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Unemployment Risk and Aggregate Consumption Behaviour

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Abstract

The joint behaviour of U.S. aggregate consumption and saving over the period 2007-2009 is hard to reconcile with the view that financial markets are frictionless. In particular, the pronounced U-shaped pattern of consumption together with the rise in saving appear inconsistent with the "permanent income behaviour" adopted by households able to fully insure idiosyncratic income risk. We propose an alternative framework where financial markets are incomplete and where households constitute a buffer stock of precautionary savings to self-insure against the (time-varying) risk of falling into unemployment, with the consequence of considerably amplifying and propagating recessions. On the methodological side, our contribution is to propose a model of the precautionary motive that can be solved in closed form because the wealth heterogeneity generated by uninsured income shocks remains minimal. We end the paper by arguing that fully incorporating uninsured and time-varying individual risks into macroeconomic analysis may drastically alter our understanding of the business cycle, macroeconomic policy, and the role of financial intermediaries.

Preliminary version

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1 Introduction

Amongst the pillars of mainstream macroeconomic analysis shaken by the ongoing financial and economic crisis, perhaps that which has attracted most attention is the assumption that financial markets work perfectly.[1] However, while few would now doubt that financial "frictions" are important, it is still unclear *which* specific frictions have first-order implications and *how* to model them in a both realistic and tractable manner. In this paper, we argue that a central such friction is that households face considerably more uninsurable labour income risk (basically, unemployment risk) than what is posited in standard macroeconomic models, and we offer an example of a tractable model in which the implications of this friction can easily be introduced and analysed. Using the model to shed light on the recent evolution of the U.S. aggregate consumption and saving, we find that it performs considerably better than its frictionless counterpart.

The basic motivation for our approach is the observation, reported in cross-sectional studies of household-level consumption and saving plans, that the latter depend substantially on labour income risk and hence on the extent of the unemployment risk faced by individuals (e.g., Cochrane, 1991; Carrol, 1992, and Guiso *et al.*, 1996).[2] As we illustrate and discuss in Section 2, one potential explanation for the large and mean-reverting decline in U.S. aggregate consumption that occurred from the mid-2008 onwards, and the contemporaneous rise aggregate saving and the saving rate, is that individuals have cut their spendings to (re-)constitute a "buffer stock" of precautionary wealth. This view is borne out by the rapid rise in the probability of involuntary layoffs that occured at about the same time, for two reasons: first, the risk of falling into unemployment is probably the largest source of idiosyncratic income risk faced by individuals; and second, this idiosyncratic risk is very imperfectly insured, and is thus likely to lead to a substantial demand for 'self-insurance' via asset accumulation.

Although the effects of unemployment risk and the precautionary motive for holding assets are likely to have first-order effects on the business cycle, they are particularly uneasy to model using current macroeconomic tools. For one thing thing, much of the theoretical/quantitative analysis of the business cycle is based on the complete-market, representative agent assumption. In this setup, a transitory increase in unemployment amounts to a

[1] See Krugman (2009) for an informal but systematic (and ruthless) assessment of mainstream macroeconomic theory.

[2] See also Jappelli (1990) for direct evidence that a share of U.S. households are liquidity-constrained

transitory fall in aggregate labour income, and such changes have, by their very transitory nature, a limited impact on human wealth. Then, 'permanent-income' behaviour implies that the representative agent should change consumption only by a small amount, with the cyclical variation in income being absorbed by large and procyclical variations in aggregate saving. This pattern is not that found in the recent data, where aggregate saving is countercyclical and consumption strongly procyclical. We argue that this failure of the standard framework might well lie in the fact it leaves no room for the precautionary motive, precisely because individual unemployment risk is assumed to be perfectly shared between households. In short, in the standard framework full insurance via security trading does the job, so that no self-insurance is needed.

Sections 3 and 4 study a simple model of the precautionary motive which, in contrast to the baseline permanent-income model, is consistent with the U-shaped pattern of consumption and the persistent increase in aggregate saving. In our model, the risk of falling into unemployment is not socialised and entirely falls on every household's shoulders. Then, rising unemployment risk leads to a strengthening of the precautionary motive for holding assets, and the increase in aggregate savings that follows considerably amplifies the fall in current consumption (relative to that implied by the complete markets model). Although this amplifying mechanism differs from the textbook Keynesian explanation based on price rigidity, it is strongly reminiscent of the Keynesian argument according to which the depth of recessions is due to large and persistent shortages of aggregate demand.

The complete insurance assumption is still widely used in macroeconomic, even when labour market outcomes are involved. The assumption of complete insurance markets together with labour market (search) frictions are introduced by Merz (1995) and Andolfatto (1996). This class of models typically studies the dynamic of unemployment assuming either that households are risk-neutral or that agents fully diversify unemployment risk within large "families". While these models yield important insights into the working of the labour market and the rate of frictional unemployment, they have little to say about the effect of unemployment risk on the countercyclicality of savings and the strong procyclicality of consumption.

