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THE EMPIRICAL IMPORTANCE OF PRECAUTIONARY SAVING

Pierre-Olivier Gourinchas Jonathan A. Parker*

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*Prepared for the AEA Papers and Proceedings, New Orleans, January 2001. Gourinchas: Department of Economics, Princeton University, Princeton NJ 08540, CEPR and NBER (email: pog@princeton.edu); Parker: Princeton University (email: parker@princeton.edu). Parker thanks National Science Foundation grant SES-9818673 for financial support. We thank Mike Woodford and our discussant Steve Davis for many helpful comments .

Abstract

One of the basic motives for saving is the accumulation of wealth to insure future welfare. Both introspection and extant research on consumption insurance find that people face substantial risks that they do not fairly pool. In theory, the consumption and wealth accumulation of price-taking households in an economy with incomplete markets differs substantially from the behavior of these same households in the equivalent economy with complete-markets. We provide a simple decomposition that characterizes the importance of precautionary saving in the U.S. economy. We use this decomposition as an organizing framework to present four main findings: (a) the concavity of the consumption policy rule, (b) the importance of precautionary saving for life-cycle saving and wealth accumulation, (c) the contribution of changes in risk to fluctuations in aggregate consumption and (d) the significant impact of incomplete markets on aggregate fluctuations in calibrated general equilibrium models. We conclude with directions for future research.

1. Introduction

One of the basic motives for saving is the accumulation of wealth to insure future welfare. Both introspection and extant research on consumption insurance find that people face substantial risks that they do not fairly pool. In theory, the consumption and wealth accumulation of price-taking households in an economy with incomplete markets differs substantially from the behavior of these same households in the equivalent economy with complete-markets. The question we address in this article is whether we find this difference to be large in practice. What is the empirical importance of precautionary saving?

The paper is organized as follows. The next section provides a simple decomposition that characterizes the importance of precautionary saving in the U.S. economy. We use this decomposition as an organizing framework in the following four sections to present results on: (Section 3) the concavity of the consumption policy rule, (Section 4) the importance of precautionary saving for life-cycle saving and wealth accumulation, (Section 5) the contribution of changes in risk to fluctuations in aggregate consumption, and (Section 6) the significant impact of incomplete markets on aggregate fluctuations in calibrated general equilibrium models. We conclude with directions for future research.

2. A useful decomposition

Consider an infinite horizon economy with a unit continuum of households facing aggregate and idiosyncratic risk to their labor income. Households can smooth consumption by trading goods over time, but not across states. Each household allocates its initial cash-on-hand at time t, x_t, between current consumption c_t and a saving technology with a risk-free rate of return R_{t+1} in order to maximize its utility:

$$V_t\left(x_t\right) \equiv \max_{c_t} u_t\left(c_t\right) + \beta\, E_t V_{t+1}\left(R_{t+1}\left(x_t - c_t\right) + \tilde{y}_{t+1}\right) \tag{1}$$

where $u_t(.)$ and $V_t(.)$ are the period utility and value function at time t, where the subscript t captures all state variables beside wealth, β is the discount factor, $\tilde{y}_{t+1}$ is a random and exogenous income process with innovation ϵ_{t+1}.

The optimal intertemporal allocation of consumption implies the Euler equation:

$$u'_t(c_t) = \beta R_{t+1} E_t u'_{t+1}(c_{t+1}). \tag{2}$$

Denote the solution to the optimization problem by a consumption rule, $c_t(x_t)$. Assuming that the period utility function exhibits constant relative risk aversion (CRRA) with coefficient ρ, we expand the Euler equation (2) to the second order about $E_t \Delta \ln c_{t+1}$ and expand $E_t \ln c_{t+1}(x_{t+1})$ around $E_t x_{t+1}$ to obtain:

$$\Delta \ln c_{t+1} = \frac{1}{\rho} \ln \beta R_{t+1} + \frac{\rho}{2} \eta_{t+1} (E_t x_{t+1})^2 \ var_t \epsilon_{t+1} + \nu_{t+1}(\epsilon_{t+1}) \tag{3}$$

where $\eta_{t+1}(x) = d \ln c_{t+1}(x) / dx$ is the semi-elasticity of consumption with respect to wealth, and $\nu_{t+1}(\epsilon_{t+1}) = \eta_{t+1} \epsilon_{t+1} + \frac{1}{2} \eta'_{t+1} \left(\epsilon^2_{t+1} - var_t \epsilon_{t+1} \right)$ is the innovation to consumption growth.

