

Wealth and Volatility*

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Abstract

Between 2007 and 2013, U.S. households experienced a large and persistent decline in net worth. The objective of this paper is to study the business cycle implications of such a decline. We first develop a tractable monetary model in which households face idiosyncratic unemployment risk that they can partially self-insure using savings. A low level of liquid household wealth opens the door to self-fulfilling fluctuations: if wealth-poor households expect high unemployment, they have a strong precautionary incentive to cut spending, which can make the expectation of high unemployment a reality. Monetary policy, because of the zero lower bound, cannot rule out such expectations-driven recessions. In contrast, when wealth is sufficiently high, an aggressive monetary policy can keep the economy at full employment. Finally, we document that during the U.S. Great Recession wealth-poor households increased saving more sharply than richer households, pointing towards the importance of the precautionary channel over this period.

Keywords: Business cycles; aggregate demand; precautionary saving; multiple equilibria, self-fulfilling crises, zero lower bound.

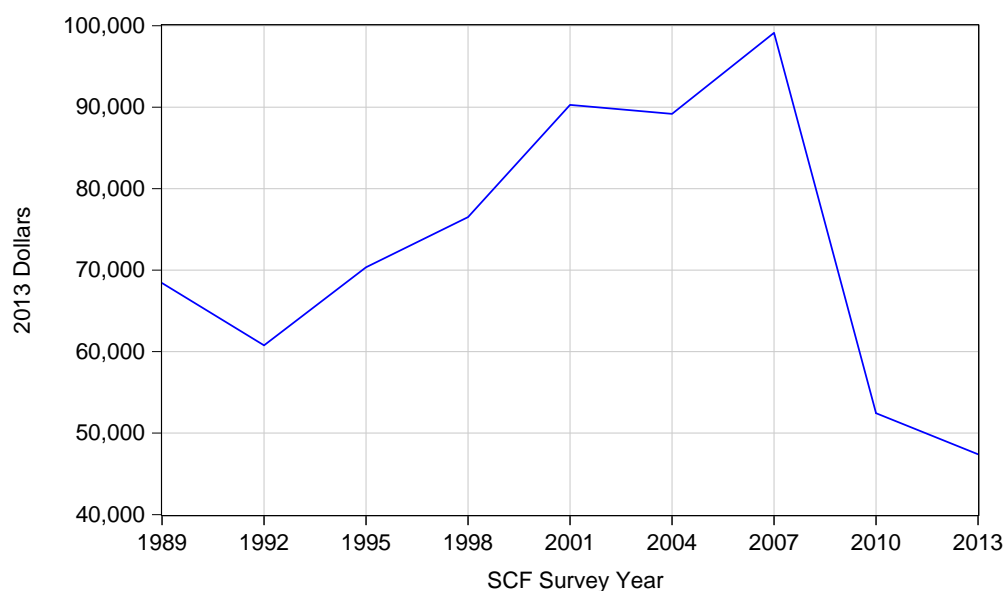
JEL classification codes: E12, E21, E52.

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1 Introduction

Between 2007 and 2013, a large fraction of U.S. households experienced a large and persistent decline in net worth. Figure 1 plots median real net worth from the Survey of Consumer Finances (SCF), for the period 1989-2013, for households with heads between ages 22 and 60. Between 2007 and 2010, median net worth for this group roughly halved and no recovery is evident in 2013. In relation to income, the decline is equally dramatic: the median value for the net worth to income ratio fell from 1.58 in 2007 to 0.92 in 2013.

Figure 1: Median household net worth in the United States



Note: Sample includes households with heads between ages 22 and 60.

The objective of this paper is to study the business cycle implications of such a large and widespread fall in wealth. We argue that falls in household wealth (driven by falls in asset prices) leave the economy more susceptible to confidence shocks that can increase macroeconomic volatility. Thus, policymakers should view low levels of household wealth as presenting a threat to macroeconomic stability. Figures 2 and 3 provide some suggestive evidence for this message.

Figure 2 shows a series for the log of total real household net worth in the United States from 1920 to 2013, together with its linear trend. The figure shows that over this period there have been three large and persistent declines in household net worth: one in the early 1930s, one in the early 1970s, and the one that started in 2007. All three declines marked the start of periods

characterized by deep recessions and elevated macroeconomic volatility.¹

Figure 2: Household net worth since 1920

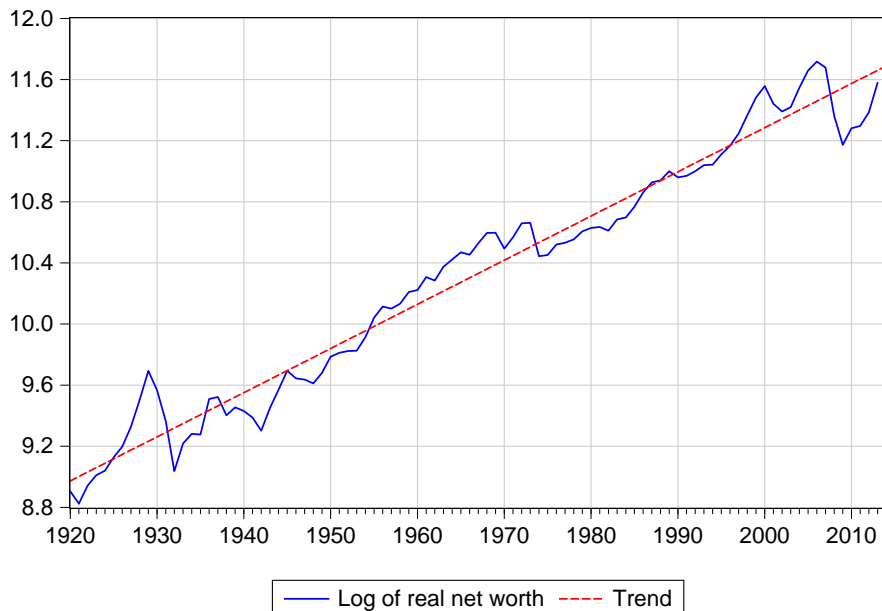
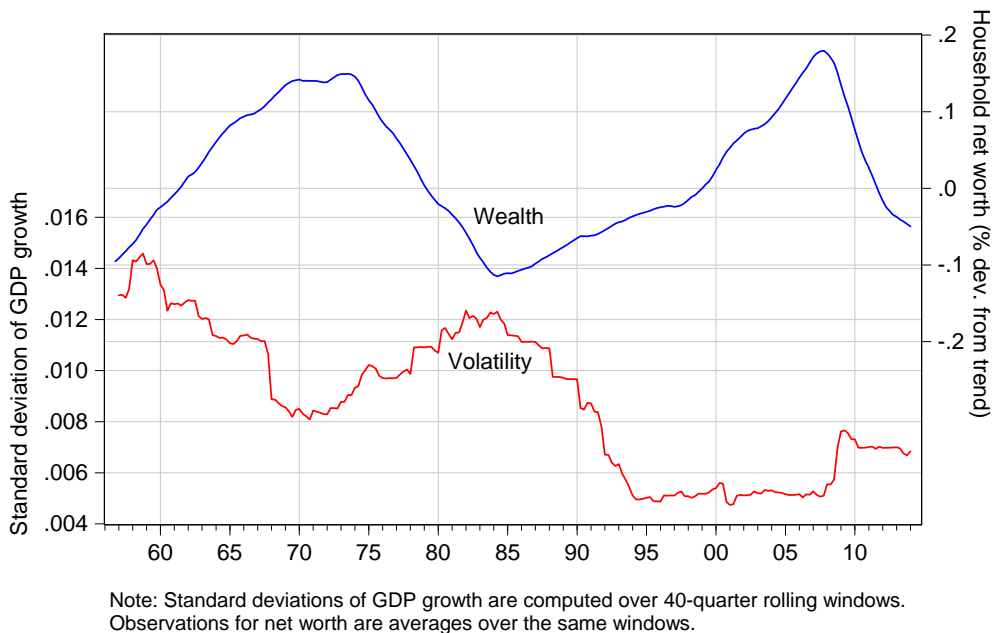


Figure 3 focuses on the postwar period, for which we can obtain a consistent measure of macroeconomic volatility. We measure volatility as the standard deviation of quarterly real GDP growth over a 10-year window. The figure plots this measure of volatility for overlapping windows starting in 1947.1 (the values on the x -axis correspond to the end of the window), together with wealth, measured as the deviation from trend (the difference between the solid and dashed lines in Figure 2) averaged over the same 10-year window. The figure reveals that periods when wealth is high relative to trend, reflecting high prices for housing and/or stocks, tend to display low volatility in aggregate output (and hence employment and consumption). Conversely, periods in which net worth is below trend tend to be periods of high macroeconomic volatility. For example, during windows ending in the late 1950s and early 1980s, wealth is well below trend, and volatility peaks; conversely, in windows ending in the early 2000s and late 1960s, wealth is well above trend and volatility is low.

There are many possible explanations for a correlation between wealth and volatility, some of which we discuss in Section 1.1. The novel idea of this paper is that the value of wealth in an

¹In order to construct a consistent series for net worth, we focus on three categories of net worth for which we can obtain consistent data throughout the sample: real estate wealth (net of mortgages), corporate securities, and government treasuries. See Appendix C for details on the construction of the series.

Figure 3: Wealth and volatility



economy determines whether or not the economy is vulnerable to economic fluctuations driven by changes in household optimism or pessimism (animal spirits). When wealth is low, consumers are poorly equipped to self-insure against unemployment risk, and hence have a precautionary saving motive which is highly sensitive to unemployment expectations. Suppose households come to expect high unemployment. With low wealth, the precautionary motive to save will increase sharply, and households' desired expenditure will fall. In an environment in which demand affects output (because, say, of nominal rigidities), this decline in spending rationalizes high expected unemployment. Suppose, instead, that households in the same low wealth environment expect low unemployment. In this case, because perceived unemployment risk is low, the precautionary motive will be weak, consumption demand will be relatively strong, and hence equilibrium unemployment will be low. Thus, when asset values are low, economic fluctuations can arise due to self-fulfilling changes in expected unemployment risk.

In contrast, when the fundamentals are such that asset values are high, consumers can use wealth to smooth consumption through unemployment spells, and thus the precautionary motive to save is weak irrespective of the expected unemployment rate. Thus, high wealth rules out a confidence-driven collapse in demand and output.

One additional important issue is the role of monetary policy, and in particular whether the

monetary authority can, by cutting the nominal interest rate, sufficiently stimulate household spending to prevent self-fulfilling confidence crises. We will show that aggressive monetary policy can indeed stabilize the economy, but only when household liquid wealth is sufficiently high.

This paper is broadly divided in two parts. In the first part we develop our theoretical analysis, while in the second we provide micro empirical evidence supporting the importance of the precautionary motive for aggregate spending.

The theory part develops a simple model of a monetary economy in which precaution-driven changes in consumer demand can generate self-fulfilling aggregate fluctuations. The model has three key ingredients. First, unemployment risk is imperfectly insurable, so that changes to anticipated unemployment change the strength of the precautionary motive to save. Second, there is a nominal rigidity, so that precaution-driven changes to consumer demand can translate into changes in equilibrium unemployment. Specifically, we assume sticky nominal wages (as in Rendahl, 2016, or Midrigan and Philippon, 2016) so that changes to consumer demand, by affecting the price level, can influence real wages and labor demand. Third, there is a monetary authority that controls the nominal interest rate, and can thereby affect aggregate demand. Importantly, however, the monetary authority's ability to stabilize the economy is constrained by the zero lower bound on interest rates.

Labor in the model is indivisible, so if real wages are too high to support full employment, a fraction of potential workers end up unemployed. We rule out explicit unemployment insurance, but assume that households own an asset (housing) that can be used to smooth consumption in the event of an unemployment spell. We avoid the numerical complexity associated with standard incomplete markets models (e.g., Huggett 1993 or Aiyagari 1994) by assuming that individuals belong to large representative households. However, the household cannot reshuffle resources from working to unemployed household members within the period. This preserves the precautionary motive, which is the hallmark of incomplete markets models.² We will heavily exploit one model property: higher liquid wealth (i.e., higher house prices, or a greater ability to borrow against housing) makes desired precautionary saving (and thus consumption demand) less sensitive to the level of unemployment risk.

We first show that if fundamentals are such that household liquid wealth is relatively high, then the monetary authority can stabilize the economy at full employment by promising to cut rates aggressively should unemployment ever materialize. The intuition is that high liquid wealth implies

²Challe and Ragot (2016) show that an alternative way to preserve a low-dimensional cross-sectional wealth distribution, while still admitting a precautionary motive, is to assume that utility is linear above a certain consumption threshold.

a weak precautionary motive, so that the monetary authority can always promise enough stimulus to undo any precaution-driven slump in demand.

When fundamentals are such that liquid wealth is low, in contrast, high unemployment can arise in equilibrium, even if the central bank is very aggressive. To see this imagine that households come to expect high unemployment. In this case, because of low liquid wealth, the precautionary motive to save would strengthen, and aggregate demand would fall. The monetary authority will try to increase aggregate demand by lowering the nominal rate, but if the precautionary motive is strong enough, then even a zero nominal rate will be insufficient to restore aggregate demand, and the initial expectation of high unemployment will be validated.

After characterizing equilibria in the model, we show that the theory can be applied to help us better understand some features of the Great Recession of 2007-2009 in the United States. A parameterized version of the model displays an equilibrium in which the economy experiences a persistent recession featuring an extended period at the zero lower bound. This zero lower bound recession is triggered by a non-fundamental negative shock to unemployment expectations, rather than by exogenous shocks to credit or to patience as in most of the existing literature. A change in expectations also drives the emergence of the zero lower bound in Schmitt-Grohe and Uribe (2017). However, in that paper the path to the lower bound involves deflationary expectations, while in our model – as in the data – the zero lower bound binds because the equilibrium real interest rate is low, and not because the economy is experiencing deflation.

In the second part of the paper we use micro data from the Consumer Expenditure Survey (CES) and the Panel Study of Income Dynamics (PSID) to document that, around the onset of the Great Recession, low net worth households increased their saving rates by significantly more than high net worth households. This pattern is especially remarkable when considered alongside a second finding, which is that low wealth households suffered much smaller wealth losses during the recession. This new evidence indicates that the precautionary motive, in the context of sharply eroded home equity wealth and rising unemployment risk, was a key driver of consumption dynamics during the recession.

1.1 Related Literature

On the theory side, there is a long tradition of models in which self-fulfilling changes in expectations generate fluctuations in aggregate economic activity (see Cooper and John, 1988, for an overview). A classic early contribution is Diamond (1982), which generates multiplicity using a thick market externality. Chamley (2014) constructs a model in which different equilibria are supported by dif-

ferences in the strength of the precautionary motive to save, as in our model. In the low output equilibrium, individuals are reluctant to buy goods because they are pessimistic about their future opportunities to sell goods and because credit is restricted. In Kaplan and Menzio (2016), multiplicity is driven by a shopping externality: when more people are employed, the average shopper is less price sensitive, thereby increasing firms' profits and spurring vacancy creation. Bacchetta and Van Wincoop (2016) note that with strong international trade linkages, expectations-driven fluctuations will necessarily tend to be global in nature. Finally, Benigno and Fornaro (2016) argue that expectations of low demand can be self-fulfilling as these expectations lead to low profits, low innovation investment, low growth, and a stagnation trap at the zero lower bound.

Perhaps the most important difference between all these papers and ours is that we focus on the role of household wealth in determining when self-fulfilling fluctuations can arise. In most models that admit nonfundamental-driven fluctuations, the theory has little to say about when fluctuations should occur. In contrast, we argue that a low level of household wealth makes the economy more vulnerable to confidence-driven recessions.

In Farmer (2013, 2014) households form expectations – tied to asset prices – about the level of output, and wages in a frictional labor market adjust to support the associated level of hiring. A model recession is driven by a self-fulfilling fall in expected asset prices, which depresses spending via a wealth effect channel. In our theory, in contrast, what drives reduced spending, causing a recession, is a self-fulfilling increase in expected unemployment, which reduces spending via a precautionary channel. These two alternative theories are not mutually exclusive, but if wealth effects were the main driver of reduced spending during the Great Recession, then high wealth households (who suffered the largest wealth losses) should have exhibited the largest spending declines. Instead, the data show that low wealth households were the ones who reduced consumption most, suggesting an important role for our precautionary mechanism.