An important class of models that dispenses with the complete markets assumption is that of "heterogenous agents" models, where uninsured idiosyncratic income risk coupled with borrowing constraint generates a very large-dimensional heterogeneity in individuals' asset holdings (e.g., Bewley, 1983; Aiyagari, 1994; Krussel and Smith, 1998). While these models have proven extremely useful for sheding light on cross-sectional inequalities in income and wealth amongst households, their applicability to the study of the business cycle and macroeconomic policy has thus far remained limited. In these models indeed, the whole history of employment statuses contributes to the determination of any agent's wealth and infinitely many types of agents, each of which having their own optimal consumption and saving plans, asymptotically coexist in the economy. Because of the technical and computational difficulties involved when handling large-dimensional cross-sectional distributions, the first generation of heterogenous agent models focused on stationary environments in which idiosyncratic labour income risk, while present, was assumed to be time-invariant (e.g., Huggett, 1993; Aiyagari, 1994). Krussel and Smith (1997, 1998) were the first to introduce aggregate shocks and time-varying labour income risk into this framework, but again computational limitations have narrowed the scope of issues that can be investigated; in particular, the time-varying nature of labour income risk is in general limited to two or three states, and the continuous changes in unemployment risk that takes place along the business cycles as well as its gradual impact on precautionary saving cannot be introduced.

Our model differs from this approach by focusing on a class of equilibria that endogenously generates a limited (in fact, minimal) degree of cross-sectional heterogeneity, and in which the interactions of idiosyncratic and aggregate shocks can straightforwardly be introduced. The particularity of our model is that it can be solved with paper and pencils and is thus liable to a variety of theoretical and quantitative explorations. Formally, this model belongs to broader class that we have been developing and which relies on reducing the cross-sectional distribution of heterogeneous households from an infinite to a finite number of types, whose behaviour is then easy to follow (see Algan *et al.*, 2009; Challe and Ragot, 2009; and Challe *et al.*, 2009 for applications of this framework pertaining to asset pricing and macroeconomic policy issues). More specifically, the class of equilibria that we focus on is based on two assumptions. The first is that unemployed households always end up facing a binding borrowing constraint if they stay unemployed for a sufficiently large number of periods. The second assumption is that the marginal utility of wealth is constant above a certain level of wealth, which can be seen as a extreme but particularly simple form of decreasing relative risk aversion. While we focus here of the simplest equilibrium having this joint property (i.e., one in which the constraint is binding from the very first period of unemployment while marginal utility is constant for all high-income agents), it is important to keep in mind that the framework can handle much larger (but, crucially, finite) cross-sectional distributions. Section 5 discusses the alternative applications of our framework and, more generally, how incorporating the large and time-varying idiosyncratic income uncertainty that agents face may alter our understanding of the business cycle, macroeconomic policy, and the role of financial intermediaries.

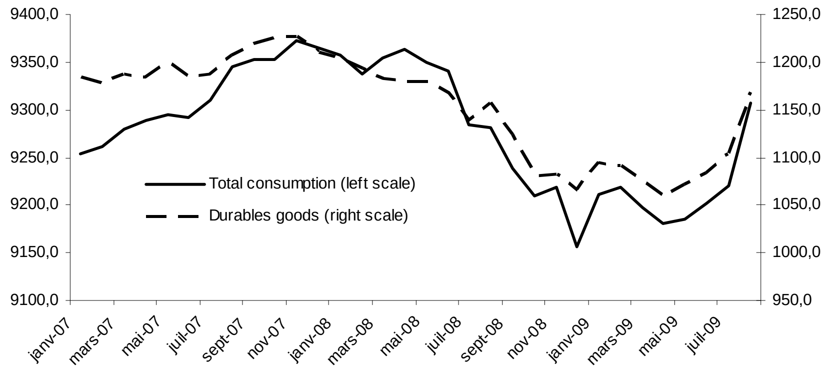
2 Consumption, saving and unemployment risk over the period 2007-2009

This Section summarises the evidence motivating the theoretical framework that follows. The first panel of Figure 1 shows the path of (private) consumption over the last couple of years, and displays two striking features. First, the drop in consumption that occured from the mid-2008 onwards is exceptionally large, both as a share of consumption before the shock and proportionally to aggregate output. Second, the path of aggregate consumption is U-shaped: the large drop in consumption has started recovering from the mid-2009. The second panel shows the dynamics of US aggregate saving over the same period.

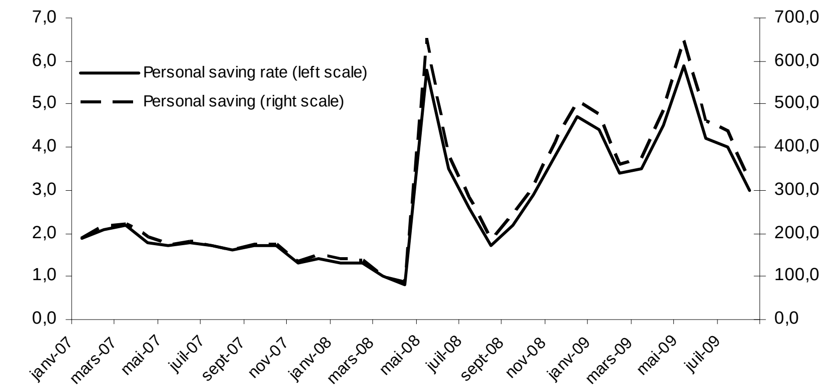
The joint behaviour of aggregate consumption and saving that has prevailed since the begining of the recession is puzzling from the point of view of the frictionless, representative agent model. In particular, the strong motive for intertemporal consumption smoothing predicted by that model implies that aggregate consumption should react strongly to permanent changes in aggregate (labour and capital) income but relatively little to transitory income changes. Hence, the baseline representative agent model can be made consistent with the particularly pronounced and U-shaped path of aggregate consumption observed since the mid-2007 only to the extent that the latter has reflected shifts in the perceived *permanent* income of private agents; under rational expectations, this would have required (unbelievably) huge revisions in permanent income forecasts. Within the Real Business Cycles framework, the general equilibrium variant of the permanent income approach, only permanent shifts in total factor productivity can generate substantial move permanent income; and it is hard to imagine, in the present case, which technological or institutional shocks would have moved production possibilities down and back up by such a large extent in such a short time. Even large crises are transitory, and hence something else than "permanent income behaviour" must have been at work behind the observed path of aggregate consumption.

