAME-IDEGA, Universidade de Santiago de Compostela

March 2017

Online at <https://mpra.ub.uni-muenchen.de/77511/>

MPRA Paper No. 77511, posted 21 Mar 2017 11:25 UTC

Precautionary Saving: a review of the theory and the evidence

Alba Lugilde^{*}, Roberto Bande and Dolores Riveiro

(GAME-IDEGA, Universidade de Santiago de Compostela)

March, 2017

Abstract

Standard macroeconomic models show that uncertainty plays a significant role in consumption and saving decisions under rather mild conditions, namely the convexity of the marginal utility of consumption. Increased uncertainty generates a positive extra saving, the so-called “precautionary saving”. Although this hypothesis has been tested by a large number of authors, both at macro and micro level, the empirical results are not conclusive, and the main conclusion that can be drawn is that there is neither consensus on the intensity of that motive for saving, nor on the most appropriate measure of uncertainty. This paper provides a comprehensive review of the literature (both theoretical and empirical) and discusses the main controversial issues and the different approaches followed by the studies addressing empirically the test of precautionary saving.

Keywords: precautionary saving, Euler equation, preferences types, empirical puzzles, uncertainty measures

JEL codes: E21, D11, D14

1. Introduction

This paper provides a comprehensive review of the theoretical and empirical literature on precautionary saving. Since the precautionary motive for saving arises in uncertainty contexts, this topic has been of especial interest over the last years, when financial, economic and political turmoil increased uncertainty about future income and thus affected household decisions on consumption and saving.

In the framework of the Life Cycle/Permanent Income model, a positive level of savings is a consequence of a future decline in the income pattern rationally expected by consumers. In such case, savings is the way to optimally allocate lifelong income to lifelong consumption. When consumption decisions are made under uncertainty, and individuals are prudent and seek protection from risk, there is a significant negative impact on current consumption. So, uncertainty generates a positive extra saving, the so-called “precautionary saving”. Essentially, precautionary saving is a phenomenon related to uncertainty on future income and, therefore, on future consumption possibilities, provided that the marginal utility of consumption is convex ($u'''(\cdot) > 0$), (for a review of the theoretical arguments, see Leland, 1968; Sandmo, 1970, and Drèze and Modigliani, 1972). An increase in uncertainty about future income will reduce current consumption modifying the slope of the consumption pattern. Being so, the assumptions about the stochastic processes of income and rates of return, as well as the specification of the utility functions, will determine the consumption pattern. Hence, the type of risk aversion inherent in preferences is relevant to understand the impact of the future income risk on saving decisions.¹

Given the standard formal conditions under which a precautionary motive for saving exists, its relevance is an issue addressed mainly empirically. Depending on the data availability and the type of analysis, this theory has been tested at both macro and micro level, using wealth, consumption or saving equations and taking panel data, cross-sectional data or time series data.² In spite of a rather large number of studies, empirical results are not conclusive. Most works find evidence of an effect of uncertainty on savings, but there is no consensus about the intensity of this reason for saving, nor on which is the most appropriate measure to approximate uncertainty. The latter issue actually becomes a major problem in analysing the effect of uncertainty on consumption and saving decisions. There are a large number of possible measures of uncertainty and determining which one is optimal is a difficult task. Besides finding a “good” measure at the theoretical level, the difficulties related to the availability of data or its adequacy must be added. All these dimensions (type of empirical approach, type of data,

measure of uncertainty, etc.) will be taken into account in summarising the main contributions of the theoretical and empirical literature on precautionary saving.³

In addition to the relevance of the precautionary motive in determining savings, it should be emphasised that the precautionary motive for saving provides a rationale for the so-called “empirical consumption puzzles”. Numerous studies conclude that the permanent income hypothesis (PIH) fails in explaining the dynamics of consumption for “excess sensitivity” (Flavin, 1981) and for “excess smoothness” (Deaton 1987). Moreover, the PIH cannot explain the “excess growth” of consumption (Deaton, 1987). Despite many arguments have been raised to explain these three puzzles (such as general equilibrium considerations, consumer’s myopia, the existence of liquidity constraints, etc.), none of them seems to offer as many simultaneous responses as the existence of a precautionary motive for saving.

The paper is organised as follows. Section 2 presents the theoretical framework underlying the existence of precautionary saving. Section 3 summarises the rationale provided by precautionary saving for the different consumption puzzles found in empirical works, while Section 4 reviews the empirical literature on the topic. Finally, Section 5 concludes.

2. Theoretical framework

In academic research savings are defined as the residual between disposable income and total current consumption, as done by National Accounts. Then, the saving theory is in fact the consumption theory and, therefore, from a theoretical point of view, the determinants of savings should be the same that those of consumption. Thus, to pave the way to the analysis of precautionary saving, in this section we present briefly and simply the standard consumption theory and its developments.⁴

In the 1950s, after that diverse empirical evidence showed that the Keynesian view was inconsistent with a number of issues both at micro and macro level (see *inter alia* Kuznets, 1946; Katona, 1949), Modigliani and Brumberg (1954), Ando and Modigliani (1963) and Friedman (1957) introduced the Life Cycle Hypothesis (LCH) and the Permanent Income Hypothesis (PIH), respectively, providing the microeconomic foundation for the macroeconomic consumption function proposed by Keynes (1936). This was the origin of the “new” theory of consumption, which replaced the “fundamental psychological law” of Keynes, and in which the consumption and savings decisions of individuals are part of an intertemporal decision process: trying to maximise the utility deriving from his/her entire life’s consumption, the consumption of an individual in a particular period depends on the income throughout all his/her life (taken as certain) and on his/her wealth.⁵

The solution to the standard consumer's intertemporal optimization problem is an Euler equation showing that individuals wish to smooth their consumption over time.⁶ In this context, saving is future consumption; a positive level of savings is motivated by the fact that consumers rationally expect a future decline in their income pattern. If consumption follows the behaviour assumed in the LCH/PIH, savings should increase when income is high relative to average income (i.e., when the transitory income is high), while they should be negative when current income is lower than permanent income.⁷

Hall (1978) was the first author in estimating the first-order condition of the intertemporal optimization problem (a consumption Euler equation) adding the rational expectations hypothesis to the consumption model. He proposed a model where consumers maximize expected utility and seek to keep constant the expected marginal utility of consumption. Hall assumes a quadratic utility function (i.e., the third derivative of utility function is zero, $u'''(\cdot) = 0$), which corresponds to analysing the so-called *certainty-equivalence case* (CEQ). This implies that agents take the same consumption decisions under both certain and uncertain income. In addition to the quadratic utility function assumption, the CEQ model considers other restrictive assumptions: additivity over time for the utility function and absence of liquidity constraints. After Hall's seminal contribution, a large number of works explored the PIH under rational expectations (see, among others, Flavin 1981; Hall and Mishkin, 1982; and Zeldes, 1989b). This literature finds that the PIH does not exactly capture consumption behaviour.⁸

Once one deviates from the certainty hypothesis and it is assumed that individuals take consumption decisions under future income uncertainty, the dynamic problem to be solved by consumers can be quite complex. The inclusion of uncertainty implies that the optimal consumption plan selected in each period may be or may not be the same than the one selected in the previous period. Temporal inconsistency, thus, becomes a central issue.

Let us consider a standard consumption model, specifically a finite life model in discrete time within a context of uncertainty. Individuals maximize their expected utility over a finite interval subject to the budget constraint. Thus, the consumer's problem at period t is to:

$$\max_{c_{t+j}} E_t \left[\sum_{j=0}^{T-t} (1 + \delta)^{-j} U(c_{t+j}, Z_{t+j}) \right] \quad (1)$$

subject to:

$$\sum_{j=0}^{T-t} C_{t+j} + \sum_{j=0}^{T-t} A_{t+j+1} = \sum_{j=0}^{T-t} Y_{t+j} + \sum_{j=0}^{T-t} A_{t+j} (1+r); \quad A_t \geq 0 \text{ given}, \quad A_{T+1} = 0 \quad (2)$$

where E_t represents the expectation conditional on all information available at time t , C_{t+j} is consumption, Y_{t+j} is labour income, A_{t+j} is nonhuman wealth, T represents the time of death (the consumer has to die without debt), Z_{t+j} includes all variables affecting utility, δ is the time preference rate and r is the interest rate.⁹ Utility is additive, strictly increasing ($u'(\cdot) > 0$) and concave ($u''(\cdot) < 0$).

Solving the consumer's problem yields the first-order condition, or Euler equation, which has the following expression for $j = 1$:

$$U'(C_t) = \left(\frac{1+r}{1+\delta} \right) E_t[U'(C_{t+1})] \quad (3)$$

Assuming rational expectations, as Hall (1978), the expected value of the marginal utility of future consumption equals the marginal utility of future consumption plus an error term, which is assumed to be white noise:

$$E_t(U'(C_{t+1})) = U'(C_{t+1}) + \varepsilon_{t+1} \quad (4)$$

Then:

$$U'(C_t) = \left(\frac{1+r}{1+\delta} \right) U'(C_{t+1}) + \varepsilon_{t+1} \quad (5)$$

Under perfect certainty (the quadratic utility assumption), equation (5) shows the consumption smoothing that consumers aim for, which is done through savings. But in a context of uncertainty about future income,¹⁰ its impact on consumption can generate a different savings path. Under some specific properties of the utility function, uncertainty generates a positive extra-saving, the so-called "precautionary saving". Retaining the properties of non-satiation ($u'(\cdot) > 0$) and risk aversion ($u''(\cdot) < 0$), i.e., utility is increasing and concave, if marginal utility is convex ($u'''(\cdot) > 0$), then savings are increasing in income uncertainty, which means that there is a positive "precautionary saving" (see Leland, 1968; Sandmo, 1970; and Drèze and Modigliani, 1972; for a theoretical review).¹¹ Since Leland's work (1968), a large number of authors have shown that once the assumption of a quadratic utility function is dropped, income uncertainty affects consumption and saving decisions.¹²

To understand the consequences of a positive third derivative of the utility function, in a context of uncertainty, let us assume (as in Hall, 1978) that in equation (3) both the interest rate and the time preference rate are equal to zero ($r = \delta = 0$) and therefore the Euler equation relating consumption along consecutive periods (equation (3)) becomes:

$$U'(C_t) = E_t[U'(C_{t+1})] \quad (6)$$

If utility is quadratic ($u'''(\cdot) = 0$), the marginal utility is linear and, therefore,

$$E_t[U'(C_{t+1})] = U'[E_t(C_{t+1})] \quad (7)$$

So, the Euler equation is reduced to:

$$C_t = E_t[C_{t+1}] \quad (8)$$

But if marginal utility is convex ($u'''(\cdot) > 0$), $U'(C_t)$ is a convex function of C_t , so that, in this case:

$$E_t[U'(C_{t+1})] > U'[E_t(C_{t+1})] \quad (9)$$

This, in turn, implies that if C_t equals $E_t[C_{t+1}]$, we have

$$E_t[U'(C_{t+1})] > U'(C_t) \quad (10)$$

Equation (10) states that a marginal reduction in C_t rises the expected utility. Moreover, an increase in uncertainty increases the expected variance of consumption, which in turn implies higher expected marginal utility when it is convex, $u'''(\cdot) > 0$. When the third derivative of utility is positive, greater uncertainty is linked to greater savings, the current consumption level decreases (causing further growth of future consumption) and the extra saving is precautionary saving (Dyan, 1993). Thereby, convex marginal utility implies greater consumption growth than under quadratic utility (i.e. that under the assumption of certainty equivalence, CEQ, where $u'''(\cdot) = 0$).