Guerrieri and Lorenzoni (2009 and 2015), Challe and Ragot (2016), and Midrigan and Philippon (2016) all emphasize the role of precautionary savings as a mechanism that amplifies fundamental shocks. Ravn and Sterk (2014), den Haan et al. (2016), and Challe et al. (2015) have in common with our paper that weak demand can amplify unemployment risk, which in turn can feed back into weak demand. However, none of these papers considers the possibility of self-fulfilling precaution-driven fluctuations. In Beaudry et al. (2017) the precautionary savings channel amplifies a negative demand shock – via higher unemployment risk – but in their model, the impetus to low demand is excessively high past wealth accumulation, whereas we emphasize vulnerability when wealth is low.

Our paper also adds to the literature exploring the causes and consequences of hitting the zero lower bound on nominal interest rates (ZLB). In Eggertsson and Woodford (2003), Christiano et al. (2011), Werning (2012), and Rendahl (2016) what drives the economy into the ZLB is increased saving, due to a temporary exogenous shock to households' patience. In Eggertsson and Krugman (2012), Guerrieri and Lorenzoni (2015), Eggertsson and Mehrotra (2014), and Midrigan and Philippon (2016) additional saving arises due to a tightening of leverage constraints. In Caballero and Farhi (2017) it is the interaction of aggregate risk interacts with a shortage of safe assets. In contrast to all these papers, in our model no exogenous fundamental shocks are required to hit the ZLB. Instead, in a low liquid wealth environment a negative shock to expectations can endogenously generate an increase in unemployment risk and a sharp decline in equilibrium interest rates.

Our emphasis on the role of asset values in shaping the set of possible equilibrium outcomes is shared by the literature on bubbles in production economies. Martin and Ventura (2016) consider an environment in which credit is limited by the value of collateral. Alternative market expectations can give rise to credit bubbles, which increase the credit available for entrepreneurs and therefore generate a boom (see also Kocherlakota, 2009). Hintermaier and Koeniger (2013) link the level of wealth to the scope for equilibrium multiplicity in an environment in which sunspot-driven fluctuations correspond to changes in the equilibrium price of collateral against consumer borrowing.

There are also papers that emphasize a link between asset values and volatility, with causation running from volatility to asset prices. For example, Lettau et al. (2008) point out that higher aggregate risk should drive up the risk premium, and hence lower prices, on risky assets such as housing and equity. In our model, asset prices are the primitive, and the level of asset prices determines the possible range of equilibrium output fluctuations (i.e., macroeconomic volatility). Lustig and van Nieuwerburgh (2005) and Favilukis et al. (2017) build models which share a key transmission channel with ours: house prices affect households' borrowing ability, and change household exposure to idiosyncratic risk. However, their focus is on understanding asset price dynamics given aggregate risk, rather than explaining aggregate risk itself.

Our emphasis on the role of confidence is also a feature of Angeletos and La'O (2013) and Angeletos et al. (2016) in which sentiment shocks (i.e., shocks to expectations about other agents behavior) can lead to aggregate fluctuations.

On the empirical side, our model is related to a large literature which relates individual expenditures to labor income risk and to wealth, in order to assess the importance of the precautionary motive for consumption dynamics. Using British micro data, Benito (2006) finds that more job insecurity (using both model-based and self-reported measures of risk) translates into lower con-

sumption. Importantly for the mechanism in our model, he finds that this effect is stronger for groups that have little household net worth. Engen and Gruber (2001) exploit state variation in unemployment insurance (UI) benefit schedules and estimate that reducing the UI benefit replacement rate by 50 percent for the average worker increases gross financial asset holdings by 14 percent. Carroll (1992) argues that cyclical variation in the precautionary savings motive explains a large fraction of cyclical variation in the savings rate.

Carroll et al. (2012) find that increased unemployment risk and direct wealth effects played the dominant roles in accounting for the rise in the U.S. savings rate during the Great Recession. Mody et al. (2012) similarly conclude that the global decline in consumption was largely due to an increase in precautionary saving. Alan et al. (2012) exploit age variation in savings responses in U.K. data to discriminate between increased precautionary saving driven by larger idiosyncratic shocks versus the direct effects of tighter credit. They conclude that a time-varying precautionary motive was the key factor: tighter credit, in their model, mostly affects the young, whereas all age groups increased saving. Mian and Sufi (2010 and 2016) and Mian et al. (2013) use county-level data to show that consumption declines during the Great Recession were larger in counties with lower initial net worth, evidence again consistent with a heightened precautionary motive. Baker (2017) uses household-level U.S. data to show that consumption responses to income shocks are muted for households with high levels of liquid wealth. Jappelli and Pistaferri (2014) reach a similar conclusion using Italian survey data. Finally, Kaplan et al. (2014) argue that the number of households for whom the precautionary motive is strong might be much larger than would be suggested by conventional measures of net worth, since there is a large group of households with highly illiquid wealth.

The rest of the paper is organized as follows. Section 2 describes the model, and Section 3 characterizes how confidence crises can arise, depending on parameters that determine household liquid wealth and the stance of monetary policy. Section 4 contains an application to the U. S. Great Recession, and Section 5 discusses some policy implications. Section 6 presents our microeconomic evidence, and Section 7 concludes.

2 Theory

There are two goods in the economy: a perishable consumption good, c , produced by a continuum of identical competitive firms using labor, and housing, h , which is durable and in fixed supply. There is a continuum of identical households, each of which contains a continuum of measure one

of potential workers. Households and firms share the same information set and have identical expectations.

2.1 Firms

Firms are perfectly competitive, and the representative firm produces using indivisible labor according to the following technology:

$$y_t = n_t^\alpha, \tag{1}$$

where y_t is output and n_t is the number of workers hired. The curvature parameter $\alpha \in (0, 1)$ determines the rate at which the marginal product of labor declines as additional workers are hired. Firms take as given the price of output p_t and must pay workers a nominal wage w_t that rises over time at a constant exogenous net rate γ_w . The price of output and the wage are both expressed relative to a nominal numeraire (money). Thus, firms solve a static profit maximization problem:

$$\max_{n_t \geq 0} \{p_t y_t - w_t n_t\} \tag{2}$$

subject to eq. (1). The first-order condition to this problem is

$$\alpha n_t^{\alpha-1} = \frac{w_t}{p_t} \tag{3}$$

Thus, fixing the nominal wage w_t , a higher price level p_t implies a lower real wage w_t/p_t and higher employment n_t . The representative firm's profits, which we denote φ_t , can be interpreted as the returns to a fixed non-labor factor.³ We will not model an explicit market for stocks, but simply assume that households collect profits at the end of the period.

2.2 Households

Households are infinitely-lived. They can save in the form of housing and government bonds. At the start of each period, the head of the representative household sends out its members to look for jobs in the labor market and to purchase consumption. If the representative firm's labor demand n_t is less than the unit mass of workers looking for jobs in the representative household, then jobs are randomly rationed, and the probability that any given potential worker finds a job is n_t . Let

$$u_t = 1 - n_t \tag{4}$$

³The technology can be re-interpreted as Cobb-Douglas, $y_t = k^{1-\alpha} n_t^\alpha$, where the fixed factor k is equal to one.

denote the unemployment rate. Because each household has a continuum of members, this is both the fraction of unemployed workers in any given household, and the aggregate unemployment rate.

Within the period, it is not possible to transfer wage income from household members who find a job to those who do not. Thus, unemployed members must rely on savings to finance consumption. If wealth is low or illiquid, it will not be possible to equate consumption between employed and unemployed household members. At the end of the period, all the household members regroup, pool resources, and decide on savings to carry into the next period.

More precisely, the representative household seeks to maximize

$$E_0 \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \left\{ (1-u_t) \frac{(c_t^w)^{1-\gamma}}{1-\gamma} + u_t \frac{(c_t^u)^{1-\gamma}}{1-\gamma} + \phi \frac{(h_{t-1})^{1-\gamma}}{1-\gamma} \right\}, \quad (5)$$

where ρ is the household's rate of time preference. The values c_t^w and c_t^u denote household consumption choices that are potentially contingent on whether an individual household member is working (superscript w) or unemployed (superscript u) at date t . The parameter ϕ defines the weight on utility from housing consumption, which is common across all household members. The parameter γ controls households' willingness to substitute consumption inter-temporally, and their aversion to risk. For most of the analysis we will focus on the especially tractable case in which $\gamma = 1$, so that the utility function is additive in logs. In that case, the utility function is effectively Cobb-Douglas between housing and non-housing consumption, a specification consistent with Davis and Ortalo-Magne (2011).

Within the period, when intra-period transfers are ruled out, household members face budget constraints specific to their employment status:

$$p_t c_t^u \leq \psi p_t^h h_{t-1} + b_{t-1}, \quad (6)$$

$$p_t c_t^w \leq \psi p_t^h h_{t-1} + b_{t-1} + w_t, \quad (7)$$

where h_{t-1} and b_{t-1} denote the household's holdings of housing and nominal one-period government bonds, and where p_t^h is the nominal price of housing. Bonds are assumed to be perfectly liquid, so they can be used dollar-for-dollar to finance consumption. Housing is imperfectly liquid within the period, so any household member can only use a fraction $\psi \in (0, 1)$ of home value to finance current consumption. The simplest interpretation of ψ is that it captures the maximum loan-to-value ratio for home equity loans. For simplicity we have assumed that stocks are perfectly illiquid, so stock wealth cannot be tapped to finance consumption while unemployed.⁴ The only difference

⁴Ownership of equities outside illiquid pension funds and retirement accounts is not widespread. In the 2010 SCF, 15.1% of households owned directly held stocks, and 8.7% owned pooled investment funds.

between the within-period constraints for unemployed versus employed household members is that the employed can also access wage income w_t . Assets are (optimally) identically distributed between working and unemployed household members because unemployment is randomly allocated within the period.

The household budget constraint at the end of the period takes the form

$$(1 - u_t) p_t c_t^w + u_t p_t c_t^u + p_t^h h_t + \frac{b_t}{1 + i_t} \leq (1 - u_t) w_t + \varphi_t + p_t^h h_{t-1} + b_{t-1}. \quad (8)$$

The left-hand side of eq. (8) captures total household consumption and the cost of housing and bond purchases. The price of bonds is $(1 + i_t)^{-1}$, where i_t is the nominal interest rate. The first term on the right-hand side is earnings for workers, the second is nominal firm profits, and the last two reflect the nominal values of housing and bonds purchased in the previous period.

Note that each household solves an identical problem, and therefore chooses the same asset portfolio. The equilibrium cross-household wealth distribution is therefore degenerate. Thus, this model of the household is a simple way to introduce idiosyncratic risk and a precautionary motive, without having to keep track of the cross-sectional distribution of wealth as in standard incomplete-markets models.

2.3 Monetary Authority

The monetary authority sets the nominal interest rate i_t paid on government bonds, which are in zero net supply. In our simple model, inflation *per se* has no direct impact on real allocations. The only reason inflation matters is via its impact on the real wage, which in turn impacts unemployment. Given this, we adopt a simple monetary rule in which the central bank responds only to deviations in unemployment from its optimal value (zero).⁵ It follows a simple rule of the form

$$i_t = i^{CB}(u_t) = \max \{ (1 + \gamma_w) (1 + \rho - \kappa u_t) - 1, 0 \} \quad (9)$$

Note that if $u_t = 0$, then the net real interest rate is equal to the rate of time preference ρ . The parameter κ defines how aggressively the monetary authority cuts nominal rates in response to unemployment. The zero lower bound constraint rules out negative nominal rates.

One way to micro-found the assumption that the monetary authority can impose a rule of

⁵In our application to the Great Recession, we have constructed numerical examples where the nominal interest also responds to fluctuations in the inflation rate, p_t/p_{t-1} . In those examples the equilibrium dynamics are essentially unchanged relative to our baseline policy rule.

the form in eq. (9) is to explicitly model money, and derive a mapping from changes in the money supply to changes in the nominal rate. In Appendix B we develop this extension formally, introducing money in the utility function and as an additional source of liquidity in households' budget constraints. We then describe the conditions under which the baseline model described above can be interpreted as the "cashless limit" of an underlying monetary economy.

2.4 Household Problem

Households take as given the unemployment rate u_t , and prices $\{p_t, p_t^h, w_t, i_t\}$. They form expectations over the joint distribution of future prices and future unemployment, and given these expectations choose $\{c_t^w, c_t^u, b_t, h_t\}$ in order to maximize eq. (5) subject to eqs. (6), (7), (8) and $\{c_t^w, c_t^u, b_t, h_t\} \geq 0$. Most of our analysis will consider perfect foresight equilibria, in which households take as given a known sequence for $\{u_t, p_t, p_t^h, i_t\}$.

The first-order conditions (FOCs) that define the solution to this problem can be combined to give two inter-temporal conditions, one for bonds, and one for stocks. The condition for bonds is

$$(c_t^w)^{-\gamma} \frac{1}{1+i_t} = \frac{1}{1+\rho} E_t \frac{p_t}{p_{t+1}} \left[(1-u_{t+1}) (c_{t+1}^w)^{-\gamma} + u_{t+1} (c_{t+1}^u)^{-\gamma} \right], \quad (10)$$

where

$$c_{t+1}^u = \begin{cases} c_{t+1}^w & \text{if } c_{t+1}^w \leq \psi \frac{p_{t+1}^h}{p_{t+1}} h_t + \frac{b_t}{p_{t+1}} \\ \psi \frac{p_{t+1}^h}{p_{t+1}} h_t + \frac{b_t}{p_{t+1}} & \text{if } c_{t+1}^w > \psi \frac{p_{t+1}^h}{p_{t+1}} h_t + \frac{b_t}{p_{t+1}}. \end{cases} \quad (11)$$

This condition is easy to interpret. The real return on the bond (gross real interest rate) is the gross nominal rate divided by the inflation rate between t and $t+1$. The marginal value of an extra real unit of wealth at $t+1$ is the average marginal utility of consumption within the household, i.e., the unemployment-rate-weighted average of workers' and unemployed members' marginal utilities. Equation (11) indicates that these two marginal utilities will be equal if household liquidity is sufficient to equate consumption within the household (so that constraint 6 is not binding). Otherwise, unemployed workers will consume as much as possible, but within-household insurance will be imperfect. Note that if $c_{t+1}^u = c_{t+1}^w$ with probability one, then the FOC looks just as it would in a representative agent model. In contrast, if there is a positive probability that both $c_{t+1}^u > c_{t+1}^w$ and $u_{t+1} > 0$, then households have a stronger incentive to save. In particular, there is then an active precautionary motive: higher next period wealth loosens the liquidity constraint for the unemployed, and improves insurance within the household.

The first-order condition for housing is

$$P_t^h (c_t^w)^{-\gamma} = \frac{1}{1+\rho} E_t P_{t+1}^h \left[(1 - u_{t+1}\psi) (c_{t+1}^w)^{-\gamma} + u_{t+1}\psi (c_{t+1}^u)^{-\gamma} \right] + \frac{1}{1+\rho} \phi (h_t)^{-\gamma}. \quad (12)$$

where $P_t^h \equiv p_t^h/p_t$ is the price of housing relative to consumption. The real financial return on housing is the change in this real price. In addition, an additional unit of housing delivers additional marginal utility $\phi (h_t)^{-\gamma}$ to all household members. Similarly to the bond, an additional unit of housing is differentially valued by employed versus unemployed household members. However, because housing is imperfectly liquid, an extra real unit of housing wealth can only be used to finance an additional ψ units of consumption by unemployed workers.

2.5 Equilibrium

An equilibrium in this economy is a probability distribution over quantities $\{u_t, n_t, y_t, \varphi_t, c_t^w, c_t^u, h_t, b_t\}$ and prices $\{i_t, p_t, p_t^h, w_t\}$ that satisfies, at each date t , the restrictions implied by eqs. (1), (2), (3), (4), (10), (11), (12), the policy rule eq. (9), the law of motion $w_{t+1} = (1 + \gamma_w)w_t$, and the following three market clearing conditions

$$(1 - u_t) c_t^w + u_t c_t^u = y_t, \quad (13)$$

$$h_t = 1, \quad (14)$$

$$b_t = 0. \quad (15)$$

The second of these reflects an assumption that the aggregate supply of housing is equal to one, while the third reflects the fact that government bonds are in zero net supply.

3 Characterizing Equilibria

In this section we show that the number of model steady states and their stability properties depend on the level of liquid household wealth, defined by the parameters ϕ and ψ , and on the aggressiveness of monetary policy, defined by the parameter κ . To preview the key results, when liquid wealth is high, and the precautionary motive to save is therefore relatively weak, an aggressive monetary policy ensures that full employment is the unique model steady state. Furthermore, this steady state is locally unstable, in the sense that it is not possible to construct sunspot shocks that feature temporary deviations from full employment. When liquidity is low, in contrast, richer

equilibrium dynamics arise, and no value for the monetary policy κ guarantees full employment. When policy is sufficiently aggressive, the model features multiple steady states, including one in which the interest rate is zero and unemployment is strictly positive. When policy is sufficiently passive, full employment is the unique steady state, but this steady state is locally stable, so that non-fundamental shocks to confidence can induce temporary recessions.