Perhaps even more puzzling from the vantage point of the frictionless model is the behaviour of aggregate saving. Indeed, the model predicts that households seek to insulate

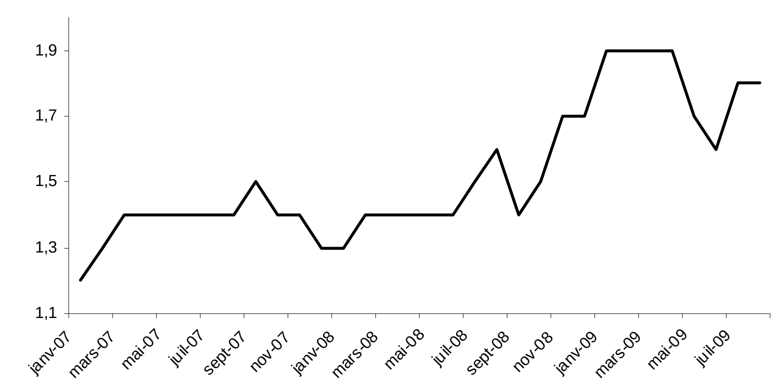
Real consumption expenditures (billions of 2005 USD)



Personal saving (Bill. of USD) and saving rate (%)



Layoffs and discharges rate (%)



current consumption from transitory changes in income by altering aggregate saving; hence, it cannot be the case that consumption falls while saving rises if the shock is perceived to be transitory. Of course, matters are a little more complicated if part of the shock is permanent, but again if households expect to be permanently poorer then both saving and consumption should fall. In short, the *joint* behaviour of aggregate consumption and saving that prevails since may 2008 appears inconsistent with the permanent income approach.

A natural explanation for this joint pattern, and the one that we pursue here, is that households have engaged in strong *precautionary saving behaviour*. By definition, an increase in the precautionary saving motive implies that, for a given level of income, agents substitue current consumption for current saving, so the latter may fall while the former rises. Moreover, if the precautionary saving motive is stronger during recessions, then it amplifies the consumption fall that would prevail without it and may render aggregate saving countercyclical.

The view that precautionary saving has been a major determinant of the depth of the ongoing recession is borne out by the dynamics of the layoff and discharge rate over the period of interest, and which we take as an indicator of the perceived risk of unemployment.[3] It is generally believed that unemployment risk is the greatest source of indisyncratic income risk faced by individuals (e.g., Carrol, 1992). Since this risk is only very imperfectly insured, we should expect agents to use precautionary savings as a substitute for the lack of social insurance. The precautionary component of aggregate savings should also be countercyclical, since recessions are typically associated with a rise in unemployment risk. The next Section develops a simple model of precautionary savings consistent with this view.

3 A simple model of precautionary saving behaviour

We consider the behaviour of a open economy facing the world gross interest rate $R \geq 1$.[4] Firms produce the unique output good thanks to the constant-return to scale technology

[3] We depict the layoff and discharge rate rather than the overall separation rate because the former is arguably a more accurate indicator of the risk of unemployment perceived by individuals. Since the beginning of 2007, the separation rate has decreased mildly, but this resulted from the composition of unvoluntary layoffs (which have risen sharply, as we document) and voluntary quits (which have fallen). See Shimer (2005) for historical evidence on the separation and job-finding rates.

[4] Our open-economy specification implies that the clearing of goods and asset markets operates internationally. The implied market-clearing conditions are spelt out in Appendix B.

$Y_t = F(K_t, N_t) = N_t f(k_t)$, where F is a neoclassical production function and $k_t = K_t/N_t$. Capital depreciates at rate δ. The optimal demand for inputs under perfect competition and constant returns to scale implies that k_t is time-invariant and equal to

$$k = f'^{-1}(R - 1 + \delta). \tag{1}$$

Since the capital-labour ratio is constant, so is the equilibrium real wage w, which is:

$$w = f(k) - kf'(k). \tag{2}$$

Total population is normalised to 1. Every household is endowed with one unit of labour, which is supplied inelastically to firms provided that the household is employed; the labour income of the employed is thus w. After one period of unemployment, households become "home producers" and earn the fixed amount $\lambda \in (0, w)$. In every period, employed household have a (time-varying) probability $\alpha_t \in (0, 1)$ of staying employed in the next period, and unemployed households have a (constant) probability $\rho \in (0, 1)$ of staying unemployment in the next period. While it is straightforward to introduce time-variations in job-finding rate $1 - \rho$ (with little changes in our results), we focus on changes in $1 - \alpha_t$, which we interpret as the layoff rate and which, as shown above, has undergone large and persistent variations since the burst of the current crisis.