Inspecting the right hand side, the first term reflects the growth rate of expected consumption that would obtain if the household faced no uncertainty, at current asset prices. The second term reflects precautionary saving as well as Jensen's inequality. When faced with greater risk to wealth ($var_t \epsilon_{t+1}$ larger), households postpone current consumption and accumulate assets so as to self-insure shocks to future marginal utility. The strength of the effect is governed by prudence $(\rho + 1)$ and the semi-elasticity of consumption with respect to wealth (η_{t+1}).[1] Finally, the last term in (3) defines the innovation to the growth rate of individual consumption in terms of the income innovation.

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[1] Since $var_t \Delta \ln c_{t+1} = \eta_{t+1} (E_t x_{t+1})^2 \ var_t \epsilon_{t+1}$, this term is equivalent to $\frac{\rho+1}{2} var_t \Delta \ln c_{t+1} - \frac{1}{2} var_t \Delta \ln c_{t+1}$. The first part reflects precautionary saving: the percentage by which expected consumption growth increases is equal to one half the variance of consumption growth innovations times the coefficient of relative prudence, $\rho + 1$. The second part in this expression reflects Jensen's inequality and the concavity of the logarithm.

Aggregating equation (3) across households, we obtain:

$$\Delta \ln C_{t+1} = \frac{1}{\rho} \ln \beta R_{t+1} + \Psi_t + \nu_{t+1} \tag{4}$$

where Ψ_t is defined as $\frac{\rho}{2} \int \eta_{t+1} \left(E_t x_{t+1}\right)^2 \; var_t \epsilon_{t+1} \, d\Lambda_t$ and Λ_t is the measure of households over their state variables. Ψ_t is the contribution of precautionary saving (and the curvature of the logarithm) to expected aggregate consumption growth. Finally, $\nu_{t+1} = \int \nu_{t+1} \left(\epsilon_{t+1}\right) d\Lambda_{t+1}$ is the innovation to aggregate consumption growth.

The components of aggregate consumption growth have the same interpretation as the components of the household equation. The first term captures consumption growth absent risk, *at given factor prices.* The second term captures precautionary saving as conventionally defined and depends on the cross-sectional distribution of expected future cash on hand $E_t x_{t+1}$, the conditional variance of income innovations $var_t \epsilon_{t+1}$, and the curvature of the consumption function c_{t+1}. This term highlights the fact that precautionary saving can propagate disturbances by altering predictable consumption growth. If $var_t \epsilon_{t+1}$ is common across households, the precautionary effect is proportional to *individual* income risk: $\Psi_t = \frac{\rho}{2} var_t \epsilon_{t+1} \int \eta_{t+1} \left(E_t x_{t+1}\right)^2 d\Lambda_t$.

The final term in equation (4) reflects the relationship between individual income shocks and aggregate consumption growth. This term highlights the fact that precautionary saving can amplify disturbances by altering household responses to idiosyncratic and aggregate shocks.

The balance of this paper presents recent research that measures the practical importance of the precautionary term Ψ_t for individual and aggregate consumption growth, as well as wealth accumulation.