3.1 Steady States: General Properties

We start by describing some general properties of model steady states. Steady states are equilibria in which all real model variables are constant. In this section we therefore drop time subscripts. In any steady state the price inflation rate will equal the rate of wage growth γ_w . The model is especially tractable in the case of logarithmic utility ($\gamma = 1$). Thus, we consider that special case in the remainder of this section. See Appendix A for detailed derivations of the following results.

Result 1: Full employment steady state. Irrespective of parameter values, the model always features a full employment steady state in which

$$\begin{aligned} u &= 0, \quad y = 1, \\ \frac{1+i}{1+\gamma_w} - 1 &= \rho, \\ P^h &= \frac{\phi}{\rho}. \end{aligned}$$

This is the only efficient allocation, given that utility is strictly increasing in consumption, and there is no utility cost from working. Note that the net real interest rate is simply the household's rate of time preference, and the real price of housing is the present value of full employment implicit rents.

At this point it is useful to define a new parameter $\lambda \equiv \psi \frac{\phi}{\rho}$. This is simply the value of liquid wealth in the full employment steady state. This parameter determines the degree of within household risk sharing. Risk sharing within the household is perfect in steady state if $c^u = c^w = y$ (consumption of unemployed and employed workers is equalized), and imperfect if $c^u = \psi P^h < y < c^w$.

Result 2: Risk sharing in steady state. Risk-sharing is perfect in any steady state if and only if $\lambda \geq 1$. In addition, if $\lambda \geq 1$ and $\kappa > 0$, then full employment is the unique steady state.⁶

⁶If $\lambda \geq 1$ and $\kappa = 0$, then there is a continuum of steady states, one for each $u \in [0, 1]$. In each such steady state

The intuition for the parametric condition $\lambda \geq 1$ is as follows. With perfect risk-sharing, the model collapses to a representative agent environment and the real house price in a steady state with output y is proportional to the representative agent's consumption, $P^h = (\phi/\rho)y$. The maximum an unemployed worker can consume ψP^h is then equal to $\psi(\phi/\rho)y$, which is larger than per capita output y if and only if $\lambda \geq 1$. Note that λ can be larger than one either because the fundamental value of housing is high (i.e., ϕ/ρ is high), or because it is easy to borrow against housing (i.e., ψ is high).

It is also easy to see why $\kappa > 0$ guarantees that full employment is the unique steady state. With perfect risk sharing, the only real interest rate $r = \frac{1+i}{1+\gamma_w} - 1$ consistent with households optimally choosing constant consumption is $r = \rho$. If $\kappa > 0$, the central bank sets $r < \rho$ whenever $u > 0$, thus ruling out steady states with $u > 0$.

For the rest of the paper, we will focus on the region of the parameter space in which $\lambda < 1$, so that risk sharing is imperfect. We start our analysis by exploring how imperfect risk sharing affects asset pricing, taking as given a constant unemployment rate u . We will then move to ask which values for u are consistent with the central bank's policy rule.

Result 3: Steady state house prices with imperfect risk sharing. Given $\lambda < 1$, the household first-order condition for housing implies the following steady state relationship between the unemployment rate u and the real house price P^h :

$$P^h = \underbrace{\frac{\phi}{\rho}(1-u)^\alpha}_{\text{fundamental component}} \times \underbrace{\frac{u + \phi}{\lambda u + (1 - (1 - \lambda)u)\phi}}_{\text{liquidity component}} \quad (16)$$

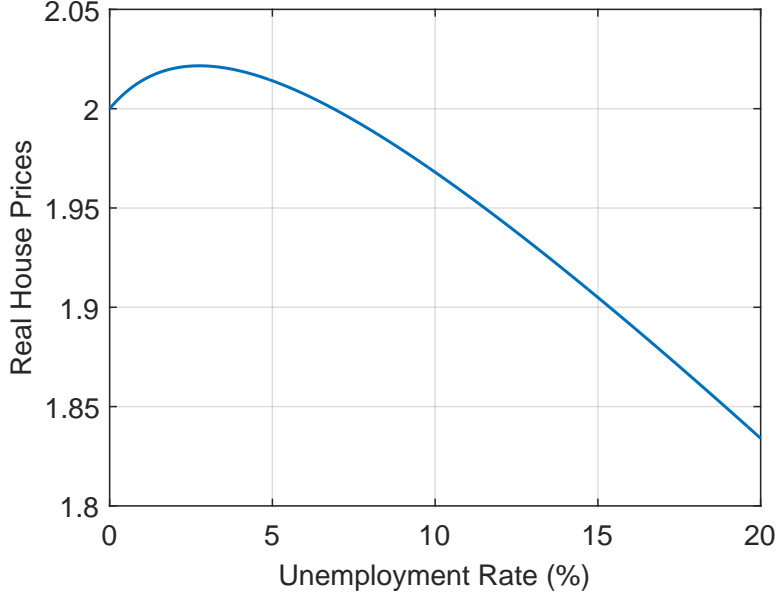
The first term in this expression is the “fundamental” component of house value, defined as the market clearing price $(\phi/\rho)y$ in a representative agent version of the model. This fundamental value declines linearly with steady state output $y = (1-u)^\alpha$. The second term, which is larger than one given $\lambda < 1$, reflects the “liquidity” premium embedded in equilibrium house prices. House prices exceed their fundamental value because housing serves a role in providing insurance within the household. The liquidity term is always increasing in the unemployment rate given $\lambda < 1$.

At $u = 0$, the steady state house price is increasing in u if $\lambda < \frac{1+(1-\alpha)\phi}{1+\phi}$. Thus, if liquidity is sufficiently low, a marginal increase in unemployment risk at $u = 0$ increases households' willingness to pay for housing because the marginal additional liquidity value of housing wealth outweighs

$y = (1-u)^\alpha$, $\frac{1+i}{1+\gamma_w} - 1 = \rho$, and $P^h = \frac{\phi}{\rho}y$.

the marginal loss in fundamental value. For higher values for unemployment, the fundamental component of home value comes to dominate, and house prices decline in the unemployment rate. As $u \rightarrow 1$, the steady state real house price converges to zero. An illustrative example of the steady state house price implied by eq. (16) is plotted in Figure 4.

Figure 4: Real house prices as a function of unemployment



Result 4: Steady state interest rates. Given $\lambda < 1$, the household first-order conditions for bonds and housing, along with the market clearing conditions for those two markets, imply the following steady state relationship between the unemployment rate u and the interest rate i :

$$i = i(u) = (1 + \rho)(1 + \gamma_w) \left(\frac{u + \phi}{u \left(1 + \frac{\rho}{\psi} - \phi\right) + \phi} \right) - 1 \quad (17)$$

The gross nominal interest rate $1 + i(u)$ is equal to $(1 + \rho)(1 + \gamma_w)$ at $u = 0$ and is declining and convex in u for all $u \in [0, 1]$.

Equation (17) can be derived starting from the steady state version of the household first-order condition for bonds, recognizing that a binding liquidity constraint implies $c^u = \psi P^h$, and then substituting in the steady state expression for P^h in eq. (16). The function $i(u)$ describes the interest rate at which households will optimally choose zero bond holdings (and hence the market for bonds will clear) given an unemployment rate u . Implicit in this expression is that for each

value for u the corresponding constant real house price clears the market for housing.

The market clearing interest rate $i(u)$ varies with unemployment because the unemployment rate determines the strength of the household's precautionary motive. In fact, it does so through two channels. First, the unemployment rate mechanically determines the fraction of household members who will be liquidity constrained. Second, the unemployment rate also affects the steady state house price, and thus the consumption differential between employed and unemployed household members. Result 4 indicates that when there is no unemployment risk, the steady state real interest rate is simply the household's rate of time preference, while increasing the steady state unemployment rate always implies a stronger precautionary motive and thus a lower interest rate.

Holding fixed the unemployment rate u , it is immediate that higher nominal wage inflation γ_w translates one-for-one into a higher market-clearing nominal interest rate. A higher value for the credit parameter ψ also raises the interest rate, by improving insurance and weakening the precautionary motive. A stronger taste for housing ϕ has the same effect: a higher ϕ translates into a higher house price, thereby improving insurance and weakening precautionary demand for bonds. Interestingly, the impact of increasing the rate of time preference ρ is ambiguous. At $u = 0$, increasing ρ (impatience) increases the market clearing interest rate, the conventional effect. At higher unemployment rates, however, making households more impatient actually lowers the interest rate. The logic is that greater impatience depresses house prices, thereby worsening insurance and strengthening the precautionary motive.

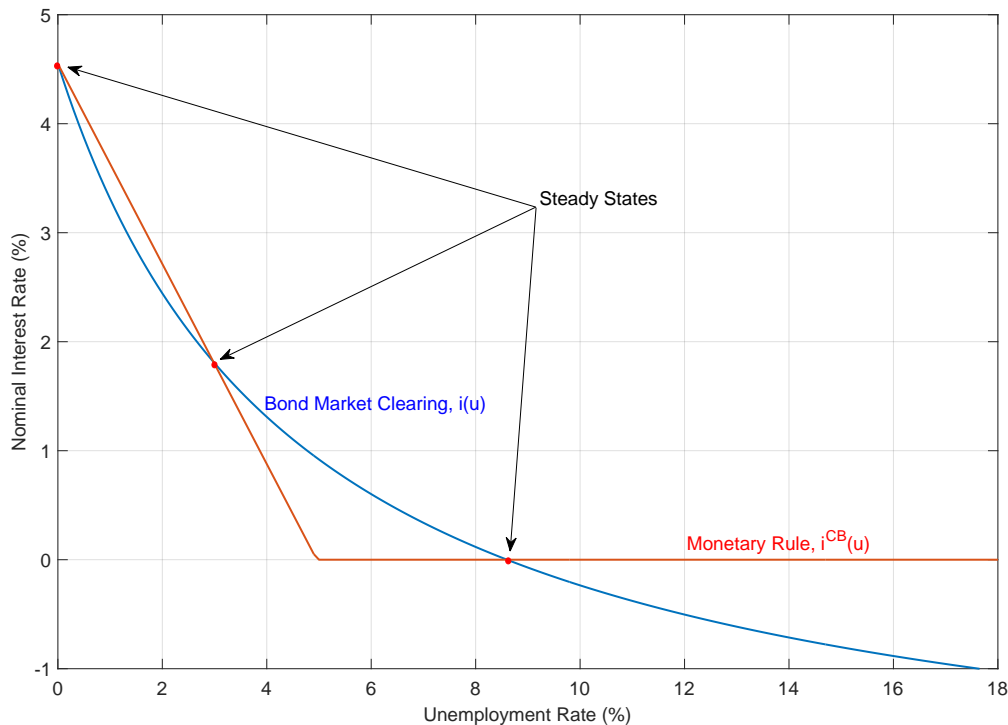
A model steady state is a pair (i, u) that satisfies both the market-clearing condition (17) and the policy rule (9). Figure 5 plots the two equations for a set of parameters that satisfy the condition $\lambda < 1$ (imperfect risk sharing). The red line is the policy rule, which kinks at $u = \rho/\kappa$ where the nominal rate hits the zero lower bound. The black line plots eq. (17), i.e., the set of (i, u) pairs at which both the housing market and the bond market clear.

A steady state is a point at which these two lines intersect, so that markets clear at exactly the interest rate dictated by the central bank's policy rule. In the graphical example, there are three steady states: one at $u = 0$, and two with positive unemployment rates.

3.2 Equilibrium dynamics

The tractability of the model delivers a complete characterization of how many model steady states exist in different regions of the parameter space, and closed-form expressions for equilibrium prices and quantities in each of those steady states. We now explore the nature of equilibrium dynamics

Figure 5: Steady states



around each steady state. Our primary interest will be in how the set of model equilibria changes with the parameters that determine the level of liquid household wealth. Before we partition the parameter space in the liquid wealth dimension, we first establish a result on how the stability of the full employment steady state depends on the choice for the parameter κ , which defines the responsiveness of monetary policy to unemployment. We define a steady state to be locally stable (unstable) if there exist (do not exist) perfect foresight equilibrium paths in which unemployment starts away from but converges to its steady state value.

Definition: Monetary policy is aggressive if $\kappa < (1 + \rho) \left(\frac{1-\lambda}{\lambda} \right)$ and is passive otherwise.

The aggressive monetary policy definition is the algebraic counterpart to the property that the policy rate function $i^{CB}(u)$ declines more rapidly with unemployment than does the market clearing rate expression $i(u)$ at $u = 0$ (see Figure 5).

Result 5: Monetary policy and stability of steady states. If monetary policy is aggressive (passive), then the full employment steady state is locally unstable (stable).

Thus, if policy is passive then there exist equilibria in which (i) the economy starts at full

employment, (ii) a non-fundamental sunspot “confidence” shock drives an unexpected jump in unemployment, and (iii) the economy then converges back to full employment. We develop intuition for Result 5 in the next section.

3.2.1 High Liquid Wealth

Definition: Liquid wealth is high if $\psi > \frac{\rho}{(1+\rho)(1+\gamma_w)(1+\phi)-1}$.

The high liquid wealth definition ensures that the steady state market-clearing nominal interest rate is positive at any unemployment rate. In particular, high liquidity ensures that $i(u) > 0$ at $u = 1$ and thus, given Result 4, at all $u \in [0, 1]$. Recall that higher wage inflation γ_w or a stronger taste for housing ϕ both push up market-clearing interest rates, and thus expand the set of values for ψ that satisfies the high liquidity definition.

Result 6: Uniqueness with high liquid wealth. If liquid wealth is high and monetary policy is aggressive, then full employment is the only steady state. If liquid wealth is high and monetary policy is passive then there may be a second steady state with positive unemployment.

Figure 6: High liquid wealth equilibria

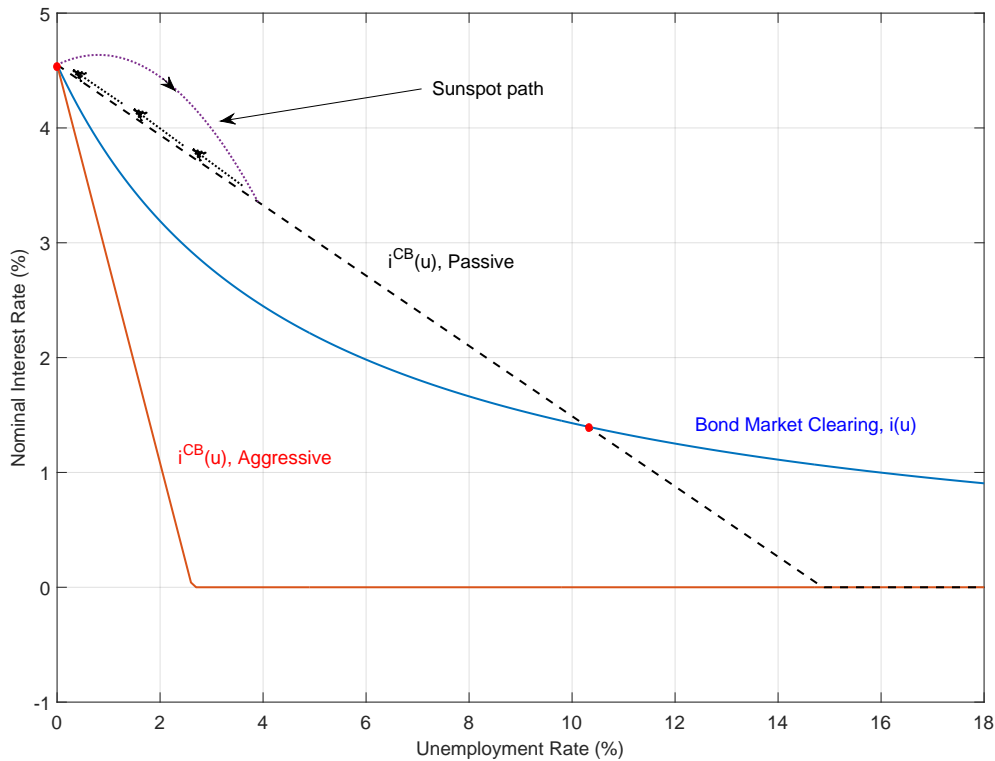


Figure 6 illustrates Result 6 graphically. The blue curve labeled $i(u)$ plots the market clearing condition, while the steeper red line represents the policy rule $i^{CB}(u)$ when the central bank is aggressive. In this case there is a unique steady state at full employment. The intuition for steady state uniqueness is that with high liquid wealth, the precautionary motive to save is relatively weak, and the interest rate that clears markets is always positive. With an aggressive monetary authority, the policy rate therefore always falls below the market clearing rate, except at full employment.