The crucial feature of our model is that agents have limited ability to insure against unemployment risk. First, we assume that unemployment insurance, either private or public, is infeasible, (e.g., due to moral hasard). Second, agents cannot borrow against future income. This joint assumption implies that agents falling into unemployment cannot limit their current income fall thanks to insurance payments or finance current consumption against their (expectedly higher) future income. This creates a precautionary saving motive whose intensity will depend on the extent of unemployment risk.

The budget constraint of houshould i is:

$$c_t^i + a_t^i = y_t^i + a_{t-1}^i R,$$

where c_t^i denotes consumption, a_t^i asset holdings, and y_t^i current income, with $y_t^i = w$ if the household is employed, $y_t^i = 0$ if the household has just fallen into unemployment and $y_t^i = \lambda$ otherwise. Households i is assumed to maximise:

$$E_t \sum_{t=0}^{\infty} \beta^i u\left(c_t^i\right), \text{ with } u(c) = \begin{cases} \gamma c^* \ln(c) & if\ c \leq c^*, \\ \Omega + \gamma c & if\ c > c^*, \end{cases}$$

and $\Omega \equiv \gamma c^* (\ln(c^*) - 1)$, $c^* > 0$, $\beta \in (0,1)$. The instant utility function $u(.)$ is parameterised by (c^*, γ). It is increasing and continuously differentiable over $(0, +\infty)$, strictly concave up c^* and linear with slope γ at and above c^*. The linearity of $u(.)$ above c^* is crucial for the construction of our equilibrium with limited household heterogeneity, for it implies that above a certain level of consumption all households share the same marginal utility and hence the same demand for assets. Concavity below c^* is also essential because households must dislike large consumption falls if they are to form any precautionary savings in the first place. Finally, we assume that β is sufficiently low so that:

$$\beta R < 1 \tag{A1}$$

Assumption (A1) ensures that agents may wish to borrow, so that some may face a binding borrowing constraint, and is necessary for the equilibrium that we study to exist.

We focus on the simplest possible equilibrium generated by our model given our assumptions about preferences and technology, and construct this equilibrium via a simple "guess and verify" method. More specifically, our equilibrium has the property that all employed households end the current period with the same level of precautionary wealth a_t, while all unemployed households end the current period with zero wealth (consequently, the wealth distribution is two-state). The first part of the conjecture will be satisfied if all employed households reach a consumption level above c^*, and the second part will be satisfied if all unemployed households face a binding borrowing constraint and hence optimally chose to liquidate their entire asset wealth instantaneously.

Since the specific type of households depends on both beginning-of-period and end-of-period wealth, it follows that under our conjecture they can be of four different types only, depending on their employment status in the current period (which determines their end-of-period wealth) and that in the previous period (on which their wealth at the end of the previous period, and hence thatat the beginning of the current period, depends). We denote by ij, with $i, j = e, u$ the type of a household, where i and j refer to their employment status in the previous and in the current period, respectively, and where e and u stand for employed and unemployed, respectively (e.g., a “eu houshold” is currently unemployed but was employed in the previous period). In short, our conjecture about the wealth distribution drastically limits the length of individual history of unemployment shock relevant to the type of a households; this is in contrast with much of the heterogenous agents literature, where the entire individual history matters and hence the economy is asymptotically populated by infinitely many types of agents (e.g., Aiyagari, 1994).

Under our conjecture the budget constraints of the different types are as follows:

$$ee : c_t^{ee} + a_t = w + a_{t-1}R \tag{3}$$

$$ue : c_t^{ue} + a_t = w \tag{4}$$

$$eu : c_t^{eu} = a_{t-1}R \tag{5}$$

$$uu : c_t^{uu} = \lambda \tag{6}$$

This can be explained as follows. uu households, who where unemployed in the previous period, ended that period with no wealth and thus enjoy neither asset nor labour market income; however, they have turned into home producers and thus get the income λ. eu households where employed in the previous period and hence ended it with wealth a_{t-1}; in the current income they get no labour income but the asset income $a_{t-1}R$, which is entirely consume (since they do not replete assets). ue households, who where unemployed in the previous period and hence start the current one with no wealth, must both build up their asset wealth, a_t, and consume, c_t^{ue}, out of their labour income w. Finally, ee household ended the previous period with wealth a_{t-1}. In the current period they get the asset income $a_{t-1}R$, the labour income w, and allocate this income to the repletion of assets, a_t, and to the consumption of goods, c_t^{ee}. In (3)–(6) w, λ and R are given; hence once a_t is known, the consumption levels c_t^{ij} can be determined as residuals.