This consumer behaviour implying that savings are increasing with income uncertainty was dubbed as “*prudence*” by Kimball (1990). In particular, Kimball defined the term “*prudence*” as “the sensitivity of the optimal choice of a decision variable to risk” (Kimball, 1990, p. 54). Kimball suggests that the theory of absolute and relative prudence is akin to the theory of risk aversion by Pratt (1964), linking both concepts. The term “*prudence*” describes the propensity to prepare to face uncertainty; in contrast to “*risk aversion*”, which measures how much one dislikes uncertainty and how much one would move away from if possible. Thus, the Arrow-

Pratt's measures of absolute and relative risk aversion have their counterparts in the theory of choice under uncertainty in terms of absolute and relative prudence.

Kimball (1990) shows that when utility is additively separable and $u(\cdot)$ is the utility of future consumption, $-u'''(\cdot)/u''(\cdot)$ is the appropriate measure of absolute prudence (γ), measuring the strength of the precautionary saving motive just as absolute risk aversion (θ), $-u''(\cdot)/u'(\cdot)$, measures the strength of risk aversion. Without taking in consideration the effects of the endogenous choice of the level of risky investment, Kimball establishes that if absolute prudence (γ) is decreasing, then labour income uncertainty will raise the marginal propensity to consume at any given consumption level. Conversely, if absolute prudence is increasing, labour income uncertainty will lower the marginal propensity to consume out of wealth at a given level of consumption.¹³ When these measures are influenced by the level of the exogenous random variable to which reference is made in the choice (in this case, consumption) relative measures of prudence (φ) and risk aversion (ρ), respectively, may be derived. Deidda (2013) and Blundell et al. (2014) use absolute prudence measures (they include decreasing absolute prudence), while Dynan (1993) and Baiardi et al. (2013) use relative prudence measures. All of them find evidence supporting a positive precautionary saving (though we should note that the evidence found by Dynan is weak). Finally, it should be stressed that Kimball uses prudence as a measure of the intensity of the precautionary motive for saving, defining the Equivalent Precautionary Premium (EPP) as a proxy of the effect of uncertainty on consumption and saving. Carroll (1994) and Carroll and Samwick (1998), using the EPP as the uncertainty measure, both find evidence of a precautionary motive for saving.

The combination of a positive third derivative of the utility function and future income uncertainty reduces current consumption and generates precautionary saving. The increase in uncertainty raises the marginal utility for a given expected consumption value and, therefore, increases the incentive to save. In this sense, several theoretical studies (see, for example, Leland, 1968; Sandmo, 1970; Drèze and Modigliani, 1972; Miller, 1974, 1976; and Skinner, 1988) have shown that provided the utility function is separable and with a positive third derivative, an increase in labour-income uncertainty, in the presence of non-complete insurance markets, will reduce current consumption and alter the slope of the consumption path.¹⁴

The consumption path will depend on the assumptions about the stochastic processes of income and rates of return, as well as on the form of the utility function. The different preference types lead to completely different reactions of consumers to uncertainty about future income. Hence, the representation of individual's saving behaviour against uncertainty is particularly sensitive to the specification of preferences (risk aversion), and thus deserves explicit attention in the

design of the consumption model. In other words, the type of risk aversion considered in the preferences is important to understand the impact of income risk.

In addition to the quadratic utility function, the most common utility functions used in the literature are the constant relative risk aversion (CRRA), defined as $U(C) = (1 - \rho)^{-1}C^{1-\rho}$ and the constant absolute risk aversion (CARA), defined as $U(C) = -\theta^{-1}\exp(-\theta C)$. As mentioned above, with the quadratic utility function (that is, $U'''(C)$ and further higher derivatives are equal to zero), consumers' utility is affected by uncertainty but their behaviour does not change in response to it. Thus, quadratic preferences yield a solution where consumers save in anticipation of declining income, but without place for risk (see, for example, Campbell, 1987). Quadratic utility function can reflect risk avoidance, but does not imply a positive precautionary demand for savings (Leland, 1968); in fact, optimal savings would not be affected by the degree of uncertainty. However, in some works the assumption of quadratic preferences is made to produce an analytical solution for consumption, since it is not possible to derive a closed form solution for consumption unless strong assumptions about the nature of uncertainty and preferences are set. In this regard, Caballero (1990) states that the use of certainty equivalence assumptions can be explained by the high degree of difficulty involved in obtaining closed-form solutions in the multiperiod optimization problem of a consumer facing a random sequence of (uninsurable) labour income shocks when the utility function is non-quadratic. Closed form solutions for optimal consumption can be obtained only in the case of the exponential utility function, where prudence is constant (Guiso et al., 1992).

The constant absolute risk aversion (CARA) preferences yield a solution that accommodates income risk (see Caballero, 1990, 1991; among others) but they have the unappealing implication that consumers react to income uncertainty in the same way whether they are rich or poor (Miles, 1997). Under CARA preferences, the adjustments for risk are linear and independent from the wealth level. Consequently, while CARA preferences allow deriving explicit solutions for the intertemporal allocation, the solutions do not represent the notion that precaution is less necessary if you are, in fact, extremely wealthy (Kimball, 1990), i.e., they do not capture rich-poor planning distinctions in a realistic way.

Consequently, quadratic preferences, which are risk neutral, or CARA preferences, for which precautionary behaviour is independent from wealth levels, show serious drawbacks for the purpose of capturing precautionary saving. As a reaction to these deficiencies, Skinner (1988), Kimball (1990) and Carroll (1994), among others, study optimal consumption assuming constant relative risk aversion (CRRA) preferences, under which precautionary saving varies inversely with the initial level of wealth. The use of CRRA functions implies risk adjustments

that vary with the level of consumer wealth, through the presence of terms reflecting the variance of income relative to wealth, so that they can be regarded as more realistic than the solutions for quadratic or CARA preferences. But with CRRA preferences an explicit consumption and saving solution is not available, and hence approximations to the optimal solutions must be derived.

Despite this analytical difficulty, given that precautionary saving decreases for higher wealth levels under CRRA preferences, while being unaffected under CARA preferences, it has been suggested (e.g. Blundell and Stoker, 1999) that CRRA preferences are the most realistic for modelling saving behaviour in empirical works, since they can capture the most plausible precautionary behaviour for rich and poor households. Moreover, in the case of the CRRA function a lower level of wealth (hence of consumption) implies, *ceteris paribus*, a larger coefficient of absolute risk aversion (Caballero, 1990). We find additional arguments in the literature for the use of the CRRA utility functions. For example, Carroll and Samwick (1998) show that the choice of a CRRA utility function is preferable because it guarantees that consumers in the model will engage in precautionary saving.¹⁵ Furthermore, as Zeldes (1989a) points out, the property of the CRRA utility, namely $u'(0) = \infty$, endogenously limits the optimal consumption to stay away from negative or zero consumption, so there is no need to impose exogenous restrictions on consumption or borrowing since the Euler equation ignores the non-negativity constraint on consumption (Zeldes, 1989b).

After this simple general summary of the theoretical framework, we will review the main contributions of the empirical literature on the evidence of precautionary savings in section 4. Prior to that, section 3 shows the contribution of the precautionary motive for saving to the explanation of the failure of the standard CEQ model in explaining the evidence on the dynamics of consumption.

3. Precautionary saving and the empirical consumption puzzles

The empirical literature has shown that the standard model based on the life-cycle or permanent income hypothesis does not adequately capture consumption behaviour, in particular, the empirical analysis suggests that it fails in explaining the dynamics of consumption both by excess sensitivity (Flavin, 1981) and by excess smoothness (Deaton, 1987), which are referred to as the “consumption puzzles”.

The results derived from Hall (1978) out from the standard model are usually tested by regressing consumption changes on lagged variables and testing the joint significance of the coefficients. However, those same coefficients are used to characterize the failure of the model.

Flavin (1981) describes significant coefficients on lagged income as “*excess sensitivity*” of consumption to income.¹⁶ She finds a strong over-response of consumption to current income relative to the predicted by the PIH. Her test revealed substantial evidence against the hypothesis of permanent income, which is rejected at the 5%, whereas in Hall’s test it cannot be rejected at the same significance level.¹⁷ On the other hand, changes in aggregate income are associated with relatively small changes in aggregate consumption, and deviations of consumption from its trend are smaller than those of income from its trend: aggregate consumption is “*smooth*” relative to aggregate income (Deaton, 1987). In addition, the PIH cannot explain the “persistent consumption growth even when the real interest rate has been negative” (Deaton, 1987), a property that has been dubbed as “*excess growth*” of consumption.

The textbook explanation for excess smoothness to unanticipated income changes is that consumption is determined by permanent income, which is smooth in relation to current income. Income variations generate relatively small variations in the permanent income, and thus in consumption.¹⁸ However, there is no logical necessity for permanent income being smoother than current income. In fact, Campbell and Deaton (1989) find that there is remarkably little evidence supporting that permanent income is really smoother than measured income in aggregate data. Deaton (1987) points out the implications of these results for the consumption function, arguing that permanent income is indeed “noisier” than current income. Therefore, the permanent income theory does not provide any direct and well supported explanation for consumption excess smoothness relative to income.¹⁹

However, Deaton (1991) offers one plausible explanation for the smoothness of consumption. He argues that individuals have a great amount of personal idiosyncratic information about the likely future course of their labour income, so that even if their income path looked very noisy to an observer it would contain only some surprises for the individual. This explains why consumption would be very smooth. The consumers’ extra information smooths their permanent income respect to the calculated measure of “permanent income”. So, the more information consumers have, the smoother their consumption will be.

“Excess sensitivity” is usually inferred from the correlation between consumption changes and lagged changes in disposable income or from large regression coefficients of consumption changes on proxies for income innovations. In this sense, the results of Campbell and Deaton (1989), in line with the work of Flavin (1981), show a positive correlation between the change in consumption and lagged changes in income, a correlation that should be zero if the PIH would hold. Another interpretation, however, would be that consumption displays excessive sensitivity if it evolves too closely to income, that is, if the difference between consumption and

income, or savings, varies less than the optimal forecast of discounted declines in labour income. Hall and Mishkin (1982) define excess sensitivity as the difference between the response in consumption and the annuity value of the increase in human and nonhuman wealth when an income innovation occurs as a result of it.²⁰

Many additional arguments have emerged to explain these puzzles: general equilibrium considerations, myopia, liquidity constraints,²¹ and different assumptions about the labour-income process, but none of these seem to provide as many simultaneous explanations as precautionary saving. A large number of papers (Hall and Mishkin, 1982; Campbell, 1987; Zeldes, 1989a; Caballero, 1990; Deaton, 1991; Carroll, 1994; and Hahm and Steigerwald, 1999, among others) show empirical evidence about the existence of precautionary savings and suggest that the precautionary motive for saving can explain these empirical puzzles. In general, these works test whether dropping the assumption of certainty equivalence can help in accounting for the excess smoothness of consumption (with respect to unanticipated changes in income) and the excess sensitivity (with respect to anticipated changes in income) better than the hypothesis that binding credit restrictions are the sole responsible (see Skinner, 1988; Zeldes, 1989b; and Caballero, 1990). In this sense, Zeldes (1989a) shows that there is greater sensitivity of consumption to transitory income under uncertainty than under CEQ since the result of excess sensitivity depends on higher derivatives of the utility function (moreover, excess sensitivity will occur for a class of utility functions that include CRRA and exclude CARA). Besides, Campbell and Deaton (1989) results are consistent with the assumption that consumption is smoother than it should be, given rational expectations about permanent income.

On the other hand, precautionary saving behaviour can also account, under reasonable parameter assumptions, for the “persistent growth of consumption, even when the real interest rate has been negative” (Deaton, 1987). When uncertainty is explicitly included into the model, a negative rate of time preference is not required to explain positive expected growth rates of individual consumption with low or negative real (risk-free) interest rates. This helps in solving the puzzle of how a low risk-free interest rate can be compatible in equilibrium with a high growth in aggregate consumption.²² Caballero (1990) shows that once precautionary saving is taken into account, the excess of consumption growth puzzle is consistent with the stochastic processes of labour income estimated for the U.S. (or alternatively, given the consumption path, precautionary saving can explain the relatively low real interest rate observed in the post-war U.S. data).