Moreover, around the full employment steady state, $i^{CB}(u)$ is steeper than $i(u)$, which ensures that this steady state is locally unstable (Result 5). Thus, confidence-driven fluctuations in unemployment cannot arise in a high liquid wealth environment with aggressive policy. Intuitively, the slope of the $i(u)$ function is a measure of how rapidly equilibrium demand declines with unemployment risk. A steeper slope indicates demand is more sensitive to unemployment, in the sense that a larger decline in the interest rate is required to maintain the market-clearing level of demand as the unemployment rate rises. If $i^{CB}(u)$ is steeper than $i(u)$, the central bank is promising to cut rates by more than is required to support demand in the event of a marginal increase in unemployment. It follows if the unemployment rate were to increase marginally, demand would exceed supply if the unemployment rate were expected to remain constant or to decline. In fact the only way a small increase in unemployment could be supported would be if households were to subsequently expect unemployment to keep increasing. It follows that with aggressive policy, the only non-explosive equilibrium path is permanent full employment.⁷

The flatter dashed black line in Figure 6, labeled “ $i^{CB}(u)$ Passive” represents instead a passive policy rule. The key problem with a passive monetary policy is that at full employment the policy rule $i^{CB}(u)$ is flatter than the market clearing condition $i(u)$. This means a fall in consumer demand, induced by pessimistic expectations about the path of unemployment, is not sufficiently counteracted by lower policy rates. Thus, there is an equilibrium path in which unemployment jumps and then steadily declines (Result 5). At each point along this path, the precautionary motive to save is offset by a combination of (i) slightly lower nominal rates, and (ii) positive expected growth looking forward. One such path is represented in the figure by the dotted path with arrows.^{8,9}

⁷Note that there are no equilibrium paths in which unemployment steadily rises until the economy converges to 100% unemployment. The reason is that the high liquidity condition ensures $i(u) > 0$ at $u = 1$, while an aggressive policy rule ensures $i^{CB}(u) = 0$ at $u = 1$.

⁸The result that expectations-driven fluctuations in unemployment are possible if the policy rate is insufficiently responsive to unemployment is closely related to the “Taylor principle” (1993) point that expectations-driven fluctuations in inflation are possible if the interest rate is insufficiently responsive to inflation (see, for example, Clarida, Gali, and Gertler, 2000).

⁹In the example plotted, under the passive interest rate policy there is a second steady state with positive unemployment and a positive nominal rate. Note that if policy were sufficiently passive then this second steady state

The main lesson we draw from this case is that with high liquid wealth, confidence crises can be avoided with appropriately aggressive monetary policy.

3.2.2 Low Liquid Wealth Equilibria

Definition: Liquid wealth is low if $\psi \leq \frac{\rho}{(1+\rho)(1+\gamma_w)(1+\phi)-1}$.

If liquid wealth is low, the precautionary motive to save is relatively strong, and the $i(u)$ function is negative for sufficiently high unemployment rates. This implies that the zero lower bound will constrain the central bank's ability to counteract a confidence crisis. Our next result summarizes the set of equilibria that can arise in this case.

Result 7: Multiplicity with low liquid wealth. If liquid wealth is low and monetary policy is aggressive, there are always at least two steady states: full employment, and a second zero lower bound (ZLB) steady state in which

$$\begin{aligned} u &= u^+ = \frac{\phi \left(1 + \gamma_w \frac{(1+\rho)}{\rho}\right)}{\frac{1-\psi}{\psi} - \frac{\phi}{\rho} - \gamma_w \frac{(1+\rho)}{\rho}} \\ y &= y^+ = (1 - u^+)^\alpha \\ i &= 0 \\ P^h &= \frac{\phi}{\rho} y^+ \times \frac{1}{1 - \psi(1 + \phi) \left(1 + \gamma_w \frac{(1+\rho)}{\rho}\right)}. \end{aligned}$$

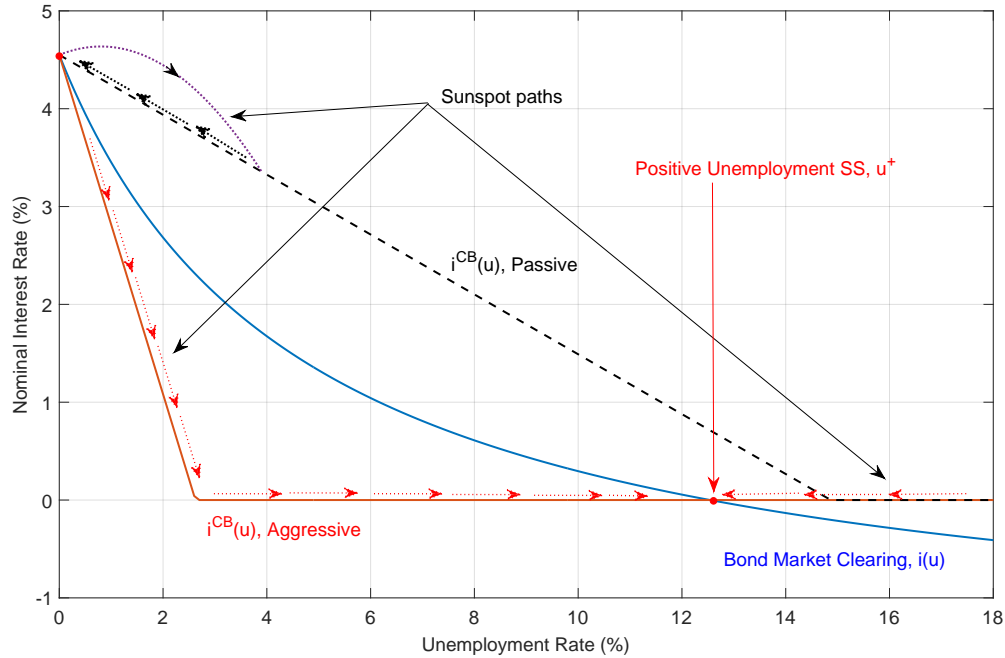
The ZLB steady state is locally stable. If liquid wealth is low and monetary policy is instead passive, and sufficiently so, then full employment is the unique steady state.

Figure 7 describes the set of possible equilibria when liquid wealth is low. The key difference, relative to the high liquid wealth case, is that aggressive monetary policy no longer guarantees steady state uniqueness. The logic is that if households expect permanent unemployment equal to u^+ their precautionary motive will be so strong that even at a zero nominal interest rate they will choose consumption equal to y^+ , thereby validating the expected unemployment rate.

Moreover, the positive unemployment ZLB steady state is locally stable, in the sense that there exist equilibrium paths with higher or lower unemployment that converge to it, like the dotted red ones marked with arrows. As in the earlier discussion of dynamics around the full employment steady state, local stability arises because at $u = u^+$ the $i(u)$ curve is steeper than the $i^{CB}(u)$ curve and thus monetary policy is locally too passive in how it responds to unemployment.

would not be present and full employment would be the unique steady state.

Figure 7: Low liquid wealth equilibria



Because the ZLB steady state is locally stable, lots of sunspot equilibria exist. For example, there is an equilibrium in which the economy starts out with full employment, but at some date an unexpected shock to expectations causes households to coordinate on a path for unemployment in which the unemployment rate jumps and then increases over time towards u^+ . An aggressive central bank will set the policy rate to zero along this entire transition, but this stimulus is exactly offset by a combination of a strong precautionary motive and the expectation that unemployment will continue to rise until the economy ends up at the u^+ steady state. Thus, when liquid wealth is low, an aggressive monetary policy cannot rule out confidence-driven crises that lead to a “stagnation” steady state.

The case of passive monetary policy is similar to the high liquid wealth case. When policy is passive, sunspot equilibria around the full employment equilibrium (the dotted black path marked with arrows) are possible. Whether or not stagnation equilibria are also possible under passive policy depends on just how passive policy is: a sufficiently passive policy ensures that the line “ $i^{CB}(u)$ Passive” never crosses the curve $i(u)$ and thus that full employment is the unique (albeit sunspot-vulnerable) steady state.

3.2.3 Global Dynamics

To conclude the analysis, in Figure 8 we numerically explore the global equilibrium dynamics, including real house price dynamics, that arise in the low liquid wealth case.¹⁰ The left panel displays possible equilibria in the case of aggressive monetary policy. There are no paths converging to full employment in this case, but there are equilibrium paths converging to the stagnation steady state. The path converging from the left displays some interesting features. In the initial phase of the equilibrium path (the vertical part) unemployment is low and nearly constant but house prices are gradually increasing. To an outside observer, the economy would appear to be experiencing a house price bubble: a steadily increasing price with no change in fundamentals. What sustains this “bubble-like” path as an equilibrium outcome is the fact that in the long run agents expect the economy will converge to the stagnation steady state with permanent unemployment, and here house prices will remain relatively high because they will have a high value as a source of liquidity.

The right panel instead depicts the equilibrium paths that arise under passive monetary policy. Recall that in this parameterization (corresponding to Figure 7) policy is sufficiently passive that the model has a unique steady state at full employment. The path plotted represents equilibria in which unemployment starts out positive, but gradually declines to zero. Note that if an unexpected sunspot shock were to cause the economy to jump from full employment to a point on this path, one would observe a jump in unemployment, but little change in house prices. This is possible because when unemployment is temporarily high, the fundamental value of housing is low and the liquidity value is high, while this decomposition is gradually reversed as unemployment declines. We explore such a scenario more fully below when we use the model to construct a narrative for the Great Recession in the United States.

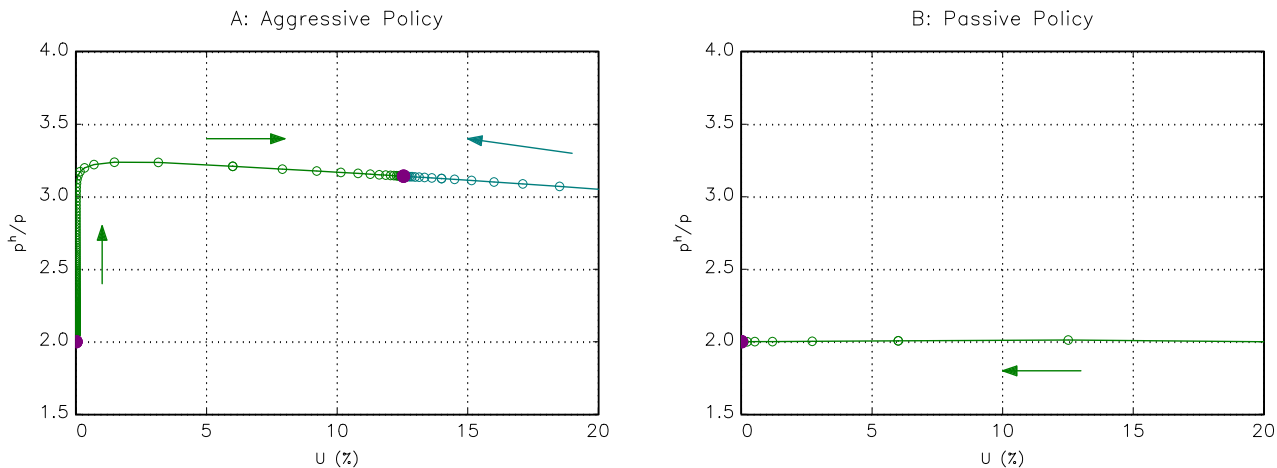
3.2.4 Alternative Models of Wage Stickiness

At this point it seems important to discuss the importance of our assumption of exogenous nominal wage growth (i.e. wage stickiness) in generating “stagnation” equilibria under aggressive policy. With a fully flexible Walrasian labor market, inelastic desired labor supply would guarantee permanent full employment. Our assumption of sticky nominal wages is therefore important for introducing the possibility that weak demand can depress the price level and push the equilibrium real wage above the value at which firms are willing to hire all workers.¹¹

¹⁰We use the same parameter values used to plot Figure 7. The arrows indicate the direction of the equilibrium path, and the circles along the stable manifolds are one model period apart.

¹¹Hall (2005), Farmer (2013), Michaillat (2012), and Shimer (2012) all exploit the observation that in frictional search and matching models of the labor market, sticky wages can be consistent with an absence of unexploited gains

Figure 8: Global dynamics with low liquid wealth



But what about intermediate cases, where wages are not fully flexible, but where wage growth does respond (negatively) to the unemployment rate? Recent work by Schmitt-Grohe and Uribe (2017) and Benigno and Fornaro (2016) has highlighted that stagnation equilibria can still arise in such cases. In particular, the economy can converge to an steady state in which the unemployment rate is positive and nominal wages fall at a constant rate, but where prices fall at the same rate, and the real wage remains too high to clear the labor market. Thus, the economy can get stuck in a “permanent” slump with a zero nominal interest rate. In fact, the more inversely sensitive is wage inflation to the unemployment rate, the harder it becomes for an aggressive central bank to avoid the deflationary steady state, because low nominal policy rates are undercut by wage and price deflation. Thus, with sufficient nominal wage flexibility, stagnation ZLB equilibria can exist even in the absence of a precautionary motive.

3.3 Policy Takeaway

The key conclusions from this section are two. First, if household liquid wealth is high, then the monetary authority can easily avoid confidence-driven recessions. By promising to respond aggressively to unemployment, the central bank can keep the economy at full employment, the efficient allocation.

Second, if liquidity is low, then setting a monetary policy rule that avoids indeterminacy is much more difficult. As in a high liquidity environment, aggressive monetary policy rules make the economy immune to sunspot shocks that generate temporary fluctuations around the full em-

from trade for individual worker-employer pairs.

ployment steady state. However, the fact that in the low liquid wealth case the model has multiple steady states (Result 7) indicates that an aggressive monetary policy cannot avoid sunspot shocks that set the economy on paths leading to a permanent slump.

In contrast, a passive policy rule, while it renders the economy vulnerable to sunspot shocks around full employment, has the advantage that it can rule out permanent slumps. The idea is that in a permanent slump households have a strong precautionary motive, and thus a low interest rate is required to support demand equal to constant expected output. If monetary policy is sufficiently passive, interest rates will never fall low enough, and thus markets can clear with positive unemployment only if the economy is expected to gradually recover.¹²

So what should the monetary authority do in a low liquid wealth environment? No simple rule in the class we have considered guarantees that the economy will remain glued to full employment. This suggests that monetary policy needs to be more “sophisticated”.¹³ It also suggests a role for alternative macroeconomic stabilization tools, a topic to which we will return in Section 5.

4 Application: The Great Recession

The dashed lines in Figure 9 shows time paths for (i) the unemployment rate, (ii) house prices, (iii) inflation, and (iv) the Federal Funds Rate in the United States between 2006 and 2016. The house price series plotted is the Case-Shiller U.S. National Home Price Index, deflated by the GDP deflator, and relative to a 2 percent trend growth rate for the real price.¹⁴ Between the start of 2007 and the end of 2008, house prices fell by 30 percent relative to trend, largely accounting for the sharp fall in median net worth documented in Figure 1. The rise in the unemployment rate was concentrated in the second half of 2008 and the first half of 2009. Thus, the fall in house prices began well before the most severe portion of the recession.

Although our model is highly stylized, we would like to know whether it can replicate these features of the U.S. Great Recession. In particular, we are interested in constructing and comparing to data an equilibrium path in which a sunspot shock, in the context of a low liquid wealth and passive monetary policy environment, triggers a jump in unemployment followed by a gradual

¹²The point that sticking to a high interest rate policy can rule out permanent slumps is sometimes labeled the “Neo-Fisherian” channel of monetary policy. It has been advocated, among others, by Schmitt-Grohe and Uribe (2017). In our model a passive policy works because high interest rates are inconsistent with expectations of permanently depressed output. In Schmitt-Grohe and Uribe the policy works because high interest rates are inconsistent with expectations of permanently low inflation.

¹³For more on this, see Atkeson, Chari and Kehoe, 2010.

¹⁴This is the average growth rate for real GDP per capita between 1947 and 2007. It is also close to the average growth rate for real house prices between 1975 and 2006 (see Figure 1 in Davis and Heathcote, 2007).

perfect foresight recovery. This exercise requires picking values for the model parameters.

We set the curvature parameter on consumption and housing to $\gamma = 3$. This implies an intertemporal elasticity of substitution of consumption of one third, which is in the middle of existing empirical estimates based on micro data (Havranek, 2015). This choice will imply a relatively strong precautionary motive.