The optimal asset holding of employed households, a_t, can be directly infered from their Euler equation. If they fall into unemployment in the next period, which occurs with probability α_t, they will become eu households in the next period, so that their marginal utility of consumption will be $u'\left(c_{t+1}^{eu}\right) = u'\left(a_t R\right)$. If they stay employed, which occurs with complementary probability, they will be ee housholds, and thus enjoy marginal utility $u'\left(c_t^{ee}\right)$, in the next period. A key condition in the construction of our equilibrium (and one that will have to be verified once the whole equilibrium is worked out) is that the consumption of the employed is sufficiently high so that $c_t^{ee}, c_t^{ue} > c^*$, while the consumption of the unemployed is so low that $c_t^{eu}, c_t^{uu} < c^*$. This implies that $u'\left(c_t^{ee}\right) = u'\left(c_t^{ue}\right) = \gamma$ while $u'\left(a_t R\right) = \gamma c^*/a_t R$. Hence, the Euler equation characterising the optimal asset demand of both ue and ee households is:

$$\gamma = \beta R\left(\alpha_t \gamma + (1-\alpha_t)\left(\gamma c^*/a_t R\right)\right) \tag{7}$$

Note that their is no expectations operator in (7). This is because the only source of uncertainty that households face when choosing their asset holdings is about whether they will keep their job or not in the next period, whereas the probabilities associated with either event is known in the current period. Solving (7) for a_t, we get

$$a_t = \beta c^* \left(\frac{1-\alpha_t}{1-\beta R \alpha_t} \right). \tag{8}$$

Crucially, the optimal asset demand (8) is increasing in $1-\alpha_t$. In short, a rise in the risk of unemployment (as typically occurs during recessions) will cause households to raise precautionary savings, which will amplify the initial fall in aggregate consumption caused by lower aggreate labour endowment.

The description of the model is complete once we have characterised the evolution of the shares of each agent type implied by the dynamics of α_t. Calling ω_t^{ij} the share of ij households at date t, simple flow accounting indicates that these shares evolves as follows:

$$\omega_t^{ee} = \alpha_{t-1} \left(\omega_{t-1}^{ee} + \omega_{t-1}^{ue} \right) \tag{9}$$

$$\omega_t^{ue} = (1-\rho) \left(\omega_{t-1}^{eu} + \omega_{t-1}^{uu} \right) \tag{10}$$

$$\omega_t^{eu} = (1-\alpha_{t-1}) \left(\omega_{t-1}^{ee} + \omega_{t-1}^{ue} \right) \tag{11}$$

$$\omega_t^{uu} = \rho \left(\omega_{t-1}^{eu} + \omega_{t-1}^{uu} \right) \tag{12}$$

We show in Appendix A that our conjectured four-agent type equilibrium exists for large (and plausible) parameter ranges. More specifically, we check that under such values the steady state counterpart of our model (i.e., one in which $\alpha_t = \alpha$) satisfies our conditions about the ranking of consumption level and the bindingness of the borrowing constraint for unemployed households. Then, if deviations of α_t from the steady state are of sufficiently small magnitude, these conditions will also hold along the stochastic model and will fulfill our conjectured equilibrium.

Having derived individual consumption and asset accumulation rules, we may now turn to the aggregate dynamics of the model.

4 Dynamics effects of a shock to unemployment risk

The previous section showed how the precautionary motive for holding wealth affects the way households react to changes in unemployment risk. We now turn to the aggregate implications of the precautionary motive, in particular with respect to aggregate consumption, asset wealth and savings.

We take the path of α_t to be the exogenous forcing variable here. N_t. At any date t, a share α_t of currently employed households will stay so in the next period, while a share $1-\rho$

of currently unemployed households, who are in number $1 - N_t$, will leave unemployment in the next period. Hence, the dynamics of total employment is given by:

$$N_t = \alpha_{t-1} N_{t-1} + (1 - \rho)(1 - N_{t-1}), \tag{13}$$

The most direct interpretation of unemployment risk as modelled here is to think of N_t as the number of firms that are operative in the economy at date t (or, equivalently, the number of divisions of the "representative firm"), each of which being able to hire one household. Then, a shock to α_t is one about the number of such firms that will remain operative in the next period, while ρ is the rate at which potential firms restart being operative.

All other variables of interest in the model depend on α_t and N_t. For example, since only employed households hold assets, end-of-period total assets are $A_t = a_t N_t$, where a_t is given by (8). Similarly, from the constant-returns-to-scale assumption, aggregate output is $Y_t = f(k) N_t$, so the asset-output ratio is simply:

$$A_t / Y_t = f(k)^{-1} a_t,$$

This ratio is countercyclical, due to the precautionary nature of the demand for wealth: when α_t decreases (i.e., unemployment risk is higher), then a_t rises while N_t fall. However, Y_t is also scaled by N_t and hence A_t / Y_t exactly tracks individual wealth.

What we are primarily concerned with here is the behaviour of aggregate consumption, C_t, and the saving rate, S_t / Y_t, induced by this precautionary demand for wealth. Aggregating the budget constraints (3)–(6) thanks to the population sizes (9)–(12), aggregate consumption is

$$C_t = -(A_t - R A_{t-1}) + (w N_t + \lambda \omega_t^{uu}), \tag{14}$$

where $A_t - R A_{t-1}$ is the change in total assets while $w N_t + \lambda \omega_t^{uu}$ is total labour income. Finally aggregates savings, $S_t = Y_t - C_t$, and the saving rate, S_t / Y_t, can be directly computed from (14) and the fact that $Y_t = f(k) N_t$.

Figure 2 below shows impulse-response functions following a change in the exogenous path for the job-loss probability, $1 - \alpha_t$. This path, which is represented in the first panel, is ad hoc and meant to be a plausible dynamics for what happend since the mid-2008 (see Figure 1); it increases linearly in the first few periods, goes through a hump, and then decreases gradually according to an AR(1) process with autocorrelation paramter 0.95. The implied dynamics of the variables of interest directly follow.