From the existing empirical evidence, we can conclude that under reasonable assumptions the link between precautionary saving motives and conditional heteroscedasticity of labour income

is potentially able to provide simultaneous explanations for the excess sensitivity and the excess smoothness puzzles. Under precautionary motives for saving, labour-income conditional heteroskedasticity affects the marginal propensity to consume even when the predisposition to risk does not change with the level of wealth (as is the case with the exponential utility function, CARA) (see Zeldes, 1989a).

4. The empirical evidence on precautionary savings

As it was shown above, at each period t , saving s_t is the residual between disposable income and current consumption.

$$s_t = \frac{r}{1+r} A_t + y_t - c_t \quad (11)$$

where Y_t is labour income; A_t is nonhuman wealth; r is the interest rate and, from the consumer utility optimization problem, consumption c_t (defined as the present value of wealth and the expected lifetime income) is given by:

$$c_t = \frac{r}{1+r} A_t + \left(\frac{r}{1+r} \right) \sum_{j=0}^T \frac{1}{(1+r)^j} E(y_{t+j} | \Omega_t) \quad (12)$$

where Ω_t denotes the information available at time t to the individual. Saving is future consumption; so, there is a direct link between saving decisions in the current period and expected changes in real income. In a context of uncertainty about the future, savings made by prudent individuals trying to protect themselves against risk is precautionary saving.

Empirical works on the analysis of precautionary savings differ, firstly, in the dependent variable used (in terms of equation (11): savings, wealth or consumption); secondly, in how uncertainty should be measured, that is, in the choice of the uncertainty measure, and the type of data to be used; and, thirdly, in the control variables included in the empirical analysis. We next present our review of the main contributions of the empirical literature, organising the section in terms of these different dimensions (see Table 1 for a brief summary). Some works test the effect of uncertainty on savings in an economy, once corrected by all control variables, while others go further and try to quantify the relevance of this motive for saving or try to identify how precautionary saving is different for different groups of individuals according to their characteristics and/or the characteristics of the environment in which they make decisions.

<TABLE 1>

Table 1. Summary of empirical papers

Authors	Dependent Variable	Data	Sample	Uncertainty Measure	Main results
<i>Baiardi, D., Manera, M., and Menegatti, M. (2013)</i>	consumption growth	macro (time-series)	Canada, France, Italy, Spain, UK and USA (1965-2007)	Financial risk and environmental risk	Both financial risk alone and the interaction between financial and environmental risks affect consumption
<i>Bande, R., and Riveiro, D. (2013)</i>	saving rate and consumption growth rate	macro (time-series)	Spain (1980-2007)	Expected variance of future regional output growth and unemployment rate	Existence of an important precautionary savings motive
<i>Banks, J., Blundell, R., and Brugiavini, A. (2001)</i>	consumption growth	micro (pseudo panel)	UK (1968 - 1992)	Conditional variance of income risk using income from all sources	Evidence of a strong and increasing precautionary motive for saving
<i>Barceló, C. and Villanueva, E. (2010)</i>	financial wealth	micro (pooled)	Spain (2002, 2005)	Type of labor contract of the main recipients of income as proxy of the probability of losing employment	Evidence of precautionary saving
<i>Benito, A. (2006)</i>	consumption	micro (panel)	UK (1992-1998)	Job loss risk: subjectives probabilities and predicted probabilities from a probit model	Evidence of precautionary savings when using the predicted measure but not using the self-reported measure
<i>Campbell, J. Y. (1987)</i>	saving	macro (time-series)	USA (1953-84)	Test of the predictive power of saving for declines in labor income	PIH is worth taking seriously as a description of the broad outlines of aggregate consumption behavior
<i>Carroll, C. D. and Samwick, A. A. (1997)</i>	wealth	micro (panel)	USA (1981-1987)	Income uncertainty decomposed into the variances of permanent and transitory shocks	Evidence of precautionary saving
<i>Carroll, C. D. and Samwick, A. A. (1998)</i>	wealth	micro (panel)	USA (1981-1987)	Equivalent Precautionary Premium and income variance	Substantial evidence that households engage in precautionary savings
<i>Carroll, C., Dynan, K. and Krane, S. (2003)</i>	wealth	micro (pooled)	USA (1983, 1989, 1992)	Estimated probability of job-loss	Statistically significant precautionary effect
<i>Carroll, C.D. (1994)</i>	consumption	micro (panel)	USA (1968-1985)	Equivalent Precautionary Premium, standard deviation of income and variance of income	There is precautionary saving
<i>Ceritoğlu, E. (2013)</i>	savings	micro (pooled)	Turkey (2003-2009)	Individual disposable income is interacted with predicted probability of becoming unemployed	Evidence of precautionary savings

Table 1. (cont.)

Authors	Dependent Variable	Data	Sample	Uncertainty Measure	Main results
<i>Chamon, M., Liu, K., and Prasad, E. (2013)</i>	savings	micro (panel)	China (1989-2009)	Variance of income shocks	Increase in transitory uncertainty can help explain the rising saving rates
<i>Dardanoni, V. (1991)</i>	consumption	micro (cross-section)	UK (1984)	Variance of labour income levels within each group (constructed according to economic occupations)	Around 60% of saving is due to precautionary motives
<i>Deidda, M. (2013)</i>	precautionary saving	micro (cross-section)	Italy (2002)	Earnings variability through: income variance, variance of income growth and square of average annual rate of income growth	Households appear to use precautionary saving to protect themselves against financial risk
<i>Dynan, K.E. (1993)</i>	consumption growth	micro (panel)	USA (1985)	Variance of consumption growth	Small precautionary motive
<i>Engen E. M., and Gruber, J. (2001)</i>	financial wealth	micro (panel)	USA (1984-1990)	Variation in Unemployment Insurance generosity and unemployment risk as the probability of being unemployed at a point in time	Significant negative relationship between UI generosity and wealth holdings with a stronger effect for individuals facing higher unemployment risk
<i>Flavin, M. (1981)</i>	consumption	macro (time-series)	USA (1949III - 1979I)	Changes in permanent income to the test the PIH and the excess sensitivity of consumption	Strong evidence against the PIH
<i>Guariglia, A., and Kim, B. Y. (2003)</i>	savings	micro (panel)	Moscow (1996, monthly data)	Time-varying measures of consumption growth variability	Strong evidence of precautionary saving
<i>Guariglia, A., and Rossi, M. (2002)</i>	consumption growth	micro (panel)	UK (1992-1997)	Variance of the earnings equation residuals	Strong precautionary motive for saving
<i>Guariglia, A. (2001)</i>	saving	micro (panel)	UK (1991-1998)	Earnings variability through: subjective probability of job loss, income variance, variance of income growth and square of average annual rate of income growth	There exists a significant precautionary component in saving behavior
<i>Guiso, L., Jappelli, T., and Terlizzese, D. (1992)</i>	demand for risky assets	micro (cross-section)	Italy (1989)	Subjective variance of real income (from information of variance of expected inflation and expected income growth)	The share of risky assets held decrease in presence of background risk

Table 1 (Cont.)

<i>Guiso, L., Jappelli, T. and Terlizzese, D. (1996)</i>	consumption	micro (cross-section)	Italy (1989)	Subjective earnings uncertainty based on household answers to two questions about the probability distribution of the rate of growth of their earnings, and the inflation in the year following the interview	Precautionary saving accounts for 2% of households' net worth
<i>Hahn, J. H. (1999)</i>	average net household savings and consumption growth rates	macro (panel)	OECD data for 22 countries (1960-1987)	Conditional variance of income	Precautionary saving motives are important explaining the cross-country differentials in consumption growth and saving rate
<i>Hahn, J. H. and Steigerwald, D. G. (1999)</i>	saving rate and consumption growth rate	macro (time-series)	USA (1981III-1994IV)	Conditional variance of income	Precautionary savings are an important source of observed changes on consumption and savings
<i>Hubbard, R. G., Skinner, J., and Zeldes, S. P. (1994)</i>	asset-income ratio and saving rate	micro (cross-section and panel data sets on households)	USA (70's, 80's)	3 sources : earnings, medical expenses & lifespan	Precautionary motives are important for explaining U.S. saving
<i>Hubbard, R. G., Skinner, J., and Zeldes, S. P. (1995)</i>	wealth accumulation	micro (cross-section and panel data sets on households)	USA (70's, 80's)	3 sources : earnings, medical expenses & lifespan	Precautionary saving motives and social insurance can explain aggregate wealth accumulation
<i>Kazarosian, M. (1997)</i>	wealth	micro (panel)	USA (1966-1981)	Variance of income	Strong precautionary savings
<i>Kopecky and Koreschkova (2014)</i>	wealth	micro (cross-section)	USA (2002, 2004, 2006)	Risk in earnings, out-of-pocket medical and nursing home expenses, and survival	There is precautionary saving, but the strength of it varies with the type of risk considered
<i>Liu, Z. (2014)</i>	financial wealth	micro (cross-section)	China (1995, 2002)	Reform of labor security (China's SOE reform in the late 1990s)	Support the precautionary saving hypothesis
<i>Love, D. A. (2010)</i>	share of risky assets	micro (panel)	USA (1980-2003, 1999-2005, 1992-2006)	Family shocks (marital-status transitions and children)	Differ depending the specific shock and by gender and the number and ages of children

Table 1 (Cont.)

<i>Lugilde, A., Bande, R. and Riveiro, D. (2016)</i>	consumption	micro (cross-section)	Spain (2008, 2011)	Self-perceived income shock, expectations about future income, subjective probability of job loss, job insecurity indicator, unemployment rates by five-year age groups.	Evidence of precautionary savings and also that the uncertainty sources change along the business cycle
<i>Lusardi, A. (1997)</i>	wealth	micro (cross-section)	Italy (1989)	Subjective variance of income	Precautionary wealth is about 3% of total wealth accumulation with OLS estimates but between 20% and 24% with instrumental variables estimates
<i>Lusardi, A. (1998)</i>	wealth	micro (cross-section)	USA (1992)	Variance of income using subjective probabilities of job loss	Precautionary saving motive is important
<i>Menegatti, M. (2007)</i>	expected consumption growth	macro (panel)	Italy (1981-2000)	Variance of GDP growth rates and conditional variance by means of the expectation of GDP growth	Confirm the importance of the precautionary saving motive on consumption decisions
<i>Menegatti, M. (2010)</i>	consumption growth and saving rate	macro (panel)	24 OECD countries (1950-2000)	Conditional variance of output growth	Data confirm that uncertainty increases saving but the effect of uncertainty on consumption growth is less clear
<i>Miles, D. (1997)</i>	consumption	micro (cross-section)	UK (1968, 1977, 1983, 1986, 1990)	Household income variability	Precautionary motives are important explaining households savings
<i>Mishra, A. K., Uematsu, H., and Fannin, J. M. (2013)</i>	wealth	micro (pooled)	USA (2007-2009)	Variance of income	Households facing higher income uncertainty accumulate more wealth
<i>Mody, A., Ohnsorge, F. and Sandri, D. (2012)</i>	household net saving rate	macro (panel)	27 advanced economies (1980-2010)	Unemployment rate, GDP volatility and stock market volatility	More than 40% of the increase in savings can be directly related to the increase in unemployment risk and GDP volatility
<i>Pericoli, F., and Ventura, L. (2012)</i>	consumption	micro (panel)	Italy (1989-2006)	Probability of marital splitting	Family disruption risk generates precautionary savings
<i>Skinner, J. (1988)</i>	saving	micro (cross-section)	USA (1972-73)	Income uncertainty proxied by occupation of head households	No evidence for the precautionary motive: those in riskier occupations saved less than average (self-selection)

4.1. The choice of the dependent variable

The theoretical framework summarised in Section 2 provides rationale for the use of alternative dependent variables in the econometric exercises: the consumption level (or consumption growth), savings (level, growth or the saving rate), or even wealth or its accumulation. The final choice often depends on the available data and on the specific analysis carried out.

