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Consumption and precautionary saving: An empirical analysis under both financial and environmental risks☆

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ABSTRACT

This paper studies the empirical relationship between consumption and saving under two different sources of uncertainty: financial risk and environmental risk. The analysis is carried out using time series data for six advanced economies in the period 1965–2007.

The results support the theoretical conclusions that both financial risk alone and the interaction between financial and environmental risks influence consumption. Moreover, we suggest a solution to some shortcomings which affect the empirical analysis performed with one-argument utility functions. Finally, we provide new estimates of indexes of relative risk aversion and relative prudence, as well as relative preference of environmental quality.

1. Introduction

Modern theory of consumption starts from the seminal papers by Modigliani and Brumberg (1954) and Friedman (1957), who studied the life-cycle permanent income model. In this context, a positive saving is motivated by the fact that consumers rationally expect a declining path of labor income. Starting from Hall (1988), a huge body of papers investigate the permanent income hypothesis under rational expectations (see, among others, Flavin, 1981; Hall and Mishkin, 1982 and Zeldes, 1989). These models assume that the utility function is quadratic,[1] which corresponds to analyzing the so-called certainty equivalent case, meaning that agents make the same consumption decisions under certain or uncertain income. This literature finds that the permanent income hypothesis does not exactly capture the behavior of consumption.[2]

Starting from Leland (1968), a great deal of theoretical literature shows that, when we remove the assumption that the utility function is quadratic, income uncertainty affects consumption and saving decisions. In the certainty case optimal consumption is still determined by permanent income, but when financial risk is introduced and standard assumptions on the utility function are made, uncertainty generates an extra-saving, called 'precautionary saving'.[3] In this case, consumption dynamics is affected by the variability of future income.

This theoretical result has been empirically analyzed in different papers which estimate an Euler condition either using data from household surveys (see, for instance, Dynan, 1993; Guariglia and Kim, 2003, 2004; Guiso et al., 1992; Lusardi, 1998), or using aggregate consumption data (e.g. Hahm, 1999; Hahm and Steigerwald, 1999; Lyhangen, 2001; Menegatti, 2007, 2010). In almost all cases, the empirical tests support the relevance of the precautionary saving assumption. However, in most of the papers which use aggregate data (e.g. Hahm, 1999; Hahm and Steigerwald, 1999; Menegatti, 2007, 2010), the effect of financial risk is clearly detected in reduced-form

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[1] This implies that the third derivative of the utility function is zero.

[2] In more detail, the empirical analysis suggests that the permanent income hypothesis fails in explaining the dynamics of consumption both for excess sensitivity (Flavin, 1981) and for excess smoothness (Deaton, 1992).

[3] More specifically, precautionary saving is positive under the convexity of the marginal utility function (e.g. Drèze and Modigliani, 1972; Kimball, 1990; Menegatti, 2001 and Sandmo, 1970).

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equations involving saving, rather than in structural-form equations computing optimal consumption growth under CRRA utility functions.[4]

A recent branch of literature has generalized the precautionary saving analysis to the case where financial risk is flanked by a second non-financial and uninsurable risk called 'background risk', which is typically either environmental risk or health risk. In this field, Courbage and Rey (2007) and Menegatti (2009a) study precautionary saving considering some specific bivariate distributions for income and background risk. Menegatti (2009b) investigates the same problem for the general case in the presence of small risks. He introduces for the first time the concept of 'two-source precautionary saving', defined as the total variation in saving due to the joint influence of income risk and background risk. Finally, Denuit et al. (2011) examine the case where those two risks are positively correlated.

The general conclusion of these contributions is that both income risk and background risk affect optimal consumption and saving, as does the interaction of the two. In particular, the possible presence of precautionary saving is determined by the size of the variance of the two risks, the sign and the size of the covariance between them and the signs of the third-order derivatives of the utility function.

The first aim of our paper is to test the effects of different kinds of uncertainty on consumption choices. In particular, we study the 'two-source precautionary saving' motive in six advanced economies, namely Canada, France, Italy, Spain, United Kingdom (UK) and United States (USA). The test is performed for the period 1965–2007 on time-series data, and is based on three elements: i) a measure of financial risk, along the lines suggested in previous empirical work; ii) a proxy for environmental risk; and iii) a variable capturing the interaction between the financial and environmental risks.

Our approach is also new because it contributes to solving the shortcomings which affect the estimates of the precautionary saving effects reported in the previous empirical literature. In fact, a possible reason for failure in testing the effects of financial risk in equations computed using optimal consumption growth rules is the omission of other relevant sources of uncertainty, such as environmental risk.

Furthermore, Dynan (1993) proposed an empirical measure of the strength of the precautionary motive, providing an estimate of the index of relative prudence in a one-risk framework.[5] Dynan, however, found that '[…] *the estimated strength of the precautionary motive appears to be simply too small. […] We can overwhelmingly reject the hypothesis that the coefficient of relative prudence is in the range implied by a reasonably parameterized CRRA utility function*' [Dynan (1993), p. 1109]. Dynan also showed that the introduction of liquidity constraints or consumers' self-selection is not sufficient to explain these results.