The parameter ρ defines the steady state full employment annual real interest rate, and we set it to 2.5%.¹⁵ The parameter γ_w defines the steady state inflation rate, and we set it to 2.0%. These two choices immediately imply a steady state full employment nominal interest rate of 4.5%, which is close to the effective Federal Funds Rate in 2006 and 2007.

We set the initial house price parameter ϕ to 0.075, implying a full employment house price ϕ/ρ equal to 3 times full employment output. This was the ratio of home value to aggregate consumption at the peak of the housing boom in the first half of 2006. We then imagine a one time permanent shock to ϕ , which reduces ϕ from 0.075 to 0.05 in 2008. This implies a reduction in the full employment house price from 3 to 2, and is a simple way to force the model to replicate the one third decline in house prices observed between 2006 and 2010. The key implication, in terms of the theory, is that this decline in ϕ will move the economy from the region of the parameter space in which liquidity is high – and where an aggressive central bank can ensure full employment – to the region in which liquidity is low – where confidence-induced recessions are always possible.

We set $\kappa = 1.5$, so that each one percentage point in the unemployment rate reduces the desired policy rate by one and a half percentage points. Taylor rules are generally specified as responding to output gaps, rather than employment, and the two standard coefficients on the output gap in the literature are 0.5 (Taylor, 1993) and 1.0 (Taylor, 1999). Using a standard Okun’s Law coefficient whereby a one percent output gap corresponds to two percentage points of unemployment, the corresponding unemployment coefficients are 1.0 and 2.0 respectively. Our choice of 1.5 is intermediate.

Given our other parameter choices, ψ will determine the consumption level for unemployed households, and thus the strength of the precautionary saving motive. There are two possible ways to measure the strength of the precautionary motive and to thereby discipline the choice for ψ . One approach is to note that the strength of the precautionary motive depends on the ratio of the consumption of the unemployed to the consumption of workers.¹⁶ Thus, one could set ψ to try to

¹⁵The real rate of interest has been in secular decline over the past two decades.

¹⁶The household bond first-order condition implies the steady state interest rate is $(1 + i) = \frac{(1 + \gamma_w)(1 + \rho)}{1 + u \left(\left(\frac{c^u}{c^w} \right)^{-\gamma} - 1 \right)}$. Thus, the strength of the precautionary motive depends on the unemployment rate u , the degree of within-household insurance $\frac{c^u}{c^w}$ (which depends in part on the liquidity parameter ψ), and the risk-aversion parameter γ .

replicate estimates of the consumption decline experienced by agents who suffer an unemployment shock. Chodorow-Reich and Karabarbounis (2016) estimate a decline in non-durables and services expenditure upon unemployment of around 21 percent. An alternative calibration approach is to note that, in the context of model equilibrium, the strength of the precautionary motive will be closely tied to the speed of economic recovery. For the bond market to clear at each date during recovery, given an interest rate stuck at zero, a stronger precautionary motive to save against unemployment risk must be offset by a stronger inter-temporal motive to spend, indicating a faster expected recovery. Thus, a larger ψ (a weaker precautionary motive) will correspond to a slower equilibrium expected recovery.

The fact that estimated empirical consumption declines upon unemployment are quite small points towards a relatively large value for ψ , as does the fact that the observed post-recession recovery in the United States was very slow. At the same time, however, in order to construct an equilibrium in which a recovery to full employment is even possible, monetary policy must be passive (Result 5), which imposes an upper bound on ψ .¹⁷ Given our other parameter values, and in particular the choice for κ , this upper bound on ψ is 0.37. Given all these considerations, for our baseline calibration we set $\psi = 1/3$, which is close to the maximum ψ consistent with the existence of a recession followed by recovery.¹⁸ This choice implies that in the period when the recession hits, consumption of the unemployed is 76 percent of that of workers, close to the Chodorow-Reich and Karabarbounis estimate.¹⁹

Figure 9 describes our simulation, model against data. The fundamental ϕ shock hits in 2008, but we assume that agents initially remain optimistic, and the economy remains at full employment. Then, in 2009, we envision a one-off unanticipated sunspot shock, in which households suffer a collective loss of confidence, triggering a 6.0 percentage point jump in the unemployment rate. The event that precipitated this loss of confidence was perhaps the collapse of Lehman Brothers in the fall of 2008. After the confidence shock, agents have perfect foresight about the futures paths for prices and unemployment.

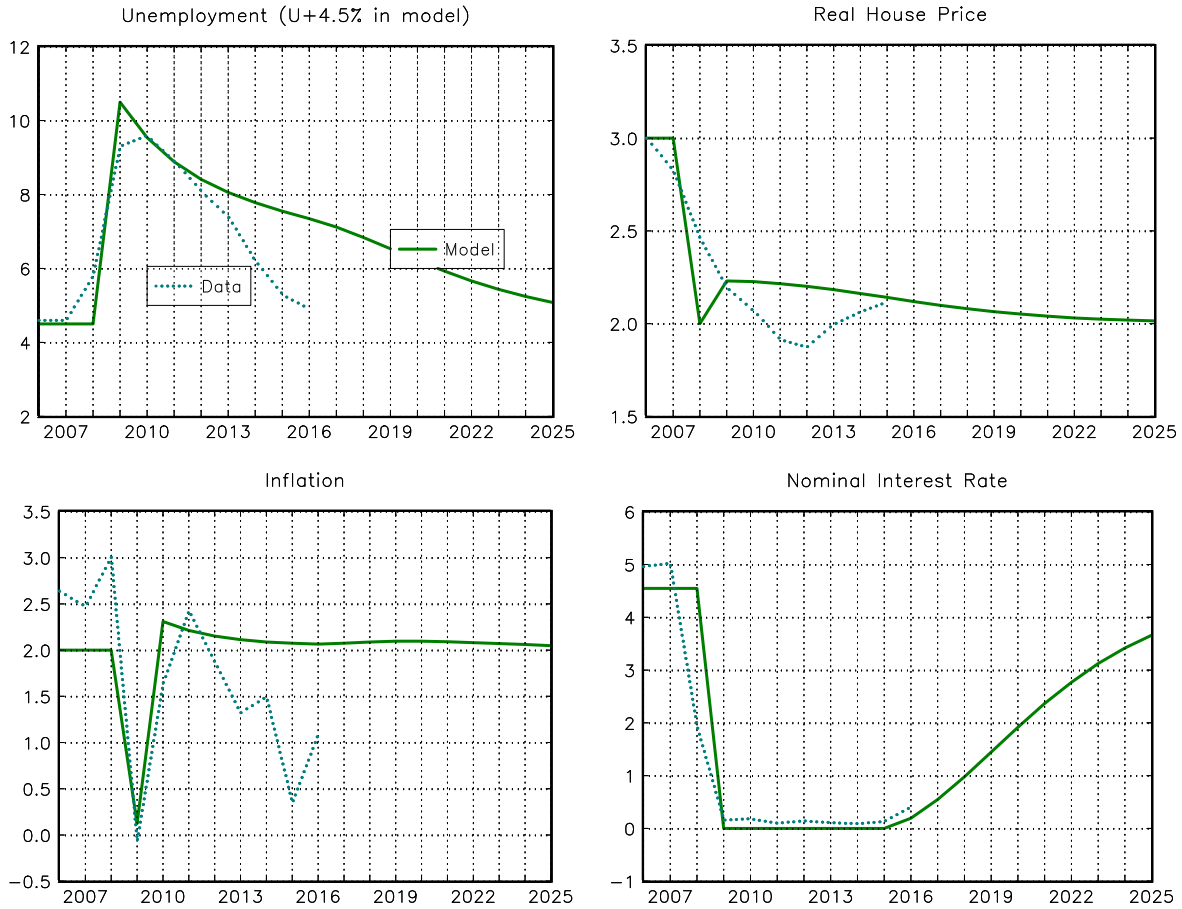
When the shock hits, households become fearful of unemployment, which they expect to persist. Their desire to build a precautionary buffer increases demand for housing and bonds, and reduces

¹⁷The condition that defines passive monetary policy in the economy with general risk aversion is a simple generalization of the definition of passivity for the case with logarithmic utility. In particular, following the same steps as for the derivation of Result 5, one can show that unemployment dynamics in the neighborhood of the full employment steady state are explosive if $\kappa > (1 + \rho) \left(\frac{1 - \lambda^\gamma}{\lambda^\gamma} \right)$ and are stable – opening the door to confidence shocks – otherwise.

¹⁸Note that our parametric condition ensuring stability of the full employment steady state only ensures local stability. Here we are looking for an equilibrium path featuring a large (non-local) jump in the unemployment rate. Numerically, this translates to a slightly tighter upper bound on ψ .

¹⁹In Appendix A we show how the equilibrium paths change with a smaller value for ψ .

Figure 9: The Great Recession: Model versus data



demand for consumption goods. The central bank would like to counteract this fall in demand by cutting the nominal rate, but it can only cut rates 4.5 percentage points before it is constrained by the zero lower bound. At a zero nominal rate, goods demand is still weak given the expected path for unemployment, and this weak demand translates into a fall in the price level. Falling prices in 2009 show up as weak inflation, as in the data. The fall in the price level in turn drives up the real wage, which reduces labor demand, which in turn validates the initial expectation of high unemployment.

Over time, the economy gradually recovers, at a similar speed to the recovery observed in the data. During this recovery, below normal interest rates and positive expected economic growth are factors encouraging spending, and these factors exactly offset the unemployment-related precautionary motive. Inflation during recovery is slightly above trend, supporting a gradual decline in the real wage. The nominal interest rate is at zero for seven years, as in the data, before gradually rising back to its steady state level.

Note that from 2009 onwards, house prices are relatively stable, as in the data, while unemployment steadily declines. This is a result of two contrasting effects of unemployment on equilibrium house prices: declining unemployment increases the fundamental component of house value, but reduces the liquidity component of house value, and thus on net house prices do not move much.

Overall, we take this exercise as indicating that a sudden loss of confidence in a low liquid wealth environment offers a promising explanation for the Great Recession in the United States.

5 Policy

We now show how a simple unemployment insurance (UI) scheme can be used to increase within-household insurance, and thereby help to rule out the possibility of confidence-driven fluctuations.

We assume that the government can implement a UI scheme in which it taxes workers lump-sum a nominal amount T_t and immediately transfers the resources raised to the unemployed in the form of a constant amount of consumption b . The budget constraint for this policy is

$$(1 - u_t)T_t = u_t p_t b.$$

Such a policy redistributes from low marginal utility workers to high marginal utility unemployed workers – precisely the reallocation that households cannot achieve when liquid wealth is low – and thereby dampens households’ precautionary motive to save. Thus, the UI scheme will shift up the $i(u)$ function in Figure 5 and – because it reduces the liquidity value of housing wealth – shift down the house price function in Figure 4 (in this sense public insurance crowds out private insurance). With a sufficiently generous UI policy, the government will be able to ensure that the $i(u)$ function lies above zero for all u , effectively shifting the economy from a low liquid wealth regime to a high liquid wealth regime. In the calibration described in our Great Recession application, a value of $b = 0.29$ (i.e., unemployment benefits are 29 percent of full employment output) is sufficient to achieve this. Thus, unemployment insurance and monetary policy are complementary policy tools when liquid wealth is low: UI effectively provides a substitute for low liquid private wealth, and an aggressive monetary policy can then be used to eliminate confidence-driven fluctuations.

There is a literature exploring how redistributive policies can be used to counter a negative aggregate shock to the economy, for example by redistributing income from households with a low marginal propensity to consume to those with a high MPC (see, for example, Kekre, 2017, or McKay and Reis, 2016). The element that is different here is that redistributive policies can work in our model by preventing a negative aggregate shock from emerging in the first place, by

dampening the feedback loop from pessimistic expectations to weak demand, and thereby ruling out self-fulfilling expectations-driven fluctuations. Thus, redistribution is valuable as an *ex ante* policy that narrows the set of shocks that can arise in equilibrium, rather than as an *ex post* policy response to mitigate the response to exogenously given shocks.

Note, however, that our simple model stacks the deck in favor of introducing public insurance because it exogenously assumes zero private unemployment insurance, while allowing for any amount of non-distortionary public insurance. A more satisfactory theory of optimal public insurance would model both the frictions that create a role for public insurance in the first place, as well as the disincentives to search and work effort associated with public taxes and transfers. However, one finding that is likely to generalize is that public policies that increase insurance against idiosyncratic risk are especially valuable at times when (i) a strong precautionary motive is restraining aggregate demand, and (ii) monetary policy is constrained by the zero lower bound.

6 Microeconomic Evidence

A key element of our model is that when households have low liquid wealth, their desired saving rate becomes more sensitive to perceived unemployment risk. When unemployment risk rises, wealth-poor households' desire to save becomes much stronger, which translates into lower equilibrium employment, and rationalizes *ex post* the fear of high unemployment. Is this mechanism empirically relevant for understanding the decline in aggregate consumption during the Great Recession? An alternative – possibly complementary – hypothesis is that negative wealth effects associated with sharp declines in asset prices played the dominant role. One way to discriminate between the two hypotheses is to note that the precautionary mechanism should be quantitatively more important for the saving behavior of low wealth households, while wealth effects should be larger for high wealth households. Thus, if the precautionary mechanism is more important in aggregate, we should expect to see relatively sharp increases in saving for low wealth households, while if traditional wealth effects played the dominant role, we should expect to see larger increases in saving among wealthier households.

In this section we provide novel evidence, based on data from the Consumer Expenditure Survey (CES) and the Panel Study of Income Dynamics (PSID), that at the onset of the recession lower wealth households exhibit systematically larger increases in their saving rates. This evidence is broadly consistent with a number of empirical studies showing that wealth is an important determinant of consumption responses to income shocks (see Section 1.1). Collectively, this evi-

dence lends support to the importance of wealth and of the precautionary motive in understanding demand dynamics.

6.1 Rich and Poor

Before contrasting savings across wealth groups, we first verified that the dynamics of aggregate consumption, income and wealth in our cross sectional data capture the broad contours of national income and product accounts aggregates over the course of the Great Recession (see Appendix C for details). The sample we select for our analysis includes all households in the PSID and the CES with a head or spouse aged between 22 and 60, and which report income and consumption for at least two consecutive interviews over the period 2004-2013. We focus on households of working age, since unemployment risk is most relevant for this group. For each data set and for each year t we split households by wealth into two equal sized groups “rich” and “poor”. In constructing our wealth ranking we measure wealth as net worth in period t relative to a measure of consumption expenditure around period t . We focus on net worth relative to consumption (as opposed to just net worth) as this ratio better captures the extent to which a household can shield consumption from income declines, and is thus more closely connected to the strength of households’ precautionary motive.²⁰

6.1.1 Summary Statistics

Table 1 reports, for the year 2006, characteristics of the rich and poor groups in both the PSID and the CES.

²⁰See Appendix C for the details on how we define these cutoffs in both the CES and the PSID. The appendix also shows that our results are robust to using net worth (not normalized by consumption expenditures) to define the rich-poor sample split.

TABLE 1. CHARACTERISTICS OF RICH AND POOR, 2006

	PSID			CES		
	Poor	Rich	All	Poor	Rich	All
Sample size (unweighted)	3,443	2,508	5,951	1,915	1,960	3,875
Mean age of head	38.0 (0.32)	47.1 (0.26)	42.5 (0.19)	40.2 (0.25)	46.4 (0.24)	43.3 (0.16)
Head with college (%)	20.5 (1.0)	36.6 (1.0)	28.6 (0.8)	24.8 (1.1)	39.4 (1.2)	32.1 (0.7)
Mean household size	2.47 (0.04)	2.73 (0.04)	2.60 (0.02)	2.79 (0.04)	2.85 (0.04)	2.82 (0.02)
Mean household net worth (\$)	12,017 (964)	619,831 (49,297)	315,997 (30,634)	11,967 (1,155)	338,535 (12,644)	175,259 (7,450)
Median household net worth (\$)	5,000 (506)	265,000 (6,789)	66,000 (3,006)	1,800 (294)	187,102 (4,893)	58,765 (2,222)
Per capita disp. income (\$)	14,951 (265)	28,476 (728)	22,052 (433)	18,739 (334)	30,184 (593)	24,401 (385)
Head unemployment rate (%)	4.2 (0.36)	1.0 (0.19)	2.5 (0.2)	1.0 (0.3)	0.3 (0.2)	0.6 (0.1)
Per capita cons. expenditure (\$)	9,832 (186)	13,101 (244)	11,548 (170)	9,185 (232)	10,858 (188)	10,013 (166)
Saving rate (%)	34.2 (0.90)	54.0 (0.95)	47.6 (0.75)	51.0 (1.18)	64.0 (0.66)	59.0 (0.59)

Note: Bootstrapped standard errors in parentheses.

All statistics (except sample size) weighted using sample weights.