Some authors have analysed the proportion of wealth (of a country or of a household) explained by the presence of uncertainty, or how the wealth-to-income ratio varies when a source of uncertainty is included into the model (see, Caballero, 1991; Hubbard et al., 1995; Guiso et al., 1996; Kazarosian, 1997; Lusardi, 1997, 1998; and Carroll and Samwick, 1998). In these cases, the relationship between uncertainty and an increase in wealth (or in the wealth-to-income ratio) reflects the existence of precautionary saving, which is expected to be stronger the greater the increase of wealth (in absolute or relative terms). Caballero (1991) finds that precautionary savings account for as much as 60% of total stock of wealth while Kazarosian (1997) estimates show that precautionary wealth ranges from 30 to 46% of total wealth. Carroll and Samwick (1998) find a strong precautionary saving using U.S. data and suggest that precautionary wealth is about a third of households' total wealth.

Other authors analyse the impact of uncertainty on consumption. If there is precautionary saving, uncertainty in the current period should increase savings and therefore decrease current consumption causing a positive future consumption growth and an increase in the slope of the consumption path. For example, Zeldes (1989a) or Carroll (1994) with U.S. data; Dardanoni (1991), Miles (1997) or Banks et al. (2001) for the United Kingdom; and Menegatti (2010) with OECD data, estimate consumption equations which include an uncertainty term, finding a positive precautionary motive for saving. However, also with U.S. data, Dynan (1993) finds weak evidence of precautionary saving. Benito's (2006) results for British households vary depending on the uncertainty measure used: he finds significant precautionary saving when using a predicted measure of uncertainty (objective measure obtained through a first-step probit model) but, with a self-reported subjective measure, results fail to support the precautionary saving hypothesis.

Finally, in several studies precautionary savings are analysed by using directly saving equations. Japelli and Pagano (1994), Hahm (1999), and Menegatti (2010) with OECD data; Hubbard et al. (1994) and Hahm and Steigerwald (1999) with U.S. data; Guariglia (2001) for British households; Guariglia and Kim (2003) for a sample of Muscovite households or Chamon et al.

(2013) using China's urban household data, are examples of empirical works following this avenue. All these studies find positive evidence on the existence of precautionary savings.

A particularly important point is raised by Deidda (2013). She uses precautionary saving as the dependent variable, finding evidence of its existence in Italy. In particular, Deidda (2013) uses the log of precautionary saving scaled by the desired permanent income. This approach is possible because the 2002 survey of the Italian Survey of Household Income and Wealth (SHIW) had a direct question about precautionary wealth, precluding thus for the need to estimate it.²³ The use of the subjective measure provided by the SHIW allows taking into account additional sources of risk beyond income risk (in particular, this author investigates the impact of both financial and labour income risk on precautionary wealth accumulation). Another advantage in using a self-reported measure of precautionary wealth rather than measures of effective consumption or wealth is that it helps disentangling the effect of precautionary behaviour from the effect of other contingencies (i.e. negative past shocks or financial market imperfections) which might reduce households' effective resources, giving rise to a low or null amount of wealth held for precautionary reasons (a bias towards zero wealth accumulation).

4.2. The measurement of uncertainty

In addition to the different issues addressed so far as regards the existence of precautionary saving and its analysis, the most important unresolved issue is how to measure uncertainty. Standard theoretical models of consumer behaviour show that the optimal pattern of consumption is described by an Euler equation, which relates the expected growth of future consumption with the conditional variance of consumption growth rate (see Attanasio, 1999).²⁴ However, as pointed by Carroll (1992), the latter cannot be directly estimated empirically since the conditional variance may be an endogenous variable depending on the accumulated wealth. This problem has been solved in the literature replacing this variable by different measures of the uncertainty on future income growth (see, Hahm, 1999; Menegatti, 2007, 2010; Mody et al., 2012; among others).

Before reviewing these alternative measures, we must take into account some considerations about the Euler equation. Hubbard et al. (1994) claim that the Euler equation may not be satisfied in two ways: "First, if there are binding borrowing constraints, so that households could be placed in a corner solution, consuming all their cash and desiring to borrow to increase their consumption. Second, the nonlinear Euler equation could be satisfied but the log-linear approximation to the Euler equation could generate apparent rejection", (Hubbard et al., 1994, p. 87). Also, Hahm and Steigerwald (1999) show that the sign of the coefficient of income

uncertainty is unclear in the standard Euler equation (they use a model of a representative consumer who lives infinite periods, has a utility function of the CARA type, and maximizes the expected present value of lifetime utility). Moreover, Lusardi (1993), combining data from the Consumption Expenditure Survey (CES) and the Panel Study of Income Dynamics (PSID) for the United States, concludes that the Euler equations are strongly rejected for all the consumption types included in the former: food consumption, “strictly nondurable consumption” (includes the lowest amount of durable goods) and non-durable consumption (includes goods which can be considered durables or semi-durables). In addition, Zeldes (1989a) claims that “the test using aggregated data generally rejects the Euler equation” (Zeldes, 1989a, p. 294).

Determining the adequate measure of income uncertainty is a complex task. There is no consensus in the literature about which measure better reflects the effect of uncertainty on consumption and saving decisions. But there is also a lack of consensus as regards the type of data that should be used, and this is the first issue we deal with: the use of macroeconomic or microeconomic data; each alternative has a number of advantages and disadvantages and, in addition, the measures of uncertainty that can be derived will differ.

Aggregate measures of income uncertainty (based on macroeconomic data) present several advantages. They are easily accessible, because, in general, there is more availability of macro data and, in addition, the time dimension is usually longer than the typically found in micro data. The use of macroeconomic data allows for comparisons between countries or areas since they have a more homogeneous construction methodology than micro data (based largely on surveys whose questions and possible answers do not necessarily coincide across countries). Furthermore, there are variables such as the unemployment rate, which are important sources of uncertainty (see, for example, Bande and Riveiro, 2013), but that can only be applied in a macroeconomic context, since they cannot be calculated at the household level.²⁵

However, aggregate measures are not likely to provide a good indicator of the uncertainty faced by individuals given that consumption (and saving) decisions are taken at the micro level (individual or household).²⁶ Therefore, micro data should be a better option than the aggregate data since the latter cannot be used to measure the specific risk of households, which may be far more relevant to consumers than the effects of a general economy shock (see Miles, 1997). In any case, micro-level data can also be affected by different problems related to uncertainty measurement. Microeconomic data are generally obtained from surveys which portray the uncertainty *measured* by econometricians, but it is likely that individuals have more information about their future income. Therefore, the measured uncertainty does not necessarily correspond

to the true uncertainty faced by the individual. Furthermore, even if this is not the case, the uninsurable component of labour-income risk may be lower than the measured income uncertainty. For instance, households could have insurances reducing non-diversifiable risk (see Caballero 1991). On the other hand, studies at individual or household level usually cover short time periods (at least shorter than those using macro data), which prevents a good understanding of the degree of persistence of labour income shocks, a relevant issue in the setting of linkages between income uncertainty and human wealth.²⁷

Both in terms of micro and macro data, several alternative measures of uncertainty have been used in empirical works. A wide branch of the literature has estimated uncertainty by the income variability; other authors have used the variability of consumption or expenditure, while others take variables related to the labour market, mainly the unemployment rate.

Income variability

Traditional but “atheoretical” measures of income uncertainty are based on the standard deviation or the variance of income (see Zeldes, 1989a; Dardanoni, 1991; Blundell and Stoker, 1999; among others). At the micro level, some examples in this direction are Caballero (1991), who measures labour income uncertainty by the standard deviation of the percentage change in the annuity value of human wealth, or Miles (1997), who uses the variance of income and its standard deviation (based on household characteristics and estimated cross-section relationships between these characteristics and the unforecasted component of income, or its square). Both find a strong precautionary saving using U.S. and U.K. data, respectively. On the other hand, using panel data for the United States, Kazarosian (1997) proxies individual-specific income uncertainty by the standard deviation of the residual of the estimated (log)income–age profile of each individual; while Guariglia and Rossi (2002), using British data, calculate the variance of the earnings equation residuals in the following year as income volatility. Both works show evidence of precautionary saving.

A theory-based measure of income uncertainty is the Equivalent Precautionary Premium (EPP) derived by Kimball (1990) and used by Carroll (1994) and Carroll and Samwick (1998) taking the Italian PSID data. Carroll (1994) uses two additional measures: the variance of normalized income and its standard deviation, and finds that in spite of a negative relationship between consumption and the three measures, the EPP performs best. Carroll and Samwick (1998) include in their wealth equations the log of the variance of the log-income as an atheoretical measure of uncertainty (besides the log of the relative Equivalent Precautionary Premium)

finding that coefficients on both variables are highly significant for the three measures of wealth considered, namely very liquid assets, non-housing non-business wealth and total net worth.

All of the measures of income uncertainty reviewed so far are *objective measures* (calculated or predicted) but *subjective measures* can also be an alternative. Guiso et al. (1992) and Lusardi (1997), using Italian data from the 1989 Survey on Household Income and Wealth (SHIW), find scant conclusive evidence in favour of the hypothesis of precautionary saving.²⁸ They analyse precautionary saving by constructing a measure of subjective earnings uncertainty based on household answers to two questions about the probability distribution of the rate of growth of their earnings, and the inflation in the year following the interview.

At the macro level, income uncertainty has been proxied by measures of the variability of GDP. The most commonly used measures of uncertainty about the growth of future output are the variance of income and the conditional variance of income²⁹ (or income growth rates). Using data for different OECD countries, Hahm (1999) and Menegatti (2010) find a positive relationship between aggregate GDP variability and savings. Menegatti (2010) finds, however, that the uncertainty effect on consumption growth does not seem to be strongly supported by the data. In his work, Hahm (1999) assumes that the process describing the series of GDP growth is the same for each country while Menegatti (2010) tries to overcome this limitation computing a measure of uncertainty which allows heterogeneity in the stochastic processes, selecting for each country the best ARMA process describing the series. On the basis of the ARMA model, he next computes conditional variability. Menegatti (2007) studies the effects of precautionary saving in Italian regions through two different measures for income uncertainty. The first is a measure given by the variance of GDP growth rates while the second is obtained by computing the conditional variance by means of the expectation of GDP growth. The results obtained confirm the importance of the precautionary saving motive on consumption decisions. Hahm and Steigerwald (1999) also use aggregate data in their study of precautionary saving in the United States. They measure uncertainty by computing expected growth using data from a survey of U.S. income forecasts, and their results support the existence of precautionary saving.

Variability of consumption/expenditure

A second branch of literature has proxied uncertainty by the variability of consumption expenditures. Dynan (1993) states that “consumption variability is a better measure of risk because the consumption of an optimizing household changes only in response to unexpected changes in income, which represent true risk” (Dynan, 1993, p. 1105). She approximates income uncertainty by the variance of consumption growth, finding a precautionary motive in

the U.S. which is too small and inconsistent with plausible risk-aversion parameters. Dynan (1993) includes financial risk as Guariglia and Kim (2003), who, in contrast, find strong evidence of a precautionary motive in a panel of muscovite households. In the same line, Baiardi et al. (2013) test the precautionary saving hypothesis for six advanced economies,³⁰ controlling for financial risk and background risk (measured either by medical expenses or a proxy for environmental risk). Their test is based on both measures and on their interaction. They find a positive and significant effect of the interaction of financial and environmental risks on consumption growth.