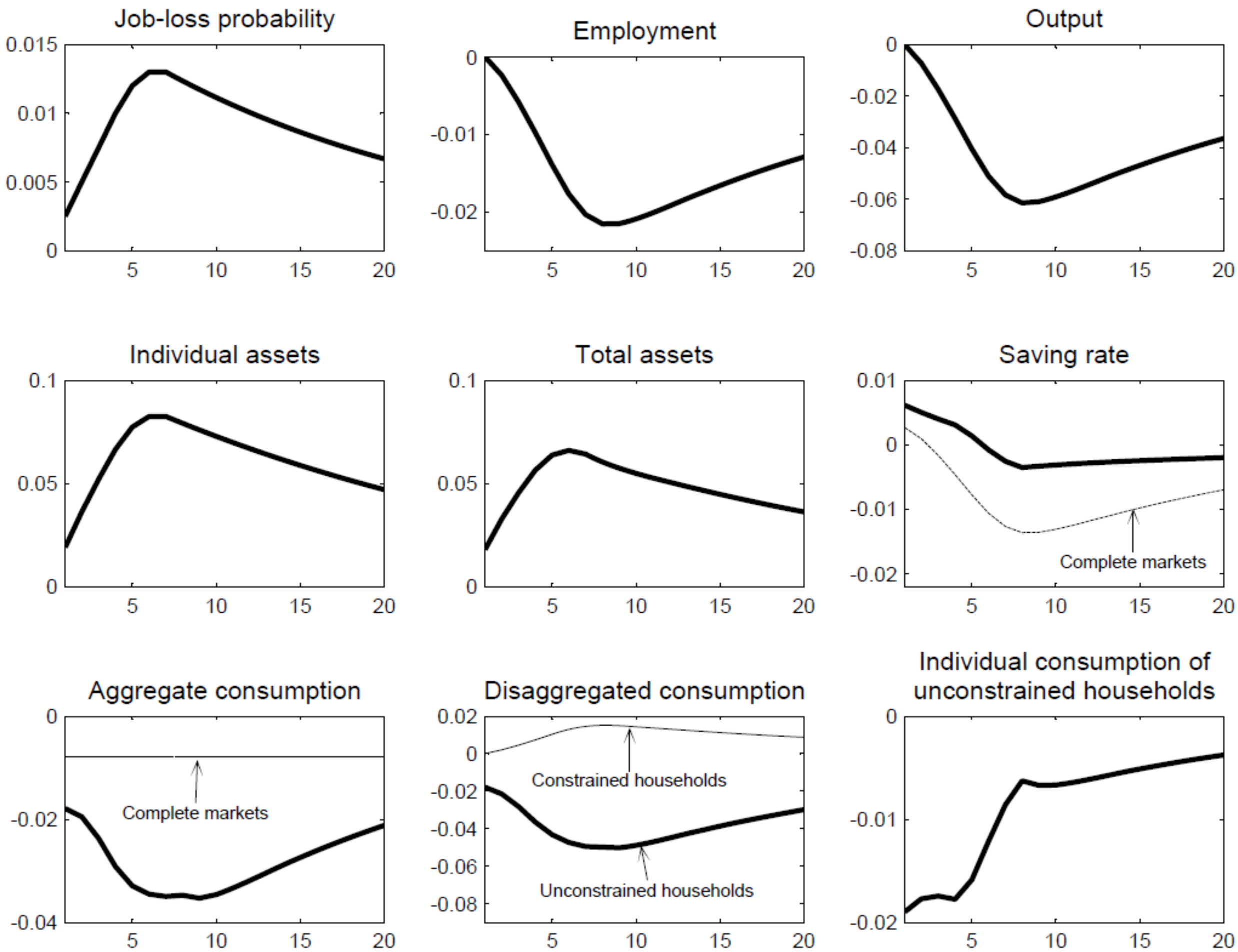


Figure 1: All variables are expressed as level deviations from the steady state.

Employment, N_t, and (market) output, Y_t, are given by (13) and $f(k)N_t$, respectively. Individal assets, given by (8), reflect the precautionary saving behaviour of employed (i.e., currently unconstrained) households and thus track the job-loss probability. In our model only employed households are unconstrained and thus hold assets; then, total assets, a_tN_t, rise because individual assets change more than the number of savers (i.e., the *intensive* asset holding margin dominates the extensive margin), and this is in turn reflected in a persistently high saving rate.

The amplifying effect of precautionary savings on aggregate consumption and its components is depicted in the last row of Figure 2. In the first panel, the response implied by our model is compared with that which would be implied by the complete markets analogue. Essentially, in the complete markets model unemployment risk is fully diversified between individuals and hence no precautionary saving behaviour takes place; formally, the aggregate labour income $wN_t + \lambda\omega_t^{uu}$ is given to the the representative agent, who aligns current consumption to total (i.e., financial and human) wealth (see Appendix C for details). The partial equilibrium nature of our model implies that complete-market consumption follows a random walk (as in Hall, 1978), while the transitory nature of the shock means that it moves by a relatively small amount (because the impact of the shock on human wealth is limited). In short, the fall in aggregate consumption that would be incurred by the representative agent is both *mild* and *acyclical*. The situation is very different under incomplete markets; in this situation, the precautionary saving motive leading to the gradual increase in total assets, A_t, is reflected in a large, gradual and persistent fall in aggregate consumption. Moreover, inasmuch as the strength of the precautionary saving motive tracks unemployment risk and that the latter is hump-shaped, aggregate consumption is mean-reverting and U-shaped, as is consistent with the evidence shown in Section 2.