Although the levels of many of these statistics differ across data sets (due in part to different coverage, sample design, and exact question asked), differences between rich and poor are comparable across the two data sets. With respect to demographics, the wealth poor group is younger and less educated. The most striking difference between the two groups, not surprisingly, is in terms of wealth. Median net worth for the poor group is near zero in both surveys, while for the rich group it is around \$265,000 in the PSID and around \$187,000 in the CES.²¹ This dramatic difference suggests that the precautionary saving motive for the poor group should be much stronger than for the rich group, while the rich group likely experiences much larger capital losses when housing and stock prices fall.

The wealth-poor group also has a higher (pre-recession) unemployment rate and has a little more than half the average income of the rich group. At the same time, the poor group has a much lower saving rate, so that differences in consumption expenditures between the two groups

²¹One reason for the difference between the two data sets is that the measure of net worth in the PSID includes more assets, such as individual retirement accounts, vehicles, and family businesses. See Appendix C for details.

are relatively small (around 20% in the CES and 30% in the PSID).²² Overall the table suggests that the two groups are quite different in nature for a variety of reasons. This is why our interest is not in the levels of their respective saving rates, but rather in how their saving rates change differentially at the onset of the Great Recession, when the labor income risk faced by both groups increases dramatically.

6.1.2 Changes in Saving Rates

We now move on to compute the object of interest: changes over time in the saving rates of households in different groups of the net worth distribution. It is important that the set of households in each wealth group is fixed when we measure the change in the saving rate between two successive periods, so that the change in the measured saving rate reflects a true change in household savings behavior, and is not a result of a change in the composition of the groups. Fortunately both the PSID and CES data sets have a panel dimension: in the PSID, households are re-interviewed every two years, while in the CES they are interviewed for four consecutive quarters, and in their first and last interviews they report both income and consumption. Let i denote a group of households (say households with wealth below the median in 2006) and $t:t+1$ denote a time interval (say 2006-2008). The change in group i 's saving rate over the interval $t:t+1$, $\Delta s_{i,t:t+1}$, is computed as

$$\Delta s_{i,t:t+1} = \frac{E(Y_{i,t+1}) - E(C_{i,t+1})}{E(Y_{i,t+1})} - \frac{E(Y_{i,t}) - E(C_{i,t})}{E(Y_{i,t})} \quad (18)$$

where Y denotes household disposable income, C denotes household consumption expenditures, and E denotes the group average (see Appendix C for more details).

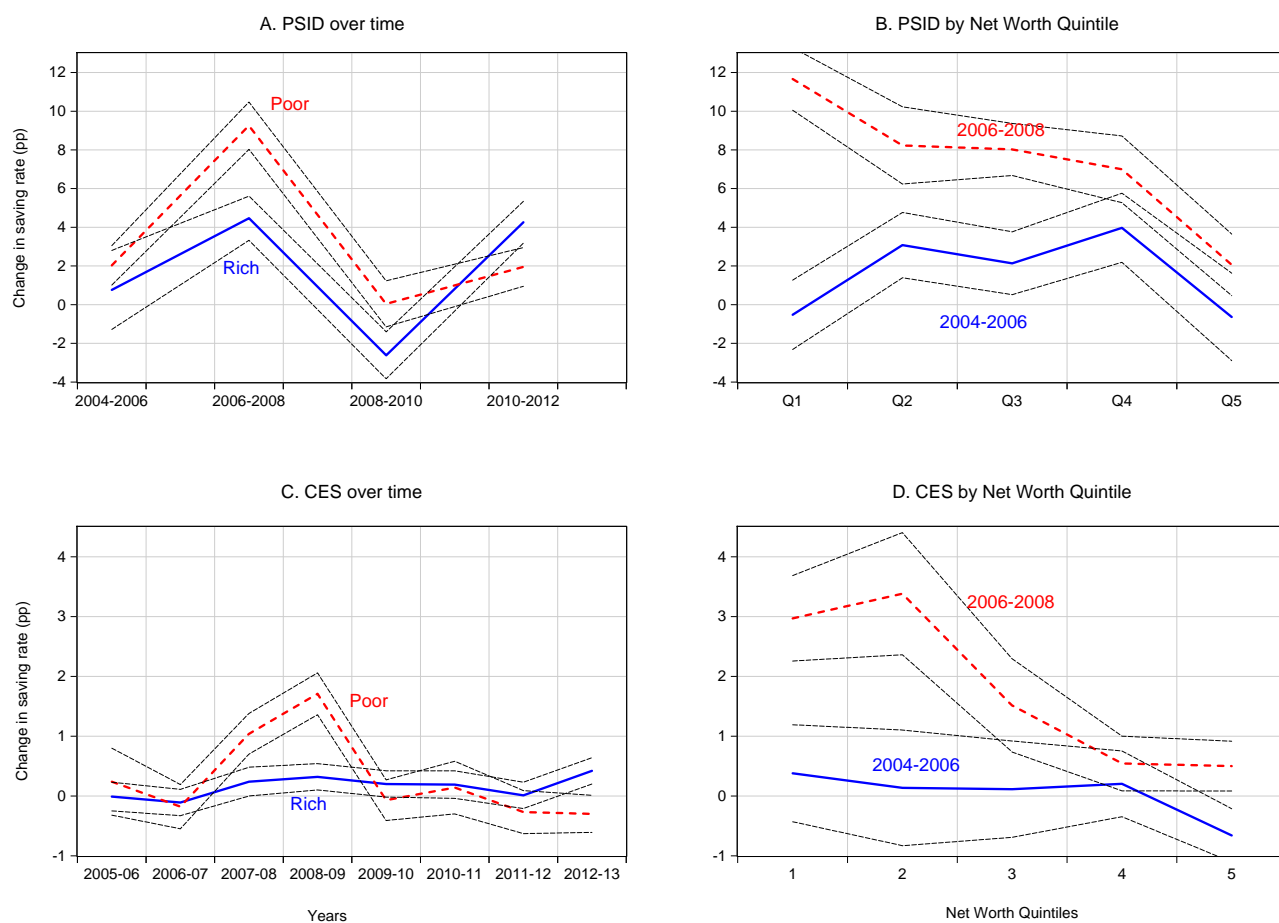
Figure 10 plots changes in saving rates computed from the PSID (top panels) and from the CES (bottom panels). The two panels on the left (A and C) show the evolution over time of the changes in saving rates of the rich and poor groups. Both panels show that in “normal” times there are no significant differences in saving rate changes between the two wealth groups, while at the onset of the Great Recession wealth-poor households increased their saving rate significantly more than wealth-rich households.²³

²²The level of the unemployment rate is quite different across the two surveys, with the CES having a much lower rate. The reason for this is that unemployment in the PSID is computed (more accurately) as the ratio of weeks (in the relevant year) reported as unemployed to the total weeks reported as working or unemployed. In the CES, in contrast, the unemployment rate is the ratio of heads who reported being unemployed for the full year to the ratio of heads who reported either working or being full year unemployed.

²³Saving rate declines in the CES appear to be smaller than in the PSID. We conjecture that this reflects the fact that the CES saving rate changes are computed over 9 month intervals and based on quarterly consumption figures, while the PSID changes are recorded over 2-year intervals and based on annual consumption figures.

The two panels on the right (B and D) disaggregate more finely by net worth, and report the changes in saving rates for the five quintiles of the net worth distribution. Here we focus on just two time periods: a pre-recession period, and the period when the economy enters recession. The plots show that as the economy moves into recession, saving rates increase for all wealth quintiles, but the increase in the saving rate is a declining function of initial net worth, with the bottom quintiles increasing their saving rates significantly, while the top quintiles experience much smaller increases.

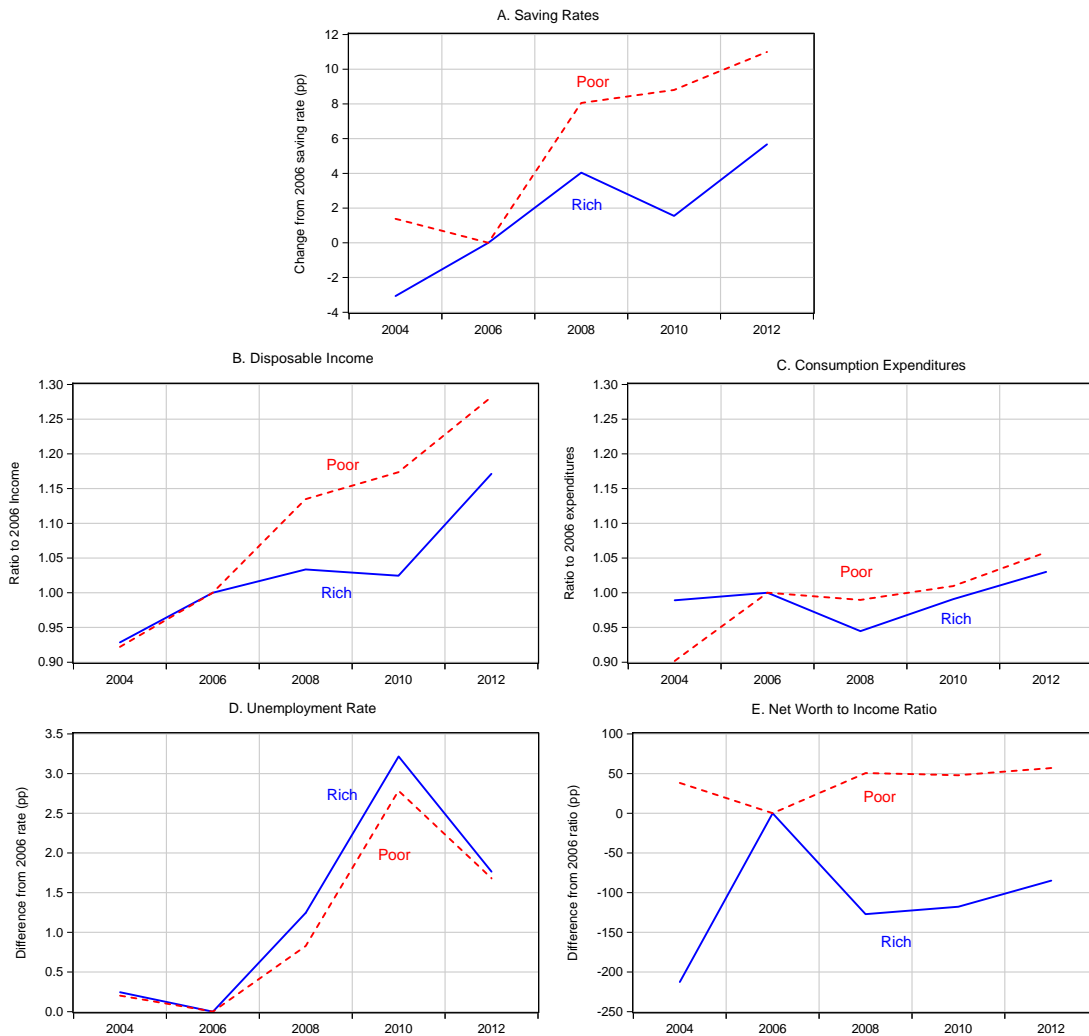
Figure 10: Changes in saving rates for rich and poor



The fact that during the Great Recession poor households increased their saving rates much more than the rich points towards an important precautionary motive in the face of rising unemployment risk. However, there are other potential explanations for this especially sharp increase in the saving rate of the poor. In particular, it is possible that the poor were more adversely affected

by deteriorating future income prospects, by rising unemployment, or by falling asset values. In order to control for these alternative explanations for the observed increase in saving we make use of the long panel nature of the PSID. The long panel nature is important as it allows to connect, for the same group of households, the change in saving behavior during the recession, to several outcomes after the recession, so as to assess whether the change in saving during the recession is related to these post recession outcomes. For this purpose we select all the households which are in the sample continuously from 2004 through 2012 and which satisfy the age restrictions specified above. This leaves us with a sample of 3,773 households, which we then divide into rich and poor groups using as a cut-off (weighted) net worth at the end of 2006 (relative to average consumption expenditures over the period 2006-2008).

Figure 11: Rich and poor: a long panel analysis



In Figure 11 we track the evolution of several variables for these two groups over time. Panel A reports saving rates, and confirms the findings of Figure 10 above: as the recession hits, both groups increased their saving rates, but the poor increased saving much more than the rich. Panels B and C report the paths for the two components of the saving rate: disposable income and consumption expenditures. Over the period 2008-2012 disposable income growth of both rich and poor slows down, but it is the income of the rich that slows more during and after the recession. This suggests that the disproportionate increase in saving of the poor cannot be attributed to their expecting relatively weak future income growth. Panel D shows that during and after the recession both groups faced similar increases in unemployment risk, suggesting that differential unemployment risk cannot explain why the poor increased their saving rate more.²⁴ Panel C shows that consumption growth of the rich declines more than consumption of the poor. This is consistent with the evidence presented in Petev et al. (2011) that high wealth households reduced consumption expenditures the most during the recession, and it is also consistent with Parker and Vissing-Jorgensen (2009), who show that in recent recessions consumption expenditures of high income households have been more cyclical than those of low income households. Note, however, that while the rich group chooses a somewhat larger reduction in consumption, they also face a much larger slowdown in income, so that their saving rate does not increase as much as the saving rate of the poor. Finally, panel E shows the path of wealth as a fraction of disposable income. Note that, relative to 2006, net worth of the rich declines by over 100% of their disposable income, while the poor actually experience an increase in net worth. A conventional wealth effects story would therefore predict a larger increase in the saving rate for the rich, contrary to the pattern observed. Note also that households in the poor group increase their net worth by around 50 percent of their income during the recession. This finding provides independent evidence that this group really is increasing saving. In addition, the net worth data confirm the popular narrative of deleveraging during the Great Recession: low wealth households cut expenditure to reduce debts and rebuild eroded balance sheets.

Overall, the evidence from the panel analysis in Figure 11 supports our hypothesis that the differential changes in saving rates shown in Figure 10 reflect a strong precautionary motive to save on the part of wealth-poor households in the face of rising unemployment risk. The magnitudes of the observed changes in saving rates are economically relevant. For example, in the PSID over the period 2006-2008, poor households increased their saving rate by about 4 percentage points more than rich households. If we attribute this difference to a stronger precautionary motive, then given that the poor account for about 1/3 of total disposable income (see Table 1), we can conclude that

²⁴The evidence in panels B and D is also consistent with De Nardi et al. (2012). They show that during the 2009 recession high income and high education households were more pessimistic about their income prospects relative to their poorer and less educated counterparts.

increased precautionary saving by the poor reduced aggregate consumption by $1/3 \times 4\% \simeq 1.3\%$ of aggregate disposable income.

7 Conclusions

The message of this paper is that when household wealth is low, a decline in consumer confidence can be self-fulfilling, because with low wealth, higher unemployment risk implies a large increase in the precautionary motive to save, rationalizing low equilibrium consumption and output. We argued that the decline in U.S. house prices in 2007 and 2008 reduced U.S. household net worth and left the U.S. economy vulnerable to just such a self-fulfilling wave of pessimism.

We developed a simple model to explore the conditions under which confidence-driven fluctuations are possible and to illustrate the connections between the level of liquid wealth, the monetary policy rule, and the nature of confidence-driven fluctuations that can arise. Precautionary motives that vary with wealth and unemployment risk play the key role in these links. These precautionary motives are central in standard intertemporal consumption theory and are consistent with consumption patterns observed in micro data during the course of the Great Recession.

An obvious project for future work is to develop a richer, more quantitative version of the model. One interesting extension would be to introduce household heterogeneity in net worth, to better understand the implications for aggregate precautionary demand of the extremely uneven distribution of net worth in the United States. A richer model of labor markets, in which desired labor supply plays a role in the long-run adjustment process, is another direction for future research. Finally, it would be interesting to introduce capital in the environment, since an increase in perceived unemployment risk would both increase the supply of saving and reduce the demand for investment, thereby changing the contours of the macroeconomic response.

References

- [1] Aiyagari, S.R. (1994) “Uninsured Idiosyncratic Risk and Aggregate Saving,” *Quarterly Journal of Economics*, 109(3), 659-684.
- [2] Alan, S., T.F. Crossley, and H. Low (2012) “Saving on a Rainy Day, Borrowing for a Rainy Day,” Institute for Fiscal Studies Working Paper W12/11.
- [3] Angeletos, G.M., F. Collard, and H. Dellas (2016) “Quantifying Confidence,” Working Paper, MIT.
- [4] Angeletos, G.M., and J. La’O (2013) “Sentiments,” *Econometrica*, 81(2), 739-779.