Unemployment

During economic downturns uncertainty about the future rises, and a good deal of uncertainty about future income is explained by rising unemployment. Therefore, another branch of the literature has chosen to proxy uncertainty by the probability of continuing to receive labour income in the future. This is closely related to the probability of being employed and therefore to the unemployment rate. As Deaton (2011) points out, unemployment typically has a greater negative impact on welfare than can be accounted for by reductions in income. Since most consumers get their income from labour, losing the job is the largest negative shock on income, and the risk of future episodes of unemployment should be a good indicator of uncertainty (see Malley and Moutos, 1996; Lusardi, 1998; Guariglia, 2001; Carroll *et al.*, 2003; Benito, 2006, for a discussion).

In empirical works, income uncertainty due to the unemployment risk is proxied by different variables. Studies based on micro data have made use of the *ex-ante* (subjective and/or predicted) probability of becoming unemployed, which is estimated on the basis of individual characteristics (Carroll et al., 2003). The works from Lusardi (1998), Guariglia (2001), Benito (2006), Ceritoglu (2013) or Lugilde et al. (2016) follow this path. The first calculates a measure of income risk from subjective probabilities of job loss provided by the first wave (1992) of the Health and Retirement Study (HRS) for the U.S. The interviewed individuals are asked to evaluate the probability of losing their jobs during the year following the survey.³¹ From that information Lusardi (1998) derives a measure of income variance (which is used in the estimation of the precautionary saving model) and finds that those perceiving a higher income risk are those saving more and accumulating more wealth. However, the contribution of precautionary saving to wealth accumulation is not very large and certainly cannot explain the wealth holdings of the very rich. Guariglia (2001) and Benito (2006) construct several uncertainty measures and test precautionary saving by using different waves of the British Household Panel Survey (BHPS). On the one side, Guariglia (2001), as Lusardi (1998),

constructs a first measure as a function of the perceived subjective probability of job loss by households.³² Moreover, she estimates three additional household specific measures of earnings uncertainty, concluding that there is a strong precautionary motive for saving whatever the uncertainty measure considered.³³ Benito (2006) follows two approaches to measure uncertainty: firstly, the subjective probability of becoming unemployed in the next twelve months, and secondly, the predicted probability of job loss (calculated from a probit model), finding different results for each measure. Predicted probabilities provide more variation in the levels of job insecurity in comparison with the dummy for subjective feelings of job insecurity. With the self-reported measure, Benito's results are that job insecurity does not decrease current consumption, and therefore he concludes that from this perspective there is not precautionary saving. But by using the estimated measure of risk he finds evidence of significant precautionary saving effects associated with unemployment risk and job insecurity.³⁴

Ceritoglu (2013), using the predicted probability of becoming unemployed derived from a first stage probit model, and Lugilde et al. (2016) using the subjective information from a similar question to the BHPS used by Guariglia (2001), construct the same measure of labour income risk as in Lusardi (1998) and Guariglia (2001). Ceritoglu (2013) finds evidence of precautionary saving for Turkish households while Lugilde et al. (2016) show that this subjective measure does not exert any effect in household consumption decisions for a sample of Spanish households.

On the other hand, for the Spanish economy, Barceló and Villanueva (2010) using data from the *Encuesta Financiera a las Familias* (EFF) (2002 and 2005 waves) analyse the hypothesis that the existence of precautionary saving implies that households perceiving greater job instability postpone their expenses (i.e., these households would show higher consumption growth rates than those households with a low probability of becoming unemployed, whose consumption patterns will be more stable over time). They approximate the probability of job loss by the type of contract of the main earner, finding that consumption growth (mainly for total nondurable consumption) is higher for households whose income earners are more exposed to risk of job loss than for those who are not. Using the same database, but for the 2008 and 2011 waves, Lugilde et al. (2016) find evidence of strong precautionary saving and also that the uncertainty sources change along the business cycle. For the expansive periods, the unemployment rate typically remains low and stable and the characteristics of the job (e.g., whether it is temporary or not, seniority, firm size, etc.) are those that influence the amount of precautionary saving. During recessions, even though these characteristics are still important, a high and rising unemployment rate becomes the main uncertainty source of households in which the reference

person is a dependent employee. These authors get these results by using a job insecurity indicator, which is included in their consumption estimations alongside the unemployment rate.

A different approach is adopted, for example, by Banks et al. (2001), who construct terms of conditional variance of income risk but also capture changes in unemployment risk, as well as changes in uncertainty related to income or wages, considering all income sources not just earnings or wages, (they also include in the equations work status variables and unemployment rates as instruments). Their results show evidence in favour of a strong and increasing precautionary motive for saving for the British households.

When macroeconomic variables are used to proxy uncertainty on the labour market status, the usual practice is to use either the observed unemployment rate (Mody et al., 2012) or subjective measures based on consumer opinion surveys on unemployment expectations (Carroll and Dunn, 1997); in both cases the conclusion is that savings increase as unemployment rises or expectations worsen. Some works following this approach are those of Mody et al. (2012), who analyse the relationship between saving rates and different sources of uncertainty (they use the aggregate unemployment rate as a proxy of income loss risk, and an alternative based on GDP volatility “to capture other aspects of income volatility not strictly linked to unemployment risk”). They find that the saving rate is positively correlated with both measures of uncertainty, i.e., both are highly significant in explaining the evolution of saving rates in 27 advanced economies. The unemployment rate and the saving rates are correlated even after controlling for disposable income growth and for the interest rate.³⁵ Bande and Riveiro (2013) follow a similar approach using regional data from the 17 Spanish regions. They test the precautionary motive for saving considering two types of uncertainty measures: the regional unemployment rate and the future income volatility (they calculate the expected variance of future regional output growth). Following Menegatti (2010), they compute the expectation of the output growth rate on the basis of the specific dynamics of GDP in each region, and conclude that there exists a precautionary motive for saving, especially when the level of uncertainty is variable and persistent over a period of time.

4.3. The control variables

Consumption and saving decisions, as well as wealth accumulation, are influenced by the consumer’s or household’s economic situation, the perceived uncertainty, but also by the household or individual characteristics and the existence of credit market constraints, among others. Thus, broadly speaking, precautionary saving depends on the personal characteristics of the individual taking consumption and savings decisions, and on the environment in which these

decisions are made, especially, the existence of public insurances and credit constraints. The empirical works on this topic widely differ on the type of control variables included in the estimations. Next we explore this dimension in our review of the empirical literature.

Firstly, consumption (and saving) decisions must depend on available resources (and/or the ability to borrow, i.e., the existence of liquidity constraints). Therefore, income should be an important determinant of consumption. Thus, current income is often included within the set of covariates (see, for example, Caballero, 1991; Miles, 1997; Hahm and Steigerwald, 1999; Guariglia, 2001; Menegatti, 2010). Lagged income has also been used as an explanatory variable (see Menegatti, 2007; or Bande and Riveiro, 2013; among others). Moreover, income can be decomposed into its transitory and permanent components (see Kazarosian, 1997; Lusardi, 1997; Guariglia, 2001; Benito, 2006; Deidda, 2013; or Liu, 2014; for example). The different income sources have also been controlled for, either those stemming from the labour market or those from other sources, such as investments (Miles, 1997, or Benito, 2006, include income from investments in their estimations).³⁶

Likewise, equations can include past consumption to capture habit formation (see, for example, Guariglia and Rossi, 2002) or different types of wealth (real, human or financial). Thus, previous year wealth is often included in the consumption equations (Caballero, 1991; Hubbard et al., 1994; for example), while Zeldes (1989a) or Carroll (1994), among others, include current human and financial wealth.³⁷

In most regressions, family dummies are included to capture the family-specific effects. Some of them, depending on their availability, are family size or composition (see, for example Skinner, 1988; Lusardi, 1993, 1997; or Banks et al., 2001), existence/number of children, dependent children³⁸ (as in Miles, 1997; Kazarosian, 1997; Lusardi, 1997; Carroll and Samwick, 1998; or Guariglia and Kim, 2003) and the number of income recipients³⁹ (Dynan, 1993; Lusardi, 1998; Guariglia and Kim, 2003; or Lugilde et al., 2016, among others). Other variables reflecting personal characteristics commonly used are age (it allows analysing consumption/income profiles by age), sex, race, marital status, health or education (see, for example, Guiso et al., 1996; Kazarosian, 1997; Carroll and Samwick, 1998; Lusardi, 1998; Guariglia, 2001; Benito, 2006; or Deidda, 2013).

As regards education, an increase in the education level may imply a lower temporal preference rate and therefore foster more savings (see Kazarosian, 1997). Dynan, 1993; Lusardi, 1993; Guariglia, 2001; Chou et al., 2006; Kureishi and Wakabayashi, 2013; Mishra et al., 2013; or

Lugilde et al. 2016; include education as a control variable and, in general, results show that more educated households save more.

Health status is included by some authors due to the assumption that individuals with poorer health have a higher probability of unforeseen medical expenses and, therefore, they will save more. Given the different types of public health systems coverage, this variable will be more relevant in some countries than in others. In this line are the results from Deidda (2013) or Guiso et al. (1996) for Italy, proxying health by the number of days the person was ill during the year previous to the survey, or the results of Lusardi (1998) using US data and measuring wealth through a set of dummies of self-reported health status. Guariglia (2001) and Benito (2006) also use a self-reported measure from UK households (both from the British Household Panel Survey, BHPS) and, while the former finds that health status does not have a statistically significant effect on savings, the latter shows that poor health status increases the probability of job insecurity (more uncertainty). In contrast, Kazarosian (1997) using health dummies (self-reported status of health) from US data, finds that, contrary to predictions, an individual in worse health saves less than one in better health.

Since unemployment episodes are one of the main factors behind income variations, there are many job-related variables that can be used to analyse which individuals are more likely to have precautionary savings. At the macro level, the variance of (regional) unemployment can be included in the set of independent variables or as instrument (for example, Lusardi, 1997, uses the regional unemployment rate as an instrument for subjective earnings variance), but at the micro level, assigning a reference unemployment rate to individuals may not be possible. Therefore, other variables that could be considered are union membership, hours worked, years of experience, employer size, job insecurity or whether the individual was unemployed in the previous year. In general, the first four variables have a negative relation with uncertainty (see Lusardi, 1997; Miles, 1997; or Benito, 2006; among others) while for the latter two the relation is positive.

The individual's type of occupation is another of the covariates most commonly found in the literature. Leland (1968) and Sandmo (1970) point out that we should expect that self-employed, farmers or sales workers "save more, as their incomes are more variable" (Leland 1968, p. 471). Deidda (2013) finds similar results for Italian households and Mishra et al. (2013) obtain that U.S. self-employed farm households accumulate more wealth. Using U.S. data, Skinner (1988) investigated the hypothesis that the average saving rate should be higher for those in riskier occupations (he approximates uncertainty through different occupation proxies). Contrary to expectations, Skinner finds that saving rates are lower for occupations with

presumably higher income uncertainty (such as self-employed and sales workers). Carroll (1994), Kazarosian (1997) and Lusardi (1997) also find results in this line. The impact of occupation might be ambiguous due to a possible self-selection bias (i.e., workers with lower risk aversion choose professions or jobs with higher income risk). The amount of savings by occupation levels depends on the different workers' risk aversion, and therefore this control variable may be a bad proxy for income risk. Carroll (1994) offers another possible explanation for lower savings of workers with riskier incomes. He asserts that "people with high income save more, regardless of the effect of uncertainty" (Carroll, 1994, p. 141), and thus if workers with riskier incomes are also workers with lower income, they will save less, regardless of uncertainty or self-selection.⁴⁰

Since the uncertainty perceived by individuals is affected by their own characteristics and/or the characteristics of the environment in which they make decisions, (as for instance the existence of a welfare system), precautionary saving may also be affected by the latter. Therefore, in recent years there is a growing literature following a rather different methodological approach: some control variables are used to cluster individuals into different groups (according to certain common characteristics) and then the effect of uncertainty on consumption/saving decisions among the different groups is analysed. Some examples are presented below.