The last two panels of Figure 2 look at disaggregated consumption levels to illustrate that precautionary savings, rather than other factors, is indeed chiefly responsible for the prolonged fall in current consumption. Indeed, one legitimate concern one may have by looking at the path aggregate consumption is that the latter could be driven by the consumption of borrowing-constrained agents (that is, those who do *not* form precautionary savings), whose current income impacts their consumption level one for one, rather than by that of unconstrained precautionary savers. The panel before last displays the total contribution of constrained and unconstrained households, and shows that much of the consumption dynamics is driven by the behaviour of precautionary savers. In fact, the total consumption of constrained households *rises* mildly, rather than falls, after the shock. This occurs for two reasons. First constrained households rise in number after the shock has taken place. Second, some of the unconstrained actually consumes *more* than they would have had the shock not occured: those who liquidate their assets (that is, *ue* households), whose precautionary wealth has *increased* since the recession has started following rising uncertainty about employment prospects. The last panel divides the total consumption of precautionary savers (i.e., *ue* and *ee* households) by the total number of such savers (i.e., $\omega_t^{ee} + \omega_t^{ue}$). This again establishes the leading role of the precautionary motive in determining the dynamics of aggregate consumption.

5 Concluding remarks

This paper has built on a now long (but probably still minoritarian) tradition in macroeconomic analysis that emphasises the importance of uninsurable income risk and borrowing constraints in determining aggregate outcomes. Early work in this literature, including those of Bewley (1983), Scheinkman and Weiss (1986), Kehoe, Levine Woodford (1991) and Imohoroglu (1992), focused on the precautionary demand for money under incomplete income insurance. Aiyagari (1994) and Huggett (1997) extended early models by analysing the effects of the precautionary motive when assets are claims to the capital stock. The latest wave of papers, including Krusell and Smith (1997, 1998) and Heathcote (2005), have introduced aggregate shocks (together with indiosyncratic uncertainty) into this framework, and have thus contributed to the extension of this approach to a variety of macroeconomic issues, including business cycles and fiscal policy. Violante *et al.* (2009) provide a survey of these models, commonly refered to as "heterogeneous agents" models.

The purpose of our current research, of which the model developed in Sections 3 and 4 is a representative example, is to offer simple classes of models/equilibria that incorporate a variety of channels related to the precautionary motive and the demand for "aggregate liquidity". Indeed, it seems to us that the scope of analysis of incomplete market models is often limited by the computationally difficult exercise of approximating the dynamics of the equilibrium wealth distribution. In contrast, our model provides an illustration of what can be achieved by confining oneself to the simplest deviation from the complete markets assumption; essentially, the outcome is a model that can accomodate uninsured individual risk, agents' heterogeneity and the precautionary saving motive, while at the same time taking the form of a standard DSGE model, for which a variety of workable solutions techniques are available. Our analysis could thus easily be extended in several directions whilst maintaining tractability, e.g., by considering endogenous interest rate adjustments (such as those which would occur in a closed or a large, open economy), more realistic labour market frictions and adjustments, a larger number of liquidation periods for the unemployed, etc.

Because incomplete markets economies typically generate aggregate inefficiencies, they leave ample room for welfare-improving policy interventions. For example, in the context of the model presented above, rising idioysncratic uncertainty leads to a much larger fall in total private demand than is (first-best) efficient. This suggests that this model may provide a rationale for aggregate demand management of the "Keynesian" kind, inasmuch as it may indirectly provides labour income insurance when direct insurance markets are missing.[5] Here again, it seems important to carry out theoretical and quantitative experiments in models that are workable and where the transmission channels of the different policy options are transparent.

More generally, it is our contention that generalising the incorporation of uninsurable risk into the various strands of economic analysis may considerably improve our understanding of the macroeconomy, both along the business cycle and in time of major crisis such a that we are experiencing now. To give substance to this view, let us think loud about some potential applications of our framework for a moment. One typical example of behaviour akin to "precautionary saving" or "aggregate liquidity hoarding" is that recentely adopted by financial institutions on several occasions. In these episodes, intermediaries hoarded base money or liquid assets to avoid any form of credit risk. This behaviour is clearly detrimental to the normal functionning of financial intermediation, and may even trigger the collapse of some financial markets (e.g., the interbank market). Take, as another example, the behaviour of firms facing uncertainty about idiosyncratic factors such as productivity, demand, etc. In this situation, high individual uncertainty leads to delayed investment in order to avoid commitment to future production. Similarly, inventory management is another well-known form of self-insurance.

To summarise, our answer to the question "What's wrong with modern macroeconomics?" is that the latter has (thus far) considerably underestimated the extent and cyclicality of the

[5] Challe and Ragot (2009) construct a model (without capital) in which expansionary fiscal policy, by altering the stock of aggregate liquidity, may boost aggregate consumption and welfare.

individual uncertainty faced by economic agents. One implication is that macroeconomics has largely overlooked the role of precautionary savings in the business cycle and the way it may affect aggregate demand. While the current paper has focused on the effect of unemployment risk and aggregate consumption, the argument applies equally well to a variety of other economic agents or institutions, such as firms and intermediaries.