- [5] Atkeson, A. V.V. Chari and P. Kehoe (2010), “Sophisticated Monetary Policies,” *Quarterly Journal of Economics* 125(1), 47-89.
- [6] Bacchetta, P., and E. Van Wincoop (2016) “The Great Recession: A Self-Fulfilling Global Panic,” *American Economic Journal: Macroeconomics* 8(4), 177-198.
- [7] Baker, S. (2017) “Debt and the Consumption Response to Household Income Shocks,” *Journal of Political Economy*, forthcoming.
- [8] Barro, R.J., and H.I. Grossman (1971) “A General Disequilibrium Model of Income and Employment,” *American Economic Review* 61(1), 82-93.
- [9] Benigno, G., and L. Fornaro (2016) “Stagnation Traps,” Working Paper, London School of Economics.
- [10] Beaudry, P., D. Galizia, and F. Portier (2017) “Reconciling Hayek’s and Keynes’ Views of Recessions,” *Review of Economic Studies*, forthcoming.
- [11] Benito, A. (2006) “Does Job Insecurity Affect Household Consumption?” *Oxford Economic Papers* 58(1), 157-181.
- [12] Caballero, R.J., and E. Farhi (2017) “The Safety Trap,” *Review of Economic Studies*, forthcoming.
- [13] Carroll, C.D. (1992) “The Buffer-Stock Theory of Saving: Some Macroeconomic Evidence,” *Brookings Papers on Economic Activity* 23(2), 61-156.
- [14] Carroll, C.D., J. Slacalek, and M. Sommer (2012) “Dissecting Saving Dynamics: Measuring Wealth, Precautionary, and Credit Effects,” IMF Working Paper 12/219.
- [15] Challe, E., J. Matheron, X. Ragot, and J. Rubio-Ramirez (2017) “Precautionary Saving and Aggregate Demand,” *Quantitative Economics* (forthcoming).
- [16] Challe, E., and X. Ragot (2016) “Precautionary Saving Over the Business Cycle,” *Economic Journal* 126(590), 135-164.
- [17] Chamley, C. (2014) “When Demand Creates Its Own Supply: Saving Traps,” *Review of Economic Studies* 81(2), 651-680.
- [18] Chodorow-Reich, G., and L. Karabarbounis (2016) “The Cyclicalities of the Opportunity Cost of Employment,” *Journal of Political Economy* 124(6), 1563-1618.
- [19] Christiano, L., Eichenbaum, M., and S. Rebelo (2011) “When is the Government Spending Multiplier Large?” *Journal of Political Economy* 119(1), 78-121.
- [20] Clarida, R., J. Gali, and M. Gertler (2000) “Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory,” *Quarterly Journal of Economics* 115(1), 147-180.
- [21] Cooper, R., and A. John (1988) “Coordinating Coordination Failures in Keynesian Models,” *Quarterly Journal of Economics* 103(3), 441-463.
- [22] Davis, M.A., and J. Heathcote (2007) “The Price and Quantity of Residential Land in the United States,” *Journal of Monetary Economics* 54(8), 2595-2620.

- [23] Davis, M.A., and F. Ortalo-Magne (2011) “Household Expenditures, Wages, Rents,” *Review of Economic Dynamics*, 14(2), 248-261.
- [24] De Nardi, M., E. French, and D. Benson (2012) “Consumption and the Great Recession,” *Economic Perspectives* 2012(Q1), Federal Reserve Bank of Chicago.
- [25] den Haan, W.J., P. Rendahl, and M. Riegler (2016) “Unemployment (Fears) and Deflationary Spirals,” Working Paper, London Business School.
- [26] Diamond, P.A. (1982) “Aggregate Demand Management in Search Equilibrium,” *Journal of Political Economy* 90(5), 881-894.
- [27] Eggertsson, G.B., and P. Krugman (2012) “Debt, Deleveraging, and the Liquidity Trap: A Fisher-Minsky-Koo Approach,” *Quarterly Journal of Economics* 127(3), 1469-1513.
- [28] Eggertsson, G.B., and N.R. Mehrotra (2014) “A Model of Secular Stagnation,” NBER Working Paper 20574.
- [29] Eggertsson, G.B., and M. Woodford (2003) “The Zero Interest-Rate Bound and Optimal Monetary Policy,” *Brookings Papers on Economic Activity* 1, 139-211.
- [30] Engen, E.M., and J. Gruber (2001) “Unemployment Insurance and Precautionary Saving,” *Journal of Monetary Economics* 47(3), 545-579.
- [31] Farmer, R.E.A. (2013) “Animal Spirits, Financial Crises and Persistent Unemployment,” *Economic Journal* 123(568), 317-340.
- [32] Farmer, R.E.A. (2014) “The Evolution of Endogenous Business Cycles,” *Macroeconomic Dynamics*, 1-14.
- [33] Favilukis, J., S.C. Ludigson, and S. van Nieuwerburgh (2017) “The Macroeconomic Effects of Housing Wealth, Housing Finance, and Limited Risk Sharing in General Equilibrium,” *Journal of Political Economy* 125(1), 140-223.
- [34] Grebler L., D.M. Blank, and L. Winnick (1956) *Capital Formation in Residential Real Estate: Trends and Prospects*, Princeton University Press.
- [35] Guerrieri, V., and G. Lorenzoni (2009) “Liquidity and Trading Dynamics,” *Econometrica* 77(6), 1751-1790.
- [36] Guerrieri, V., and G. Lorenzoni (2015) “Credit Crises, Precautionary Savings, and the Liquidity Trap,” Working Paper, Booth School of Business, University of Chicago.
- [37] Hall, R.E. (2005) “Employment Fluctuations with Equilibrium Wage Stickiness,” *American Economic Review* 95(1), 50-65.
- [38] Havranek, T. (2015) “Measuring Intertemporal Substitution: The Importance of Method Choices and Selective Reporting,” *Journal of the European Economic Association* 13(6), 1180-1204.
- [39] Hintermaier, T., and W. Koeniger (2013) “Collateral Constraints and Self-Fulfilling Macroeconomic Fluctuations,” Working Paper, University of Bonn.

- [40] Huggett, M. (1993) “The Risk-Free Rate in Heterogeneous-Agent Incomplete-Insurance Economies,” *Journal of Economic Dynamics and Control* 17(5-6), 953-969.
- [41] Jappelli, T., and L. Pistaferri (2014) “Fiscal Policy and MPC Heterogeneity,” *American Economic Journal: Macroeconomics*, 6(4), 107-36.
- [42] Kaplan, G., and G. Menzio (2016) “Shopping Externalities and Self-Fulfilling Unemployment Fluctuations,” *Journal of Political Economy* 124(3), 771-825.
- [43] Kaplan, G., B. Moll, and G.L. Violante (2016) “Monetary Policy According to HANK,” Working Paper, New York University.
- [44] Kaplan, G., G.L. Violante, and J. Weidner (2014) “The Wealthy Hand-to-Mouth,” *Brookings Papers on Economic Activity* (Spring).
- [45] Kekre, R. (2017) “Unemployment Insurance in Macroeconomic Stabilization”, Working Paper, Booth School of Business, University of Chicago.
- [46] Kocherlakota, N. (2009) “Bursting Bubbles: Consequences and Cures,” Mimeo, Federal Reserve Bank of Minneapolis.
- [47] Lettau, M., S.C. Ludvigson, and J.A. Wachter (2008) “The Declining Equity Premium: What Role Does Macroeconomic Risk Play?” *Review of Financial Studies*, 21(4), 1653-1687.
- [48] Lustig, H.N., and S.G. van Nieuwerburgh (2005) “Housing Collateral, Consumption Insurance, and Risk Premia: An Empirical Perspective,” *Journal of Finance*, 60(3), 1167-1219.
- [49] Martin, A., and J. Ventura (2016) “Managing Credit Bubbles,” *Journal of the European Economic Association* 14(3), 753-789.
- [50] McKay, A., and R. Reis (2016) “The Role of Automatic Stabilizers in the U.S. Business Cycle” *Econometrica*, 84(1), 141–194.
- [51] Mian, A., K. Rao, and A. Sufi (2013) “Household Balance Sheets, Consumption, and the Economic Slump,” *Quarterly Journal of Economics*, 128(4), 1687-1726.
- [52] Mian, A., and A. Sufi (2010) “Household Leverage and the Recession of 2007 to 2009,” *IMF Economic Review*, 58(1), 74-117.
- [53] Mian, A., and A. Sufi (2016) “Who Bears the Cost of Recessions? The Role of House Prices and Household Debt,” NBER Working Paper 22256.
- [54] Michailat, P. (2012) “Do Matching Frictions Explain Unemployment? Not in Bad Times,” *American Economic Review* 102(4), 1721-1750.
- [55] Midrigan, V., and T. Philippon (2016) “Household Leverage and the Recession,” Working Paper, New York University.
- [56] Mody, A., F. Ohnsorge, and D. Sandri (2012) “Precautionary Savings in the Great Recession,” *IMF Economic Review* 60(1), 114-138.
- [57] Parker, J., and A. Vissing-Jorgensen (2009) “Who Bears Aggregate Fluctuations and How?” *American Economic Review*, 99(2): 399-405

- [58] Petev, I.D., L. Pistaferri, and I. Saporta-Eksten (2011) “Consumption and the Great Recession: Analysis of Trends, Perceptions, and Distributional Effects,” in Grusky, D.B., Western, B., and Wimer, C. (eds), *The Great Recession* (Russell Sage) 161-195.
- [59] Rendahl P. (2016) “Fiscal Policy in an Unemployment Crisis,” *Review of Economic Studies* 83(3), 1189-1224.
- [60] Ravn M., and V. Sterk (2014) “Job Uncertainty and Deep Recessions,” Working Paper, University College London.
- [61] Shimer, R. (2012) “Wage Rigidities and Jobless Recoveries,” *Journal of Monetary Economics* 59, S65-S77.
- [62] Schmitt-Grohe. S. and M. Uribe (2017) “Liquidity Traps and Jobless Recoveries,” *American Economic Journal: Macroeconomics* 9(1), 165-204..
- [63] Taylor, J.B. (1993) “Discretion Versus Policy Rules in Practice,” *Carnegie-Rochester Conference Series on Public Policy* 39, 195-214.
- [64] Taylor, J.B. (1999) “An Historical Analysis of Monetary Policy Rules,” in Taylor, J.B. (ed), *Monetary Policy Rules*, University of Chicago Press, 319-348.
- [65] Werning, I. (2012) “Managing a Liquidity Trap: Monetary and Fiscal Policy,” Working Paper, MIT.

Appendix A. Proofs

We first describe the steady state versions of the model equilibrium conditions, which are useful for proving several of the following results. Consider a steady state with a constant unemployment rate u . The market clearing conditions are

$$h = 1 \tag{19}$$

$$b = 0 \tag{20}$$

and

$$c^w(u) = \frac{y(u) - uc^u(u)}{1 - u} \tag{21}$$

where

$$y(u) = (1 - u)^\alpha$$

Given the market clearing conditions eqs. 19 and 20, the steady state versions of the household's first-order conditions for houses and bonds are

$$P^h(u)c^w(u)^{-\gamma} = \frac{P^h(u)}{(1 + \rho)} [(1 - \psi u) c^w(u)^{-\gamma} + \psi uc^u(u)^{-\gamma}] + \frac{\phi}{(1 + \rho)} \tag{22}$$

$$c^w(u)^{-\gamma} \frac{1}{1 + i(u)} = \frac{1}{(1 + \rho)} \frac{1}{(1 + \gamma_w)} [(1 - u) c^w(u)^{-\gamma} + uc^u(u)^{-\gamma}] \tag{23}$$

where $P^h(u) = p^h(u)/p(u)$ is the steady state real house price, and

$$c^u(u) = \max \left\{ c^w(u), \psi \frac{p^h(u)}{p(u)} \right\}.$$

The steady state version of the firm's FOC is

$$W(u) = \alpha(1 - u)^{\alpha-1}$$

where $W(u) = w_t/p(u)$ is the real wage.

The central bank policy rule is

$$i(u) = \max \{ (1 + \gamma_w)(1 + \rho - \kappa u) - 1, 0 \}.$$

Result 1: Full employment steady state

At full employment, the policy rule implies $i = (1 + \gamma_w)(1 + \rho) - 1$. It is immediate that at this interest rate and $u = 0$, the bond FOC is satisfied. Then, from the housing FOC, the real house price is given by $P^h = \phi/\rho$.

Result 2: Risk sharing in steady state

To prove that if risk sharing is perfect then $\lambda \geq 1$, note that with perfect risk sharing the real house price equals the present value of implicit rents, $P^h = \phi y/\rho$. A necessary condition for risk sharing to be perfect is that the value of liquid wealth has to be at least as high as per capita

output, i.e.,

$$\psi P^h \geq y.$$

Substituting in the expression for P^h yields

$$\lambda \equiv \psi\phi/\rho \geq 1$$

We now prove, by contradiction, that if $\lambda \geq 1$ then risk sharing is perfect. Assume that $\lambda \geq 1$ and that risk sharing is imperfect. If risk sharing is imperfect, then the real price of housing (using Result 3 below) is

$$P^h = \frac{\phi}{\rho} y \frac{u + \phi}{\lambda u + (1 + (\lambda - 1)u)\phi}.$$

In addition, a necessary condition for risk sharing to be imperfect is $\psi P^h < y$. Substituting in this inequality the expression for P^h yields

$$\lambda \frac{u + \phi}{\lambda u + (1 + (\lambda - 1)u)\phi} < 1$$

which simplifies to

$$u > 1$$

which is impossible, thus contradicting the assumption of imperfect risk sharing.

Result 3: Steady state house prices with imperfect risk sharing

Assuming imperfect risk sharing,

$$c^u(u) = \psi P^h(u) \tag{24}$$

Imposing $\gamma = 1$ (logarithmic utility) the steady state house price equation eq. 22 can then be written as

$$\frac{P^h(u)}{c^w(u)} = \frac{\phi + u}{\rho + \psi u}$$

Spending by workers, using 21, is

$$c^w(u) = \frac{(1 - u)^\alpha - u\psi P^h(u)}{1 - u} \tag{25}$$

Substituting this into the previous equation, one can solve out for $P^h(u)$:

$$\begin{aligned} P^h(u) &= \frac{\phi}{\rho} (1 - u)^\alpha \frac{u + \phi}{\frac{\psi\phi}{\rho} u + \left(1 + \left(\frac{\psi\phi}{\rho} - 1\right)u\right)\phi} \\ &= \frac{\phi}{\rho} (1 - u)^\alpha \frac{u + \phi}{\lambda u + (1 + (\lambda - 1)u)\phi} \end{aligned}$$

Result 4: Steady state interest rates.

The steady state version of the bond first-order condition, can be written, after substituting in

market clearing conditions, as

$$\begin{aligned}\frac{1}{c^w} \frac{1}{1+i(u)} &= \frac{1}{1+\rho} \frac{1}{1+\gamma_w} \left(\frac{1-u}{c^w} + \frac{u}{c^u} \right) \\ \frac{1}{1+i(u)} &= \frac{1}{1+\rho} \frac{1}{1+\gamma_w} \left((1-u) + u \frac{c^w}{c^u} \right)\end{aligned}$$

Now substitute in 25 and 24

$$\frac{1}{1+i(u)} = \frac{1}{1+\rho} \frac{1}{1+\gamma_w} \left((1-u) + \frac{u^{(1-u)^\alpha - u\psi P^h(u)}}{\psi P^h} \right) \quad (26)$$

Substituting in eq. 22 gives the expression in the text:

$$1+i(u) = (1+\rho)(1+\gamma_w) \left(\frac{u+\phi}{u\left(1+\frac{\rho}{\psi}-\phi\right)+\phi} \right) \quad (27)$$

It is immediate to show that if $u = 0$, then $1+i(u) = (1+\rho)(1+\gamma_w)$. Differentiating eq. 27 with respect to u , it is straightforward to show that the equilibrium interest rate $i(u)$ is declining in u given $\lambda < 1$. Similarly, $\lambda < 1$ ensures that the second derivative of $i(u)$ with respect to u is positive, so $i(u)$ is a convex function of u .

Result 5: Monetary policy and stability of steady states.

If monetary policy is aggressive, then the full employment steady state is locally unstable, in the sense that there are no perfect foresight equilibrium paths that converge to this steady state in which the initial unemployment rate is positive. If monetary policy is passive, then the full employment steady state is stable, and sunspot shocks are possible.