Potential changes in the family structure constitute an important source of risk: the financial position changes when people marry, divorce or have children, as wealth increases or divides, and the spending needs and the expected future income of household change (see Love, 2010). Being so, some works analyse differences in the precautionary behaviour of individuals according with their marital status or gender Pericoli and Ventura (2012), using data from the Italian Survey on Households Income and Wealth, show that an increase in the objective probability of family dissolution has a negative impact on non-durable consumption and a positive impact on household precautionary saving (they estimate that precautionary saving accounts for 11% of total household savings). Kureishi and Wakabayashi (2013) analyse wealth for a sample of Japanese single women, taking two groups: those who do not expect to get married within the next three years, and those expecting to be married in the same period. Their results show that single women who are not likely to get married within three years have higher wealth target for preparing for illness, disaster, and emergency as well as for retirement, that is, expectations of remaining single in the future cause women's precautionary savings. They also conclude that the higher a single woman's annual income, the higher her wealth target for precautionary purposes.

In relation with differences by the age of the individual, Chamon et al. (2013) conclude that Chinese households with younger heads respond more strongly to a shock to the transitory variance of income, and their argument is that households with the youngest household heads need to save more in order to build a buffer stock of savings. Kopecky and Koreshkova (2014) highlight the difference in the uncertainty sources for young and elderly: during the working period individuals face earnings uncertainty but retired individuals face uncertainty with respect to their survival as well as medical and nursing home expenses (Kopecky and Koreshkova, 2014, p. 2). Their results show that precautionary saving account for 12% of aggregate savings in U.S., and they conclude that saving is made in order to self-insurance against old-age health expenses given the absence of complete public health care for the elderly.

As mentioned earlier, uncertainty about the future and its effect on consumption/saving decisions are greatly affected by the existence of insurances covering unforeseen events, specially health and unemployment insurance. In fact, there is a growing concern about the design, the implementation and the required changes in health and unemployment insurance systems to guarantee their sustainability. In this regard, there are a large number of studies relating the consumption/ saving decisions with the existence of this kind of insurances for countries with very different systems. Liu (2014) points out that the policy reforms in China have increased job uncertainty, fostering precautionary saving, due to the gradual abolition of guaranteed lifetime employment and benefits. Ceritoglu, 2013, in his study on household saving decisions in Turkey, shows that health insurance coverage is an important factor affecting workers' participation in the workforce (and hence on precautionary saving), since most individuals get health insurance and social security coverage through their employment contracts (Ceritoglu, 2013, p. 117). Gruber (1997), using annual observations on food consumption expenditures from the PSID, finds strong evidence that unemployment insurance smooths the individual consumption of American households. The results from Engen and Gruber (2001) are in the same line. Using U.S. micro data, they find that a reduction in the unemployment benefit increases gross financial asset holdings and that this effect is stronger for individuals facing higher unemployment risk and weaker for older workers. Since the young have low savings and high incentives to find a job, Michelacci and Ruffo (2015) claim that the unemployment benefits should be more generous for the young; this result is consistent with that of Engen and Gruber (2001): the effect of a change in the unemployment insurance is stronger for young workers. On the other hand, estimations of Chou et al. (2006) show that the introduction of National Health Insurance in Taiwan decreased households' savings by 1% to 10%, depending on the econometric technique used. Also, using Taiwanese data, Kuan and Chen (2013) find that the National Health Insurance (NHI) has a negative effect on households

savings. They also show that the NHI has greater impact on the households with higher income and those with retiring head, mainly on high savers in these groups (high savers tend to have a greater reduction in savings after the national insurance is enforced)

As explained earlier, precautionary savings exist because under an uncertainty context individuals behave prudently and they decrease the consumption rate, increasing the rate of saving. Being so, the higher the financial literacy of individuals, the better the individual's perception on the existence and consequences of uncertainty would be and, therefore, the greater the effect of uncertainty on savings. In fact, in the last years there is another growing branch of the literature analysing the relationship between individual or household saving decisions and their level of financial literacy. Bernheim et al (2001), in a study for the US, find that financial education at high school increases the rate at which individuals save and accumulate wealth during their adult lives. Van Rooig et al (2012) also find evidence of a positive relationship between financial literacy and wealth accumulation in the Netherlands, and the reason for that result, according to the authors, is that "financial literacy knowledgeable individuals are more likely to invest in stocks and have a higher propensity to plan for retirement" (p. 471). In this regard, several works analyse the relationship between financial literacy and retirement planning or retirement saving adequacy (see, Lusardi and Mitchell, 2011, for the US; Alessie et al., 2011, for the Netherlands or Bucher-Koenen and Lusardi, 2011, for the case of Germany). However, greater financial education does not always guarantee better financial decisions and higher savings rates. In fact, the results of the effects of previous financial literacy efforts and household saving decisions are mixed (see Gale et al, 2012, for a review of several studies).

A final set of explanatory variables commonly included in precautionary savings estimations are related to the credit market and household's financial status. Guariglia (2001), for example, takes into account whether households expect their financial situation to deteriorate or to improve, if it is worse or better than expected, and if it is simply good or bad. Additional variables can be whether the household received help from parents or friends, the financial development at regional level, whether the households owns a credit card or the number of years of relationship with a bank. Some of these variables are included by Guiso et al. (1992) or Deidda (2013), for example. The former show that one explanation for Italy's high savings rate is the relatively low level of development of financial markets while the latter finds that Italian households receiving help from relatives significantly reduce their need to save for precautionary motives.

Finally, we should point out that the existence of credit constraints has generated a considerable discussion in the literature in terms of their likely effect on precautionary saving.⁴¹ It is unclear how the existence of liquidity constraints influences consumption and saving decisions. The PIH assumes that individuals can borrow at the same interest rate they receive for their savings. But usually the interest paid on credit card debt, car lettering, and other types of loans is much higher than the interest on financial assets in which saving can be allocated. In addition, some individuals have reached the limit of its borrowing capacity and cannot keep borrowing whatever the interest rate is. Therefore, in those studies in which the PIH is rejected empirically, liquidity/borrowing constraints are often suggested as a possible explanation.⁴² Borrowing constraints may influence consumption and saving decisions but it remains unclear how these relate to precautionary saving: whether they are substitutes, i.e., the existence of credit constraints imply the non-existence of precautionary saving, if borrowing constraints reinforces income risk effects or even if they are not related.

Some authors avoid including liquidity constraints in their analysis of precautionary savings (see, for example, Zeldes, 1989a). Others include them and find that they may induce precautionary saving even when utility is quadratic, i.e. the imposition of liquidity constraints turns the consumption function concave (see, for example, Carroll and Kimball, 2001);⁴³ or that they can increase aggregate savings with cross-section variation of income even in the absence of uncertainty (Feigenbaum, 2011). On the other hand, the presence of income risk affects the relationship between borrowing constraints and the composition of the household portfolio. Households expecting to be liquidity constrained hold less risky assets. The general conclusion is that liquidity constraints may increase savings in two ways. On the one hand, when the liquidity constraint becomes a spending limit, the individual will consume less than he would does otherwise. This happens because if an individual would like to transfer additional resources from “tomorrow” to “today” but he is limited in doing so, the marginal utility of consumption “today” respect to “tomorrow” should be greater than the one predicted in a model without constraints (Zeldes, 1989b). On the other hand, even when such restrictions do not impose spending limits, the threat of future restrictions discourages present consumption. Liquidity constraints encourage individuals to save in order to insure them against the effects of future income falls. In this sense, liquidity constraints interact with and reinforce the precautionary saving motive (Deaton, 1991; Deidda, 2013; Blundell et al., 2014), i.e. the effect of borrowing constraints reinforces that of income risk (Guiso et al., 1992).

5. Conclusions

This paper presents a comprehensive review of the literature on precautionary saving where saving is defined as the difference between disposable income and consumption expenses, and therefore the determinants of consumption also determine savings. In the context of the standard LC/PIH model, savings smooths the consumption pattern, which should be financed with an irregular (but certain) income flow. In this case, there is no risk and there is no need to be prudent, but only to assign optimally. Once we introduce uncertainty about future income, since individuals tend to behave prudently, precautionary saving arises. The models show that if the assumption that the utility function is quadratic is removed (and it is assumed instead that the marginal utility is convex, $u'''(\cdot) > 0$), uncertainty affects consumption and savings decisions and generates an extra positive saving, the precautionary saving. In other words, an increase in uncertainty about future income will reduce current consumption and will alter the slope of the consumption pattern.

The consideration of precautionary saving allows to give a satisfactory explanation to some inconsistencies reached in the empirical tests of the standard theory of consumption, which have been dubbed as the consumption puzzles.

Since saving is defined as a residual, most of the empirical works on precautionary savings take as the dependent variable either accumulated wealth or consumption, and in general they use micro data because they best capture consumption and saving decisions, which are decisions taken at the individual level. In addition to income and wealth, a number of control variables are included in the explanation of savings. Not only socio-demographic variables (like gender, age, marital status, children, education or financial literacy) are commonly used to control for characteristics of individuals (or to group them to analyse the different uncertainty effect on savings decisions) but also the risk coverage of unemployment or health through public insurances are considered. The main problem that arises when analysing the uncertainty effects on consumption and saving decisions is how to measure uncertainty and in fact the empirical literature has not reached a consensus about taking subjective or objective measures nor about the particular uncertainty proxy. Not only it is necessary to find a measure which is consistent at a theoretical level, but the difficulties involved with missing data or its adequacy must also be added.

Although most of the reviewed works find evidence of precautionary motive for saving, there is not a consensus on the magnitude of the precautionary saving and some works conclude that this motive is nearly irrelevant. Therefore, there is still much to be done and the contributions that can be made in this field are numerous.

Acknowledgements: Alba Lugilde acknowledges financial support from the Spanish Ministry of Education through the FPU grant FPU13/01940. Comments from other members of the GAME research group are acknowledged. Remaining errors are our sole responsibility.

Notes

* Corresponding author. Address: IDEGA, Avenida das Ciencias, Chalet nº 1. Campus Vida, University of Santiago de Compostela. 15782 Santiago de Compostela. A Coruña (Spain). Phone: +34 881 814 339. E-mail: alba.lugilde@usc.es.

¹ Pratt (1964) is the seminal reference for the theory of risk aversion.

² Although we include references to works using macroeconomic data, this survey is focused mainly on studies using microeconomic data.

³ A review of the literature on the evidence of precautionary savings using exclusively U.S. data is provided by Browning and Lusardi (1996).

⁴ Attanasio (1999) and Attanasio and Weber (2010) provide a comprehensive survey of the standard model of the consumption/saving decisions.

⁵ Although the standard Life Cycle Model of saving decisions is widely used in the literature, there is an increasingly developed alternative approach stemming from the behavioral economics. Behavioral models of savings consider that individuals do not decide how much to save in order to smooth consumption over time by solving in each period the standard optimization problem as economist would suggest; for several reasons. Essentially, they consider that, in general, households have not the ability to solve the hard dynamic optimization problems and compute the correct saving rate. This problem would be partly solved by a greater level of financial literacy. There is a growing literature relating financial decisions, particularly savings, and the financial literacy level of individuals (an overview in Lusardi and Mitchell, 2014). But, even being able to compute the optimal consumption-saving plan, households may not have sufficient willpower to execute this plan: households might lack the “*self-control*” to reduce current consumption in favour to future consumption, showing also a tendency to “*procrastination*” (Thaler, 1994; Laibson, 1997; Thaler and Benartzi, 2004; Gul and Pesendorfer, 2004). In this survey, focused on precautionary saving by prudent individuals who try to protect themselves against the future risk, we do not deal with the literature focused on that alternative approach on saving.

⁶ What the equation really shows is that individuals try to keep the marginal utility of expenditure constant over time; but since expenditure and the marginal utility of expenditure are monotonically related, this leads to smoothing of consumption.

⁷ The temporal distribution of income is not relevant for consumption, but is relevant for savings. While consumption in one period is a function of current, previous and future income, savings are defined as the difference between current income and current consumption.