3. The Consumption Function

The precautionary term is irrelevant in two special and important cases. First, if one assumes certainty equivalence, the consumption rule is linear in wealth and satisfies: $\left(c_{t+1} \left(E_t x_{t+1}\right) / c_t\right)^{\rho} =$

βR. Second, under complete markets the marginal rate of intertemporal substitution of all households moves in lock-step and their consumption growth is equated across states and time. All households face only the risk observable in *aggregate* consumption data. Since the unconditional variance of real per-capita quarterly consumption growth in U.S. postwar data is a mere 0.000045, $\Psi_t \approx 0$, and the impact of precautionary saving on consumption growth is trivial. In either case, consumption behavior is well-approximated by Friedman's permanent income hypothesis (PIH) in which consumption is a linear function of the sum of cash-on-hand and the expected present discounted value of labor income.

In general, however, significant uninsurable income risk leads to a *strictly* concave consumption rule, and possibly the failure of the PIH as a reasonable approximation of consumption behavior.[2] With an increasing and strictly concave consumption function, households with low cash on hand face large amounts of consumption risk and respond strongly to changes in cash on hand. In terms of equation (3), significant concavity of $c_{t+1}(x)$ implies precautionary saving affects individual consumption growth at low wealth levels. In terms of equation (4), the shape of the consumption function and the distribution of wealth in the economy jointly determine the importance of precautionary saving for aggregate consumption growth.

Parker (1999) estimates the consumption policy rule by estimating nonparametric regressions of household consumption on a set of household-level state variables using survey data on U.S. households from the Consumer Expenditure Survey (CEX). For this paper, we run a nonparametric regression from this data, normalizing household consumption and income by an unconditional income measure.[3] Figure 1 shows household consumption functions estimated from a kernel regression of consumption on liquid wealth and age groups for households with low current incomes. All consumption functions have substantial curvature

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[2] See Carroll and Kimball (1996) for some exceptions.

[3] Household consumption and cash on hand (debts, saving, checking, bond and stock accounts) are normalized by their unconditional expected income. Figure 1 shows households with less than half this unconditional income level. The data and normalization are described in more detail in Parker (1999).

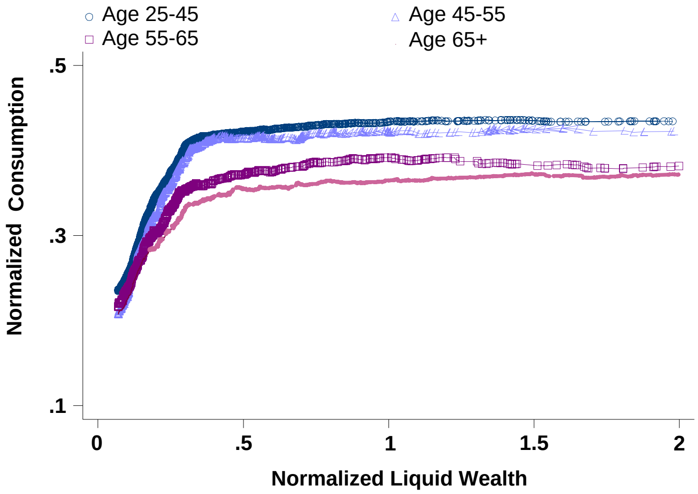

Figure 1: Consumption Functions by Age for Low Income. *Source*: Authors' Calculations.

and look quite like those displayed in simulation studies of consumption behavior under significant uncertainty (e.g. Zeldes (1989), Deaton (1991), Carroll (1997)). The functions imply that precautionary saving is important at low wealth levels: the marginal propensity to consume for households with poor incomes and low wealth is estimated to be around forty percent. Since a significant share of U.S. households have little liquid wealth, the curvature of the utility function implies a large effect of precautionary saving on consumption growth.

4. Consumption Over the Life Cycle

While estimation of consumption functions is useful for testing and evaluating the strength of precautionary saving, it is limited by the lack of structure that is placed on the data. In Gourinchas and Parker (1999), we estimate and simulate a dynamic stochastic model of household expenditures over the life cycle with uninsurable income uncertainty. Using the Method of Simulated Moments, we focus on *structural* estimation of the parameters of the consumption problem in equation (1). We summarize this analysis here, and apply our decomposition in equation (4) by age to quantify the importance of consumption risk for the life-cycle profile of consumption and the accumulation of liquid wealth.