Appendix

A. Existence conditions

This appendix works out the sufficient conditions for the equilibrium analysed in the body of the paper to exist. We must check that our equilibrium conditions are satisfied in the steady state, as characterised by the deterministic counterparts of (3)–(6), (8), and (9)–(12). There are two sets of conditions for the equilibrium to exist. First, the ranking of consumption levels must be consistent with the conjectured ranking under which the equilibrium was derived, i.e., $c^{uu} < c^{eu} < c^* < c^{ue} < c^{ee}$. From (3) and (4), it is necessarily the case that $c^{ue} < c^{ee}$. Using (8), the condition that $c^{ue} = w - a > c^*$ gives:

$$w > c^* \left(1 + \frac{\beta (1-\alpha)}{1 - \beta R \alpha}\right) \tag{15}$$

From (8) and (5), we have that $c^{eu} < c^*$ if and only if $R\beta < 1$, which holds by assumption (A1). Finally, from (5) and (6) the condition that $c^{uu} = \lambda < c^{eu} = aR$ gives:

$$\frac{c^*}{\lambda} > \frac{1 - \beta R \alpha}{\beta R (1-\alpha)} \tag{16}$$

Second, the borrowing constraint must be binding for eu- and uu-households. Since $c^{uu} < c^{eu}$ under condition (16), while the probability of leaving unemployment is the same for the two types, we only need to check that it is binding for eu-households, which is the case if and only if:

$$u'(c^{eu}) > \beta R \left(\rho u'(c^{uu}) + (1-\rho) u'(c^{ue})\right).$$

With $c^{eu} = aR$ and $c^{uu} = \lambda$ to the left of c^* and c^{ue} to the right of c^*, this inequality becomes:

$$a\beta R^2 \left(\frac{\rho}{\lambda} + \frac{1-\rho}{c^*}\right) < 1 \tag{17}$$

The stochastic equilibrium constructed in the paper exists whenever conditions (15)–(17) are jointly satisfied and fluctuations around the steady state are small. They are satisfied for any plausible parameter configuration provided that γ and c^* are chosen appropriately.

B. National income accounting

Clearing of the capital markets operates through international capital movements. End-of-period assets, A_t, serve to form the capital stock at the beginning of the next period, K_{t+1}, as well as net foreign assets at the beginning of the next period, F_{t+1}. We thus have:

$$A_t = K_{t+1} + F_{t+1}$$

Firms maximisation under constant returns to scale implies that market output, Y_t, is

$$Y_t = wN_t + (R - 1 + \delta) K_t,$$

while total domestic output, which incorporates home production, is $\tilde{Y}_t = Y_t + \lambda\omega_t^{uu}$. Solving the market output equation for wN_t, substituting it into (14) and using the asset market clearing condition, we get the accounting identity

$$C_t + (K_{t+1} - (1 - \delta) K_t) + (F_{t+1} - RF_t) = \tilde{Y}_t,$$

where the expressions inside the first and second pairs of brackets are savings invested domestically and savings invested abroad, respectively. Since the latter are also equal to net exports, changes in net foreign assets are net exports plus capital income from abroad, i.e.,

$$\Delta F_{t+1} = (X_t - M_t) + (R - 1) F_t.$$

C. The representative agent economy

In order to construct the equivalent open-economy, representative agent economy, we must first set this agent's subjective discount factor, β^{ra}, to $1/R$ (otherwise foreign borrowing or lending would be unlimited). We then endow this agent with the aggregate labour income $wN_t + \lambda\omega_t^{uu}$, and compute the implied optimal consumption and saving plans given the forcing sequence $\{\alpha_t\}_{t=0}^{\infty}$. We assume that $\alpha_t = \alpha$ until some date T. At $t = T$, a unanticipated shock occurs that sets α_t in motion; once the shock has occured, the path for α_t is perfectly anticipated. With $\beta^{ra} = 1/R$, the Keynes-Ramsey rule implies that $C_{t+1} = C_t$ for all $t \geq T$. Iterating the period budget constraint (14) forward, yields the following intertemporal budget constraint (IBC):

$$\sum_{i=0}^{\infty} \left(\frac{C_{t+i}}{R^i} \right) = \sum_{i=0}^{\infty} \left(\frac{wN_t + \lambda\omega_t^{uu}}{R^i} \right) + RA_{t-1}.$$

Using the IBC and the optimality condition $C_{t+1} = C_t \; \forall t \geq T$, we find that:

$$C_t = \Lambda (H_t + RA_{t-1}),$$

where $H_t = \sum_{i=0}^{\infty} \left(wN_t + \lambda \omega_t^{uu} \right) / R$ is the representative agent's human wealth, RA_{t-1} his (begining-of-period) financial wealth and $\Lambda = (R-1)/R$ is the propensity to consume out of wealth. With the economy being in the steady state before $t = T$, we have $A_{t-1} = A_{t-2}$, so that the change in aggregate consumption triggered by the shock is simply the shock to human wealth, i.e., $\Delta C_t = \Lambda \Delta H_t$. Then, using unindexed variables to denote steady state values, we have:

$$\Delta C_t = \Lambda \left(H_t - H \right) = \Lambda \sum_{i=0}^{\infty} \left(w \left(\frac{N_{t+i} - N}{R^i} \right) + \lambda \left(\frac{\omega_t^{uu} - \omega^{uu}}{R^i} \right) \right).$$

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