⁸ Rather, the empirical analysis suggests that the PIH fails in explaining the dynamics of consumption both for excess sensitivity (Flavin, 1981) and for excess smoothness (Deaton 1987). We will address this issue in Section 3.

⁹ Both the time preference rate and the interest rate can be assumed as constant among households and over time or not. For example, Benito (2006) or Chamon et al. (2013) assume the former specification, while Dynan (1993) assumes that the time preference rate is constant among households and over time but that the interest rate is different among households. Zeldes (1989b) allows each family having a different preference rate and Attanasio and Weber (2010) take the preference rate varying over time.

¹⁰ In general we will consider uncertainty regarding future income, but uncertainty may be associated with other future exogenous variables, including demographic variables or the environment in which individuals make their decisions (Browning and Lusardi, 1996).

¹¹ Menegatti (2001) shows that the positive third derivative of the utility function is implied by the assumption that the sign of $u'''(\cdot)$ is invariant when the level of c_t changes.

¹² Leland (1968) was the first to theoretically analyze the existence of precautionary saving in a two-period model. Then, Sandmo (1970) and Drèze and Modigliani (1972) expanded Leland's two period approach, while Miller (1974, 1976) and Sibley (1975) continued the analysis in a multiperiod context.

¹³ In addition, Menegatti (2001) relates these terms (prudence and risk aversion) with the third and fourth derivatives of the utility function since $d^3U(c)/dc^3 > 0$ is a necessary condition for decreasing absolute risk aversion (DARA) while $d^4U(c)/dc^4 < 0$ is a necessary condition for decreasing absolute prudence (DAP), which implies that precautionary saving declines as individual wealth rises (Kimball, 1990).

¹⁴ Pratt's principle of decreasing absolute risk aversion is sufficient to obtain a positive sign on the precautionary demand for savings (Leland, 1968; Sandmo, 1970).

¹⁵ The coefficient of relative risk aversion ρ indexes the strength of both risk aversion and prudence. With this utility function, the main necessary condition for generating a "buffer stock" saving behavior is that, if income were certain, consumers would wish to spend more than their current income. The analytical condition which guarantees this in the discrete-time version of the model with only transitory shocks to income is $(R\beta)^{-1/\rho} < G$, where $R = 1 + r$ is the gross interest rate, $\beta = 1/(1 + \delta)$ is the discount factor (being δ the discount rate) and $G = 1 + g$, being g the expected growth rate of income. Under a broad range of parameter values as long as consumers are prudent ($\rho > 0$) and impatient ($\rho^{-1}(r - \delta) < g$) this conditions holds.

¹⁶ Flavin (1981) tests the hypothesis that the consumption response to a previously anticipated change in income should equal zero. She tests for excess sensitivity to anticipated changes in income.

¹⁷ Hall (1978) uses a broader definition of consumption (nondurable and services consumption) while Flavin (1981) uses only consumption on nondurable goods.

¹⁸ If the smoothness of consumption relative to income is taken to measure the relative variance of variations, smoothness is explained by the permanent income theory.

¹⁹ Sluggish adjustment of consumption would reconcile all the evidence, and permanent income could be less smooth than current income without contradicting the known smoothness of consumption (Campbell and Deaton, 1989).

²⁰ This definition of excess sensitivity differs from Flavin's (1981).

²¹ For example, Guariglia and Rossi (2002) point out that the existence of liquidity constraints is one of the most accredited explanations for the excess sensitivity of consumption to disposable income. They find that consumption changes do not exhibit "excess sensitivity" to income changes, which they interpret as indicating that the assumption that preferences are separable over time is erroneous and it might play some role in the empirical failure of the life-cycle/permanent income model. However, Zeldes (1989a) finds that consumption will exhibit excess sensitivity to transitory income and high expected growths of consumption, relative to the simple PIH benchmark, even in the absence of borrowing constraints.

²² The extra growth in aggregate consumption will be a function of the uncertainty on individual income, which is significantly larger than on average aggregate income (Zeldes, 1989a).

²³ The question is as follows: *"People save in various ways (depositing money in a bank account, buying financial assets, property, or other assets) and for different reasons. A first reason is to prepare for a planned event, such as the purchase of a house, children's education, etc. Another reason is to protect against contingencies, such as uncertainty about future earnings or unexpected outlays (due to health problems or other emergencies). About how much do you think you and your family need to have in savings to meet such unexpected events?"*

²⁴ Usually, the Euler equation includes also income growth, to capture the existence of liquidity constraints or myopia effects of the consumers who consume all of their income.

²⁵ Among the works using macro data we highlight the contributions of Hahm (1999), Hahm and Steigerwald (1999), Lyhagen (2001), Menegatti (2007, 2010), Mody et al. (2012) or Bande and Riveiro (2013).

²⁶ According to Browning and Lusardi (1996), this is the reason for just considering works using micro data in their review of the empirical literature on savings.

²⁷ Among the group of works using micro data we highlight the contributions of Hall and Mishkin (1982), Skinner (1988), Zeldes (1989a, b), Guiso et al. (1992, 1996), Dynan (1993), Lusardi (1993, 1997, 1998),

Carroll (1994), Carroll and Samwick (1997), Kazarosian (1997), Miles (1997), Banks et al. (2001), Guariglia (2001), Guariglia and Kim (2003), Benito (2006), Deidda (2013) and Lugilde et al. (2016).

²⁸ Precautionary saving accounts for 2% of households' net worth according to Guiso et al. (1992). Lusardi (1997) finds that precautionary wealth is only about 3% of total wealth accumulation using OLS estimates, while the percentage rises to a range between 20% and 24% when instrumental variables estimates are used.

²⁹ The conditional variance of income is computed on the basis of deviations of output growth from its expected value (i.e., the conditional variance of output growth and not just its variance).

³⁰ Canada, France, Italy, Spain, United Kingdom and the United States; over the period 1960-2007.

³¹ The question is as follows: "*Sometimes people are permanently laid off from jobs that they want to keep. On a scale from 0 to 10 where 0 equals absolutely no chance and 10 equals absolutely certain, how likely is it that you will lose your job during the next year?*"

³² The seventh and eighth survey waves include the following question: "*In the next twelve months, how likely do you think it is that you will become unemployed?*" the responses are scaled to 0-1 and they can be interpreted as a subjective probability distribution of job loss.

³³ The first measure is obtained by taking the square of the difference between detrended household earnings in the first and the last year of her sample, divided by the number of years in the sample to have an annual rate. The second one is the variance of income, Y_t , over the eight available waves (this measure assumes that all income shocks are transitory). The last measure is the variance of income over waves two to eight (variance of $Y_t - Y_{t-1}$), and contrary to the previous one, this measure assumes that all income shocks are entirely permanent.

³⁴ In addition, he also finds that consumption responds more to permanent income than to transitory income.

³⁵ Their results show that "more than two fifths of the increase in savings can be directly related to the increase in unemployment risk and GDP volatility. Saving rates also significantly increased in response to financial wealth losses, which may have themselves been caused by the increase in uncertainty".

³⁶ Under this approach, permanent income shocks can be used as proxies for uncertainty.

³⁷ Wealth can be used to classify households into rich or poor and some measures of this variable can be a proxy to credit constraints (for example, Zeldes, 1989b, classifies as liquidity constrained those households with low savings or financial assets levels).

³⁸ On the one hand, children can be a source of security in retirement, thereby decreasing saving (Kazarosian, 1997); on the other hand, consumption should be increasing with the number of children, and saving capacity would decrease (Miles, 1997).

³⁹ Guiso et al. (1996) include the number of pension recipients, pointing out that they have less income risk.

⁴⁰ Given the self-selection problem, Dynan (1993) notes that "while it is plausible that people will choose their occupations or industries partly on the basis of their attitudes toward risk, it seems less likely that risk plays a noticeable role on people's decisions concerning education, number of earners in a household, or holdings of liquid assets" (p. 1112). So, a way to tackle the problem of self-selection is to focus on the sets of instruments for which self-selection is less likely to occur.

⁴¹ We should note that according to some authors (see, for example, Jappelli and Pagano, 1994) borrowing constraints may foster a higher rate of economic growth by inducing capital accumulation, since aggregate saving will be higher than in the presence of perfect credit markets.

⁴² Under certainty, the life-cycle model predicts that borrowing constraints should bind only during youth. In a context of uncertain on earnings, out-of-pocket medical expenses, and lifespan, this will no longer be the case. However, Guiso et al. (1992) and Hubbard et al. (1995) point out that the younger are likely to be liquidity constrained (especially until their mid-thirties) and, in addition, under a consumption floor, borrowing constraints can bind at any time in the life cycle (Hubbard et al., 1994).

⁴³ The effects of credit constraints and precautionary saving are very similar since both stem from the concavity of the consumption function (Carroll and Kimball, 2001).

References

1. Alessie, R., Van Rooij, M. and Lusardi, A. (2011) Financial Literacy and Retirement Preparation in the Netherlands. *Journal of Pension Economics & Finance*, 10(4), pp. 527-545.
2. Ando, A., and Modigliani, F. (1963) The “life cycle” hypothesis of saving: Aggregate implications and tests. *The American economic review*, 53(1), 55-84.
3. Attanasio, O. (1999) Consumption in J. Taylor y M. Woodford (eds.), *Handbook of Macroeconomics*, Vol. 1, 741-812. Amsterdam: Elsevier Science.
4. Attanasio, O., and Weber, G. (2010) Consumption and saving: models of intertemporal allocation and their implications for public policy. *Journal of Economic literature*, 48(3), 693-751.
5. Baiardi, D., Manera, M., and Menegatti, M. (2013) Consumption and precautionary saving: An empirical analysis under both financial and environmental risks. *Economic Modelling*, 30, 157-166.
6. Bande, R., and Riveiro, D. (2013) Private Saving Rates and Macroeconomic Uncertainty: Evidence from Spanish Regional Data. *The Economic and Social Review*, 44 (3), 323-349.
7. Banks, J., Blundell, R., and Brugiavini, A. (2001) Risk pooling, precautionary saving and consumption growth. *The Review of Economic Studies*, 68(4), 757-779.
8. Barceló, C. and E. Villanueva (2010) Los Efectos de la Estabilidad Laboral sobre el Ahorro y la Riqueza de los Hogares Españoles. *Banco de España, Boletín Económico*, June, 81-86.
9. Benito, A. (2006) Does job insecurity affect household consumption? *Oxford Economic Papers*, 58, 157-181.
10. Bernheim, D., Garrett, D. and Maki, D. (2001) Education and saving: The long-term effects of high school financial curriculum mandates. *Journal of Public Economics*, 80, pp. 435–465
11. Blundell, R., and Stoker, T. M. (1999) Consumption and the timing of income risk. *European Economic Review*, 43(3), 475-507.
12. Blundell, R., Etheridge, B., and Stoker, T. (2014) Precautionary Saving for Consecutive Life-Cycle Risks. *Mimeo*.
13. Browning, M., and Lusardi, A. (1996) Household saving: Micro theories and micro facts. *Journal of Economic literature*, 34(4), 1797-1855.
14. Bucher-Koenen, T. and Lusardi, A. (2011) Financial Literacy and the Retirement Planning in Germany. *Journal of Pension Economics & Finance*, 10(4), pp. 565-584.
15. Caballero, R. J. (1990) Consumption puzzles and precautionary savings. *Journal of monetary economics*, 25(1), 113-136.
16. Caballero, R. J. (1991) Earnings uncertainty and aggregate wealth accumulation. *The American Economic Review*, 859-871.
17. Campbell, J. Y. (1987) Does saving anticipate declining labor income? An alternative test of the permanent income hypothesis. *Econometrica*, 55, 1249-1273.
18. Campbell, J.Y. and Deaton, A. (1989) Why is consumption so smooth? *Review of Economic Studies*, 56, 357-374.
19. Carroll, C. D. (1992) The Buffer-Stock Theory of Saving: Some Macroeconomic Evidence. *Brookings Papers on Economic Activity*, Vol. 2, 61-127.
20. Carroll, C. D. (1994) How does future income affect current consumption? *The Quarterly Journal of Economics*, 111-147.