Gourinchas and Parker (1999) model household consumption as a life cycle problem in which households receive stochastic labor income and choose consumption and saving from age 26 to age 65, then retire. There is no aggregate risk, so that the real interest rate R is constant. Individual earnings are stochastic: $Y_{a+1} = P_{a+1}U_{a+1}$ where a denotes age, U_{a+1} is a transitory shock, and P_a is the permanent component of income and follows a geometric random walk with drift G_{a+1}: $P_{a+1} = G_{a+1}P_aN_{a+1}$. N_{a+1} and U_{a+1} are both i.i.d., log-normally distributed with mean 0 and variance σ_n^2 and σ_u^2.

Under these assumptions, the expected growth rate of consumption over age for a given cohort is given by:

$$E_a\Delta \ln C_{a+1} = \frac{1}{\rho}\ln \beta R + \Psi_a \tag{5}$$

where Ψ_a reflects the contribution of precautionary saving to the cohort profile.

Our procedure chooses the parameters of the consumer problem, given estimates of the income process, so as to match the life-cycle profile of consumption $\{\ln C_a\}$ estimated from the CEX. With a 3% real interest rate R, we estimate $\beta = 0.96$ (0.017) and $\rho = 0.51$ (0.17). The fitted expected consumption profile matches the data quite well, indicating that the shape of the life-cycle consumption profile can be attributed to precautionary saving.

With these estimates in hand, we infer a profile for the precautionary term Ψ_a over age, according to equation (5). Figure 2 reveals a striking *pattern*: the precautionary term is especially important at young ages, and contributes an average of 4% per annum to consumption growth for the first ten years. Labor income uncertainty is paramount for young households, who, on average, hold little wealth. Labor income risk becomes negligible for older households, who, on average, hold large amounts of liquid wealth.

This structural approach provides a natural decomposition of household liquid wealth into its precautionary and life-cycle components. To do so, we calculate the average life-cycle wealth that would obtain if all income risk were eliminated, at the prevailing risk free rate. We define precautionary wealth as the difference between liquid wealth, as predicted by

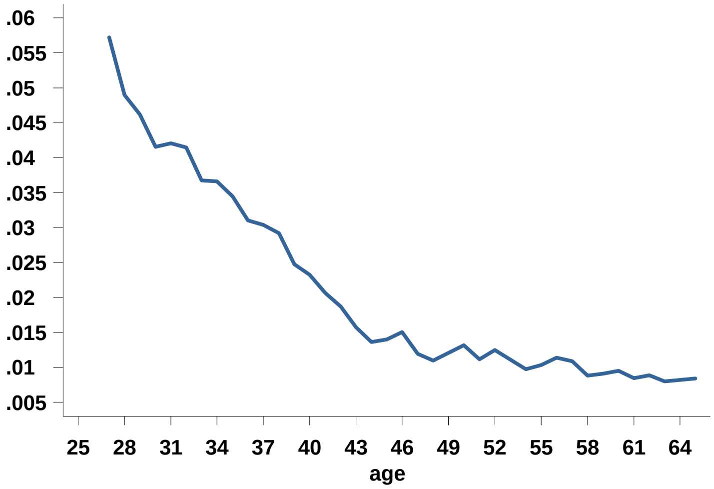

Figure 2: Life Cycle Profile of the Precautionary Component.

Source: Authors' Calculations.

the model, and life-cycle wealth. Because we work with discretionary income, liquid wealth excludes the accumulation of Social Security wealth, pension wealth, and wealth in consumer durable goods. Our results indicate a liquid wealth per household of roughly $110,000 (in 1992 dollars). Precautionary wealth represents about 65% of liquid wealth.

5. Fluctuations

While our structural model finds an important role for precautionary saving in consumption growth and wealth accumulation, we also find that consumer behavior is quite heterogeneous. Young households face steep income growth early in life and behave as buffer stock consumers. This finding suggests that the U.S. economy may respond quite differently to aggregate shocks than predicted by a model in which households face no significant consumption risk. How important is precautionary saving for booms and recessions?