In this field the aim of our paper is to provide new estimates of the size of relative prudence and of relative risk aversion, which are determined by taking into account the effects of environmental risk, together with the effects of financial risk.

The theoretical analysis of a two-risk framework clearly indicates the relevant role in determining the agent's optimal behavior of so-called 'cross-prudence'. This is related to the effects of uncertainty in one argument of the utility function (such as environmental quality) for the optimal level of the other argument (consumption) along the lines suggested by Eeckhoudt et al. (2007), Courbage and Rey (2007), Menegatti (2009a,b) and Gollier (2010).[6] The third aim of our paper is to propose the first empirical analysis of consumption in a two-risk framework, as well as to examine the relevance of direct and indirect effects of environmental uncertainty on consumption.

The paper is organized as follows. In Section 2 the theoretical model is presented and the equations to be estimated are derived. Section 3 describes the dataset. Section 4 discusses empirical results. In Section 5 estimates of different indexes of risk aversion and prudence are illustrated. Finally, Section 6 concludes.

2. The theoretical model and the estimated equations

We consider a multiperiod framework where consumer's preferences in period t are described by the two-argument utility function $U(C_t,E_t)$, where C_t is consumption and E_t is the environmental quality level, which is given for the agent. We assume that $U(C_t,E_t)$ is increasing and concave with regard to each argument. Letting $U_c(C_t,E_t)=\partial U/\partial c$, $U_e(C_t,E_t)=\partial U/\partial e$, $U_{cc}(C_t,E_t)=\partial^2 U/\partial c^2$, $U_{ce}(C_t,E_t)=\partial U/\partial c\partial e$ and so on, our assumptions imply $U_c(C_t,E_t)>0$, $U_e(C_t,E_t)>0$, $U_{cc}(C_t,E_t)<0$ and $U_{ee}(C_t,E_t)<0$. These last two conditions imply aversion toward risk on consumption and aversion toward risk on the environmental quality.

Given such preferences and extending the univariate framework of Carroll (1992, 1997), we consider a bivariate intertemporal consumption model:

$$\max_{C_t} \mathbb{E}\sum_{t=0}^{T}\beta^t U(C_t,E_t) \tag{1}$$

subject to

$$W_{t+1}=(1+r)(W_t+Y_t-C_t)$$

where Y is income, W is net wealth, r is the constant interest rate and $R=1+r$ is the interest factor, δ is the subjective intertemporal discount rate, and $\beta=1/(1+\delta)$ is the subjective intertemporal discount factor.

Problem (1) is solved by maximizing the following Lagrangian:

$$L=\mathbb{E}\sum_{t=0}^{T}\beta^t\left[U(C_t,E_t)-\lambda_t\left(W_{t+1}-R(W_t+Y_t-C_t)\right)\right].$$

The first-order conditions are:

$$\frac{\partial L}{\partial C_t}=\beta^t\left[U_c(C_t,E_t)-R\lambda_t\right]=0, \tag{2}$$

$$\frac{\partial L}{\partial W_{t+1}}=-\beta^t\lambda_t+\beta^{t+1}R\mathbb{E}\left[\lambda_{t+1}\right]=0, \tag{3}$$

$$\frac{\partial L}{\partial \lambda_t}=W_{t+1}-R(W_t+Y_t-C_t)=0. \tag{4}$$

Combining Eqs. (2) and (3) we get the Euler's equation:

$$\beta R\mathbb{E}\left[U_c(C_{t+1},E_{t+1})\right]=U_c(C_t,E_t). \tag{5}$$

Following Dynan (1993) approach in the univariate case, we compute a second-order Taylor approximation of $U_c(C_t,E_t)$, and substituting in the left-hand side of condition (5), we obtain[7]:

$$\begin{aligned}\beta R\mathbb{E}\big[&U_c+(C_{t+1}-C_t)U_{cc}+(E_{t+1}-E_t)U_{ce}+1/2(C_{t+1}-C_t)^2U_{ccc}\\&+1/2(E_{t+1}-E_t)^2U_{cee}+(C_{t+1}-C_t)(E_{t+1}-E_t)U_{cce}\big]=U_c.\end{aligned} \tag{6}$$

[4] Different justifications for this result are provided in the literature and are related to potential excessive restrictions in the use of a specific class of utility functions, effects of agent's impatience, lags in saving adjustment or consequences of subsequent changes in income risk.

[5] The concept of prudence was first introduced by Kimball (1990) and is related to the sign of the third derivative of the utility function: an agent is prudent when this derivative is positive and imprudent when it is negative. About the interpretation of prudence see also Menegatti (2001) and Eeckhoudt and Schlesinger (2006).

[6] Examination of the cross-prudence effect on environmental policy is provided by Baiardi and Menegatti (2011).

[7] To simplify notation we omit the arguments of the utility function and of its derivatives.