21. Carroll, C. and Dunn, W. (1997) Unemployment Expectations, Jumping (S,s) Triggers, and Household Balance-sheets. *NBER Macroeconomics Annual*, Vol. 12, 165-217.
22. Carroll, C. D., and Kimball, M. S. (2001) Liquidity constraints and precautionary saving (No. w8496). *National Bureau of Economic Research*.
23. Carroll, C. D. and Samwick, A. A. (1997) The Nature of Precautionary Wealth. *Journal of Monetary Economics*, Vol. 40, 41-71.
24. Carroll, C. D. and Samwick, A. A. (1998) How important is precautionary saving? *Review of Economics and Statistics*, 80(3), 410-419.
25. Carroll, C. Dynan, K. and Krane, S. (2003) Unemployment Risk and Precautionary Wealth: Evidence from Households' Balance Sheets. *The Review of Economics and Statistics*, Vol. 85, No. 3, 586-604.
26. Ceritoğlu, E. (2013) The impact of labour income risk on household saving decisions in Turkey. *Review of Economics of the Household*, 11(1), 109-129.
27. Chamon, M., Liu, K., and Prasad, E. (2013) Income uncertainty and household savings in China. *Journal of Development Economics*, 105, 164-177.
28. Chou, S. Y., Liu, J. T., and Hammitt, J. K. (2006) Households' precautionary behaviors—the effects of the introduction of National Health Insurance in Taiwan. *Review of Economics of the Household*, 4(4), 395-421.
29. Dardanoni, V. (1991) Precautionary savings under income uncertainty: a cross-sectional analysis. *Applied Economics*, vol. 23, 153-160.
30. Deaton, A. (1987) Life-cycle models of consumption: is the evidence consistent with the theory? In *Bewley, T. F. (ed.) Advances in Econometrics*, Vol II (Amsterdam: North-Holland), 121-148.
31. Deaton, A. (1991) Saving and liquidity constraints. *Econometrica*, 59, 1221-1248.
32. Deaton, A. (2011) The Financial Crisis and the Well-Being of Americans. *NBER Working Paper, No. 17128*.
33. Deidda, M. (2013) Precautionary Saving, Financial Risk, and Portfolio Choice. *Review of Income and Wealth*, 59(1), 133-156.
34. Drèze, J. and Modigliani, F. (1972) Consumption decisions under uncertainty. *Journal of Economic Theory*, 5, 308-35.
35. Dynan, K. E. (1993) How prudent are consumers? *Journal of Political Economy*, 1104-1113.
36. Engen E. M., and Gruber, J. (2001) Unemployment insurance and precautionary saving. *Journal of monetary Economics*, 47(3), 545-579.
37. Feigenbaum, J. (2011). Precautionary saving or denied dissaving. *Economic Modelling*, 28(4), 1559-1572.
38. Flavin, M. (1981) The adjustment of consumption to changing expectations about future income. *Journal of Political Economy*, 89, 974-1009.
39. Friedman, M. (1957) A Theory of the Consumption Function. *Princeton, NJ: Princeton University Press*.
40. Gale, W., Harris, B. and Levine, R. (2012) Raising Household Saving: Does Financial Education Work? *Social Security Bulletin*, 72 (2), 39-48.
41. Gruber, J. (1997) The consumption smoothing benefits of unemployment insurance. *American Economic Review*, 87, 192–205
42. Guariglia, A. (2001) Saving behaviour and earnings uncertainty: Evidence from the British Household Panel Survey. *Journal of Population Economics*, 14(4), 619-634.

43. Guariglia, A., and Kim, B. Y. (2003) The Effects of Consumption Variability on Saving: Evidence from a Panel of Muscovite Households. *Oxford Bulletin of Economics and Statistics*, 65(3), 357-377.
44. Guariglia, A., and Rossi, M. (2002) Consumption, habit formation, and precautionary saving: evidence from the British Household Panel Survey. *Oxford Economic Papers*, 54(1), 1-19.
45. Guiso, L., Jappelli, T., and Terlizzese, D. (1992) Earnings uncertainty and precautionary saving. *Journal of Monetary Economics*, 30(2), 307-337.
46. Guiso, L., Jappelli, T., and Terlizzese, D. (1996) Income risk, borrowing constraints, and portfolio choice. *The American Economic Review*, 158-172.
47. Gul, F. and Pesendorfer, W. (2004) Self-Control and the Theory of Consumption. *Econometrica*, 72(1), 119-158.
48. Hahm, J. H. (1999) Consumption Growth, Income Growth and Earnings Uncertainty: Simple Cross-Country Evidence. *International Economic Journal*, 13(2), 39-58.
49. Hahm, J. H. and Steigerwald, D. G. (1999) Consumption adjustment under time-varying income uncertainty. *Review of Economics and Statistics*, 81(1), 32-40.
50. Hall, R. (1978): "Stochastic Implications of the Life Cycle-Permanent Hypothesis: Theory and Evidence". *Journal of Political Economy*, 86(6), p. 971-987.
51. Hall, R. E. and Mishkin, F. (1982) The sensitivity of consumption to transitory income: estimate from panel data on households. *Econometrica*, 50, 461-481.
52. Hubbard, R. G., Skinner, J., and Zeldes, S. P. (1994) The importance of precautionary motives in explaining individual and aggregate saving. In: *Carnegie-Rochester Conference Series on Public Policy*, Vol. 40, 59-125. North-Holland.
53. Hubbard, R. G., Skinner, J., and Zeldes, S. P. (1995) Precautionary saving and social insurance (No. w4884). *National Bureau of Economic Research*.
54. Jappelli, T., and Pagano, M. (1994) Saving, growth, and liquidity constraints. *The Quarterly Journal of Economics*, 83-109.
55. Katona, G. (1949) Effects of Income Changes on the Rate of Saving. *Review of Economics and Statistics*, 31 (2), pp. 95-103.
56. Kazarosian, M. (1997) Precautionary savings — a panel study. *Review of Economics and Statistics*, 79(2), 241-247.
57. Keynes, J. M. (1936). *The general theory of interest, employment and money*. MacMillan. London.
58. Kimball, M. S. (1990) Precautionary Saving in the Small and in the Large. *Econometrica: Journal of the Econometric Society*, 53-73.
59. Kopecky, K. A., and Koreshkova, T. (2014) The impact of medical and nursing home expenses on savings. *American Economic Journal: Macroeconomics*, 6(3), 29-72.
60. Kuan, C. M., and Chen, C. L. (2013) Effects of National Health Insurance on precautionary saving: new evidence from Taiwan. *Empirical Economics*, 44(2), 921-943.
61. Kureishi, W. and M. Wakabayashi (2013): "What motivates single women to save? The case of Japan". *Review of Economics of the Household*, vol. 11(4), p. 681-704.
62. Kuznets, S., (1946) *National Product Since 1869* (assisted by L. Epstein and E. Zenks). *New York: National Bureau of Economic Research*.
63. Laibson, D. (1997) Golden Eggs and Hyperbolic Discounting. *Quarterly Journal of Economics*, 112(2), 443-478.

64. Leland, H. E. (1968) Saving and uncertainty: The precautionary demand for saving. *The Quarterly Journal of Economics*, 465-473.
65. Liu, Z. (2014) Job uncertainty and Chinese household savings. *FRBSF Economic Letters*, 2014, 03.
66. Love, D. A. (2010) The effects of marital status and children on savings and portfolio choice. *Review of Financial Studies*, 23(1), 385-432.
67. Lugalde, A., Bande, R. and Riveiro, D. (2016) Precautionary saving in Spain during the Great Recession: evidence from a panel of uncertainty indicators. *IDEGA-Working Papers, Área de Analise Económica*, 61.
68. Lusardi, A. (1993). Euler Equations in Micro Data: Merging Data from Two Samples. *CentER Discussion Paper*, 1993.
69. Lusardi, A. (1997) Precautionary saving and subjective earnings variance. *Economics Letters*, 57(3), 319-326.
70. Lusardi, A. (1998) On the importance of the precautionary saving motive. *American Economic Review*, 449-453.
71. Lusardi, A. and Mitchell, O. (2011) Financial Literacy and Retirement Planning in the United States. *Journal of Pension Economics & Finance*, 10 (4), pp. 509-52.
72. Lusardi, A. and Mitchell, O. (2014) The Economic Importance of Financial Literacy: Theory and Evidence. *Journal of Economic Literature*, 52(1), 5-44.
73. Lyhagen, J. (2001) The effect of precautionary saving on consumption in Sweden. *Applied Economics*, Vol. 33, 673-681.
74. Malley, J and Moutos, T. (1996) Unemployment and Consumption. *Oxford Economic Papers*, Vol. 48, 548-600.
75. Menegatti, M. (2001) On the conditions for precautionary saving. *Journal of Economic Theory*, 98(1), 189-193.
76. Menegatti, M. (2007) Consumption and uncertainty: a panel analysis in Italian Regions. *Applied Economics Letters*, 14(1), 39-42.
77. Menegatti, M. (2010) Uncertainty and consumption: new evidence in OECD countries. *Bulletin of Economic Research*, 62(3), 227-242.
78. Michelacci, C., and Ruffo, H. (2015) Optimal life cycle unemployment insurance. *The American Economic Review*, 105(2), 816-859.
79. Miles, D. (1997) A household level study of the determinants of incomes and consumption. *The Economic Journal*, 1-25.
80. Miller, B. L. (1974) Optimal consumption with stochastic income stream. *Econometrica* 42, 253-266.
81. Miller, B. L. (1976) The effect on optimal consumption of increased uncertainty in labor income in the multiperiod case. *Journal of Economic Theory* 13, 154-167.
82. Mishra, A. K., Uematsu, H., and Fannin, J. M. (2013) Measuring precautionary wealth using cross-sectional data: the case of farm households. *Review of Economics of the Household*, 11(1), 131-141.
83. Modigliani, F. and Brumberg, R. (1954) Utility analysis and the consumption function: An interpretation of cross-section data. *Franco Modigliani, I*.
84. Mody, A., Ohnsorge, F. and Sandri, D. (2012) Precautionary savings in the Great recession. *IMF Economic Review*, 60(1), 114-138.
85. Pericoli, F., and Ventura, L. (2012) Family dissolution and precautionary savings: an empirical analysis. *Review of Economics of the Household*, 10(4), 573-595.

86. Pratt, J. W. (1964) Risk Aversion in the Small and in the Large. *Econometrica*, 32, 122-136.
87. Sandmo, A. (1970) The effect of uncertainty on saving decisions. *The Review of Economic Studies*, 353-360.
88. Sibley, D.S. (1975) Permanent and transitory effects in a model of optimal consumption with wage income uncertainty. *Journal of Economic Theory*, 11, 68-82.
89. Skinner, J. (1988) Risky income, life cycle consumption, and precautionary savings. *Journal of Monetary Economics*, 22(2), 237-255.
90. Thaler, R. (1994) Psychology and Savings Policies. *American Economic Review*, 84(2), 186-192.
91. Thaler, R. and Benartzi, S. (2004) Save More Tomorrow: Using Behavioral Economics to increase Employee Saving. *Journal of Political Economy*, 112(1), 164-187.
92. Van Rooij, M., Lusardi, A. and Alessie, R. (2012) Financial Literacy, Retirement Planning and Household Wealth. *The Economic Journal*, 122 (May), 449-478
93. Zeldes, S. P. (1989a) Optimal consumption with stochastic income: Deviations from certainty equivalence. *The Quarterly Journal of Economics*, 275-298.
94. Zeldes, S. P. (1989b) Consumption and liquidity constraints: an empirical investigation. *The Journal of Political Economy*, 305-346.