We modify (4) to incorporate interest rate risk and obtain:

$$\Delta \ln C_{t+1} = \frac{1}{\rho} \left(E_t \ln R_{t+1} + \ln \beta \right) + \Psi_t + \nu_{t+1} \tag{6}$$

where, to a second order approximation, $\Psi_t = \frac{1}{2\rho} \int var_t \left(r_{t+1} - \rho \Delta \ln c_{t+1} \left(\epsilon_{t+1}, r_{t+1} \right) \right) d\Lambda_t$ depends upon the cross sectional distribution of households and the joint properties of r_{t+1}, the innovation to $\ln R_{t+1}$, and ϵ_{t+1}.

Parker and Preston (2001) decompose aggregate consumption growth according to equation (6). They first estimate the *nonlinear* consumption Euler equation (2) on the consumption of groups of households using the CEX and allowing for family size and female hours worked as preference shifters. Nonlinear estimation assumes -correctly- that innovations to marginal utility are unpredictable and so consistently estimates preferences in the presence of precautionary saving, unlike linearized models that assume that consumption growth innovation are uncorrelated with anything known at t, besides $\frac{1}{\rho} \left(\ln \beta + \ln E_t R_{t+1} \right)$. Second, with estimates in hand, Parker and Preston (2001) construct a measure of the precautionary saving term in equation (4) as $\hat{\Psi}_t = -\frac{1}{\hat{\rho}} \hat{E}_t \int \ln \left(1 + \hat{u}_{t+1} \right) d\Lambda_{t+1}$, where expectations $\hat{E}_t$ are taken with respect to a set of instruments known at t. Measurement error in consumption growth is contained in $\hat{u}_{t+1}$ but only biases inference on precautionary saving if it is predictable.

While standard errors are large, point estimates suggest the following. First, the variance of predictable movements in consumption that are due to movements in the precautionary term are of the same order of magnitude as those due to movements in the real interest rate. Due to measurement error in household consumption, this methodology does not provide an estimate of the contribution of risk to the trend growth rate of consumption, but this is potentially large. Second, movements in consumption due to precautionary saving are negatively correlated with movements in consumption due to the real interest rate. This finding can rationalize the puzzlingly low correlation between aggregate consumption growth rates and the real interest rate.

The importance of precautionary saving for understanding economic fluctuations seems large. For example, consider a positive, temporary shock to government spending that lowers precautionary saving. Then, precautionary saving and the real interest rate work in opposite directions on consumption, so that government spending crowds out more investment and has a larger impact on economic activity. To evaluate this particular hypothesis requires a measure of structural shocks. To consider alternative policies requires a structural model.

6. The importance of heterogeneity

In a recent influential paper, Krusell and Smith (1998) find that in an infinite horizon economy with incomplete markets, transitory idiosyncratic labor income shocks, and aggregate productivity shocks, the dynamics of aggregate variables are well characterized simply in terms of aggregates (*quasi-aggregation*). The key insight is that agents with high marginal propensities to consume also have low wealth holdings and do not matter for aggregate dynamics. Further, they show that dynamics of their economy with homogenous preferences do not differ from those of its representative-agent, complete-markets counterpart (*quasi-representative agent*), since households can smooth transitory income shocks with a little savings.

Gourinchas (2000) studies a similar general equilibrium model with overlapping generations and persistent shocks to income, using a household-level income process similar to Gourinchas and Parker (1999).[4] The additional realism, particularly the addition of persistent income shocks, matters for equilibrium dynamics. Quasi-aggregation is still a very close approximation. Comparing economies with different degrees of idiosyncratic permanent and transitory income risk, Gourinchas shows that in all cases the simulated average marginal propensity to consume is small, around 6-7% for most of the household life. This result highlights the endogenous response of household decision rules to the underlying economic uncertainty: agents adjust their consumption and asset holdings so as to avoid -on average- episodes where their marginal utility might fluctuate a lot.

Gourinchas (2000) also shows that the second result -quasi-representative agent- does not hold: the dynamics of aggregate consumption, income and wealth differ significantly from

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[4] See also Storesletten, Telmer and Yaron (1999).

their representative-agent counterparts. Under quasi-aggregation, the precautionary term in equation (6) Ψ_t can be expressed as $\bar{\Psi}_t(\bar{x}_t, z_t)$ which depends only upon aggregate wealth $\bar{x}_t$ and aggregate shocks z_t while the innovation ν_{t+1} can be expressed as $\nu_{t+1}(\bar{x}_t, z_t, z_{t+1})$ and depends also upon next period's aggregate shock z_{t+1}. The functions $\bar{\Psi}_t$ and ν_{t+1} are amalgams of the cross-sectional distribution of the curvature of the consumption rule and the conditional variance of income and interest rate innovations. Hence heterogeneity still matters through the shape of these equilibrium functions.

For instance, Gourinchas (2000) finds that higher levels of individual income risk relative to aggregate risk lowers the aggregate income-aggregate consumption correlation and the excess smoothness coefficient -the ratio of the standard deviation of consumption growth to income growth. The reason is that aggregate shocks -which become smaller relative to the overall level of individual income uncertainty- can be better smoothed.

So precautionary saving can have a large effect on aggregate dynamics and wealth accumulation, consistent with the findings from the previous sections, once a proper account of individual uninsurable risk is taken into account.

7. Directions for future research

Five important challenges lay ahead.

First, a fuller characterization and calibration of the response of a 'precautionary' economy to realistic monetary, fiscal and productivity shocks, along the lines of the modern VAR and DSGE literatures would sharpen our understanding of precautionary saving.

Second, as discussed in the preceding section, the importance of precautionary saving depends crucially on the persistence and insurability of individual earnings innovations ϵ_{t+1}. In a recent paper, Constantinides and Duffie (1996) construct an exchange economy with incomplete markets where individual income processes have the 'right' amount of persistence and the 'right' correlation with asset returns -and hence the 'right' precautionary term ψ_t, that accounts, in equilibrium, for the joint fluctuations in aggregate income, aggregate consumption and asset returns. An interesting research agenda attempts to separate individual income processes into their aggregate and idiosyncratic, permanent and transitory components. As Constantinides and Duffie (1996) demonstrate, a key dimension is the extent to which the variance of the permanent component of earnings is counter-cyclical.

Third, lower frequency movements in U.S. consumption remain puzzling. The growth rate of consumption per capita slowed from two and a half percent in the late 50's and 60's to one and a half percent in the 80's and 90's (Parker (2000)). The representative growth model suggests that slow growth should be associated with low real interest rates. Yet the opposite happened: real interest rates increased by over one percent between the two periods. Did consumption risk decrease in the 80's and 90's so that consumption growth fell despite the increase in real rates? More recently, the standard deviation of quarterly consumption and output has steadily declined since the early 1980s. One possibility is that the two long expansions of the past twenty years have allowed people to accumulate substantially more assets, move up the consumption rule and reduce the sensitivity of individual and aggregate consumption to transitory income shocks.[5]

Fourth, the recent poor macroeconomic performance of Japan is often blamed on high perceived uncertainty about the future and the associated low consumption -a consequence, it is argued, of the progressive demise of a social organization built on permanent employment. We are currently considering whether the logic of this hypothesis can be captured in a realistic model of the economy. In a standard one-good model, precautionary saving need not deliver such an outcome, as higher uncertainty leads to either higher investment or a current account surplus and hence no obvious need for an output decline. The empirical relevance of this explanation should also be tested and its applicability may well be broader than the Japanese slump.

Finally, there is little documentation of the importance of precautionary saving for trend

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[5] Olivier Blanchard suggested this possible application of the precautionary saving framework.

consumption growth. Variations in consumption growth across countries are largely unexplained by differences in real interest rates. One possibility is that the extent of consumption risk and hence the precautionary term explains these cross-country differences in capital accumulation.

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