Assuming perfect foresight, the first-order condition for bonds can be written as

$$\frac{1}{c_t^w} \frac{1+\rho}{1+i_t} = \frac{1}{\frac{p_{t+1}}{p_t}} \left[\frac{1-u_{t+1}}{c_{t+1}^w} + \frac{u_{t+1}}{c_t^u} \right]$$

where P_t^h is the real house price. From the firm's first-order condition,

$$\frac{p_{t+1}}{p_t} = \frac{(1+\gamma_w)(1-u_{t+1})^{(1-\alpha)}}{(1-u_t)^{(1-\alpha)}}$$

Assuming the unemployed are borrowing constrained and imposing market clearing we have

$$\begin{aligned}c_t^u &= \psi P_{t+1}^h \\ c_t^w &= (1-u_t)^{\alpha-1} - \frac{u_t}{1-u_t} \psi P_t^h\end{aligned}$$

Finally, the policy rule (assuming the ZLB is not binding) is

$$i_t = (1 + \gamma_w)(1 + \rho - \kappa u_t) - 1$$

Substituting all these expressions into the bond FOC gives.

$$\begin{aligned} & \frac{1}{(1 - u_t)^{1-\alpha} \left((1 - u_t)^{\alpha-1} - \frac{u_t}{1-u_t} \psi P_t^h \right)} \frac{1}{(1 + \gamma_w)(1 + \rho - \kappa u_t)} \\ = & \frac{1}{1 + \rho} \frac{1}{(1 + \gamma_w)(1 - u_{t+1})^{1-\alpha}} \left[\frac{1 - u_{t+1}}{(1 - u_{t+1})^{\alpha-1} - \frac{u_{t+1}}{1-u_{t+1}} \psi P_{t+1}^h} + \frac{u_{t+1}}{\psi P_{t+1}^h} \right] \end{aligned}$$

or

$$\frac{1}{(1 - u_t(1 - u_t)^{-\alpha} \psi P_t^h)} \frac{1 + \rho}{(1 + \rho - \kappa u_t)} = \frac{1 - u_{t+1}}{1 - u_{t+1}(1 - u_{t+1})^{-\alpha} \psi P_{t+1}^h} + \frac{u_{t+1}}{(1 - u_{t+1})^{1-\alpha} \psi P_{t+1}^h}$$

Let $LHS(u_t, P_t^h)$ and $RHS(u_t, P_t^h)$ denote the left and right-hand sides of this equation. Now take a first-order Taylor series approximation to this equation around $u = 0$ and $P^h = \phi/\rho$. Thus,

$$\begin{aligned} & \frac{\partial}{\partial u_t} LHS(u_t, P_t^h)|_{(0, \phi/\rho)} \times u_t + \frac{\partial}{\partial P_t^h} LHS(u_t, P_t^h)|_{(0, \phi/\rho)} \times \left(P_t^h - \frac{\phi}{\rho} \right) \\ \simeq & \frac{\partial}{\partial u_{t+1}} RHS(u_{t+1}, P_{t+1}^h)|_{(0, \phi/\rho)} \times u_{t+1} + \frac{\partial}{\partial P_{t+1}^h} RHS(u_{t+1}, P_{t+1}^h)|_{(0, \phi/\rho)} \times \left(P_{t+1}^h - \frac{\phi}{\rho} \right) \end{aligned}$$

It is straightforward to verify that the partial derivatives with respect to P_t^h and P_{t+1}^h are zero, and that

$$\begin{aligned} \frac{\partial}{\partial u_t} LHS(u_t, P_t^h)|_{(0, \phi/\rho)} &= \psi \frac{\phi}{\rho} + \frac{\kappa}{1 + \rho} \\ \frac{\partial}{\partial u_{t+1}} RHS(u_{t+1}, P_{t+1}^h)|_{(0, \phi/\rho)} &= \frac{\phi}{\rho} \psi - 1 + \frac{1}{\frac{\phi}{\rho} \psi} \end{aligned}$$

Thus, at $u = 0$ and $P^h = \phi/\rho$ a first-order approximation to the bond FOC gives

$$\frac{u_{t+1}}{u_t} \simeq \frac{\psi \frac{\phi}{\rho} + \frac{\kappa}{1 + \rho}}{\frac{\phi}{\rho} \psi - 1 + \frac{1}{\frac{\phi}{\rho} \psi}}$$

Now suppose we contemplate the perfect foresight dynamics for $u_0 = \varepsilon > 0$, where ε is small so the approximation around $u = 0$ is good. Do the dynamics of the system take us towards full employment, or does unemployment tend to grow over time?

Unemployment will revert to full employment if $\frac{u_{t+1}}{u_t} < 1$ which in turn is satisfied if

$$\begin{aligned} \psi \frac{\phi}{\rho} + \frac{\kappa}{1+\rho} &< \frac{\phi}{\rho} \psi - 1 + \frac{1}{\frac{\phi}{\rho} \psi} \\ \kappa &< (1+\rho) \left(\frac{1 - \frac{\psi\phi}{\rho}}{\frac{\psi\phi}{\rho}} \right) = (1+\rho) \left(\frac{1-\lambda}{\lambda} \right) \end{aligned}$$

This is precisely the condition that defines passive monetary policy.

Result 6: Uniqueness with high liquid wealth.

We want to prove that if liquid wealth is high and monetary policy is aggressive, then full employment is the only steady state.

First, recall that if liquid wealth is high, then $i(u) > 0$ for all u .

Second, recall that aggressive monetary policy ensures $\kappa > -\frac{\partial i(u)}{\partial u}$ at $u = 0$, so that the $i^{CB}(u)$ is steeper than $i(u)$ at $u = 0$. Because $i(u)$ is convex (Result 4) while $i^{CB}(u)$ is linear, it follows immediately that $i(u) > i^{CB}(u)$ for all $u \in (0, \rho/\kappa]$ (the point where $i^{CB}(u)$ kinks).

Now, recall again that high liquidity ensures that $i(u) > 0$ for all u . Thus, $i(u) > i^{CB}(u) = 0$ for all $u \in (\rho/\kappa, 1]$.

Combining these results, the only value for u at which $i(u) = i^{CB}(u)$ is $u = 0$.

Result 7: Multiplicity with low liquid wealth

When liquidity is low and monetary policy is aggressive, there are two steady states: full employment, and a second steady state in which

$$\begin{aligned} u &= u^+ = \frac{\phi \left(1 + \gamma_w \frac{(1+\rho)}{\rho} \right)}{\frac{1-\psi}{\psi} - \frac{\phi}{\rho} - \gamma_w \frac{(1+\rho)}{\rho}} \\ y &= y^+ = (1 - u^+)^\alpha \\ i &= 0 \\ P^h &= \frac{\phi}{\rho} y^+ \times \frac{1}{1 - \psi - \phi\psi - \psi\gamma_w(1 + \phi) \frac{(1+\rho)}{\rho}} \end{aligned}$$

This solution for u^+ comes from setting $i = 0$ in eq. 27 and solving for u . The solution for P^h then follows from substituting the solution for u into eq. 22.

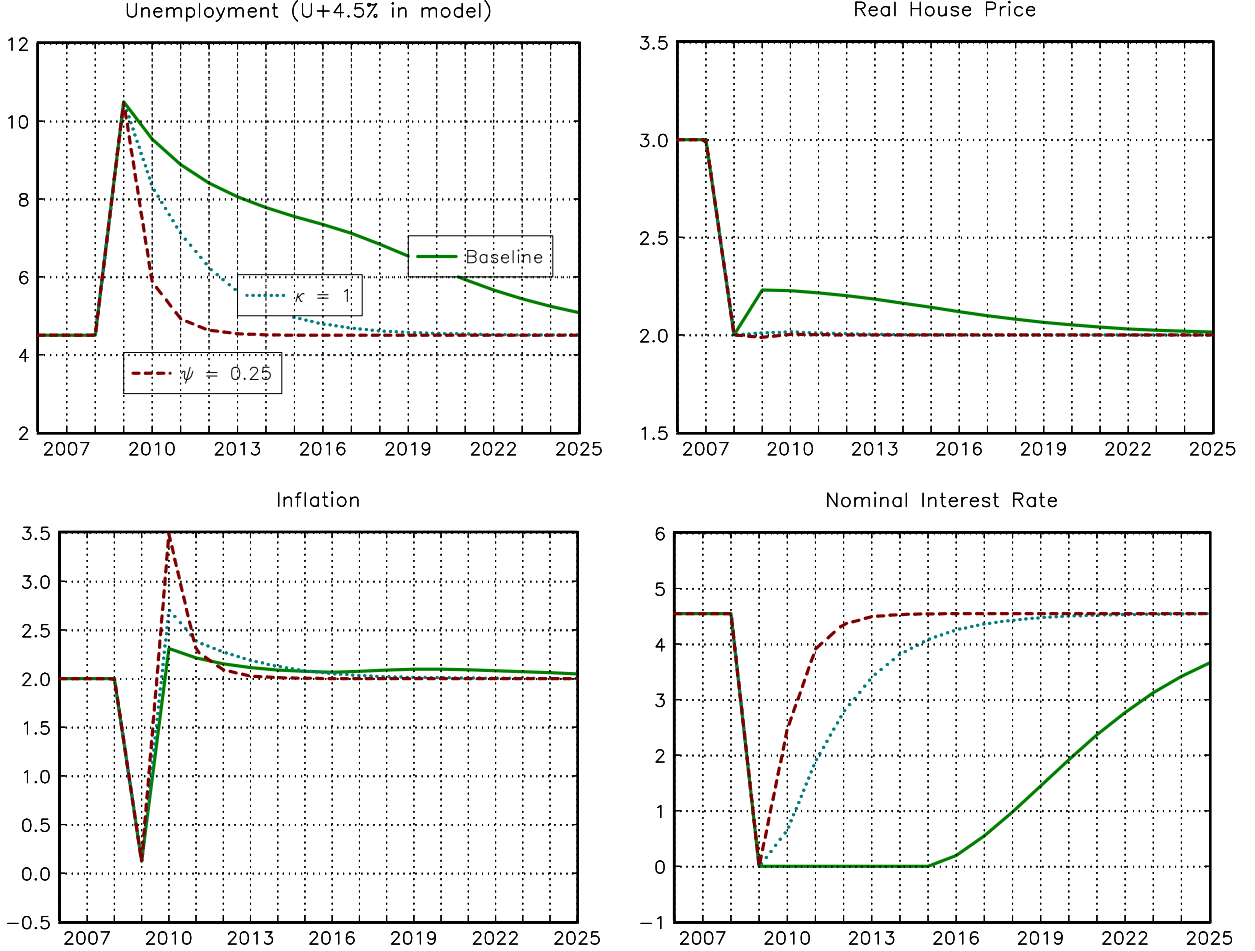
Great Recession Simulation Sensitivity

How sensitive is the shape of the recovery to alternative parameter values? We have experimented with alternative values for ψ and κ . With a lower value for κ – a less aggressive monetary policy – the recovery is faster. A lower value for κ implies higher interest rates during recovery, encouraging saving. In equilibrium, this stronger incentive to save is offset by the fact that a swifter recovery implies a stronger incentive to borrow.

With a lower value for ψ – i.e., less liquidity – the recovery is again faster, consistent with

the intuition described in the main text. Figure 12 plots our baseline against two alternatives: (i) $\kappa = 1.0$ (instead of 1.5), and (ii) $\psi = 0.25$ (instead of $1/3$).

Figure 12: The Great Recession: Alternative calibrations



Appendix B. An Explicit Monetary Model

In our baseline model, we did not model money explicitly. We simply assumed that the central bank could dictate the nominal interest rate. To better understand the mechanics of interest rate control, it is useful to explicitly introduce money, and to trace out the details of how changes in the money supply allow the central bank to achieve its interest rate targets. In the monetary model we lay out here, households are willing to hold both interest-bearing bonds, and non-interest-bearing money because real money balances deliver direct utility. In particular we add a new term to the period utility function, so that households now seek to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ (1 - u_t) \frac{(c_t^w)^{1-\gamma}}{1-\gamma} + u_t \frac{(c_t^u)^{1-\gamma}}{1-\gamma} + \phi \frac{(h_{t-1})^{1-\gamma}}{1-\gamma} + v \left(\frac{m_t}{p_t} \right) \right\},$$

where m_t denotes nominal balances, and p_t is the price of consumption in units of money. We assume that the function $v\left(\frac{m_t}{p_t}\right)$ is increasing, differentiable, and concave, and constant above some threshold \bar{M} , so that $v'\left(\frac{m_t}{p_t}\right) = 0$ for $\frac{m_t}{p_t} \geq \bar{M}$.

We will assume that money, like bonds, is perfectly liquid. The government can change the money supply by distributing new cash Δ_t in a lump-sum fashion. If $\Delta_t < 0$, the government imposes a lump-sum nominal tax on households, payable in cash.

The household budget constraints are now

$$\begin{aligned} p_t c_t^u &\leq \psi p_t^h h_{t-1} + b_{t-1} + m_{t-1} + \Delta_t, \\ p_t c_t^w &\leq w_t + \psi p_t^h h_{t-1} + b_{t-1} + m_{t-1} + \Delta_t, \end{aligned}$$

and

$$(1 - u_t)p_t c_t^w + u_t p_t c_t^u + p_t^h (h_t - h_{t-1}) + \frac{1}{1 + i_t} b_t + m_t \leq (1 - u_t) w_t + \varphi_t + b_{t-1} + m_{t-1} + \Delta_t.$$

We now get the following inter-temporal conditions for houses, h_t , bonds, b_t , and money, m_t , respectively:

$$\begin{aligned} \frac{p_t^h}{p_t} (c_t^w)^{-\gamma} &= \frac{1}{1 + \rho} E_t \frac{p_{t+1}^h}{p_{t+1}} [(1 - u_{t+1}\psi) (c_{t+1}^w)^{-\gamma} + u_{t+1}\psi (c_{t+1}^u)^{-\gamma}] + \frac{\phi}{1 + \rho} u'(h_t), \\ (c_t^w)^{-\gamma} \frac{1}{p_t} \frac{1}{1 + i_t} &= \frac{1}{1 + \rho} E_t \frac{1}{p_{t+1}} [(1 - u_{t+1})(c_{t+1}^w)^{-\gamma} + u_{t+1}(c_{t+1}^u)^{-\gamma}], \\ \frac{1}{p_t} (c_t^w)^{-\gamma} - \frac{1}{p_t} v'\left(\frac{m_t}{p_t}\right) &= \frac{1}{1 + \rho} E_t \frac{1}{p_{t+1}} [(1 - u_{t+1})(c_{t+1}^w)^{-\gamma} + u_{t+1}(c_{t+1}^u)^{-\gamma}]. \end{aligned}$$

Note that the right-hand sides of the first-order conditions for bonds and money are identical, so the left-hand sides must also be equal, which implies

$$v'\left(\frac{m_t}{p_t}\right) = (c_t^w)^{-\gamma} \frac{i_t}{1 + i_t}.$$

This condition is intuitive. The higher is the interest rate, the higher must be the marginal utility of real balances (i.e., the smaller must be real balances) so that households remain indifferent between earning interest on bonds versus enjoying utility from money.

In equilibrium, the quantity of money m_t that households choose to hold in period t – money demand – must equal money supply, which is the quantity of money previously in circulation plus the quantity of new money injected:

$$m_t = m_{t-1} + \Delta_t.$$

Suppose that at some date t , the central bank wants to cut the nominal rate. It can achieve this by injecting more money into the economy – raising Δ_t . Given a sticky wage, the price level will increase by less than the money supply, so higher nominal balances means higher real balances. Higher real balances reduces the marginal utility of saving additional money, and, by making money less attractive as a savings vehicle, allows the bond market to clear at a lower nominal rate i_t . The

money injection will increase consumer demand via two channels. First, lower interest rates will encourage households to spend rather than save. Second, higher real balances will provide additional liquidity to unemployed household members, and reduce the precautionary motive to save. This second channel is absent in the baseline model, in which money is not modeled explicitly. Higher consumer demand will tend to push up the price level, and given a sticky nominal wage, this will expand labor demand and output.²⁵

Note that to push the nominal interest rate all the way to zero requires increasing the money supply above the point at which the marginal utility of real balances hits zero. When money provides no direct utility on the margin, households will be indifferent between saving in the forms of bonds versus money only if bonds – like money – pay no interest.

In general this explicit monetary model will not generate identical allocations to those in the model without money laid out in the main text, even given the same interest rate rule. The reason is that when real balances are in positive net supply, the total supply of assets in the economy is increased, and this will improve within household insurance. However, if the utility function over real balances $v\left(\frac{m}{p}\right)$ has the property that satiation is reached at a very small value for \bar{M} , and if the monetary authority never expands the money supply beyond the point required to deliver its target rate $i^{CB}(u)$ – i.e., if real balances never exceed \bar{M} , which delivers $i = 0$ – then equilibrium real balances will always be very small, and thus the allocations in the models with and without money will be very similar. In particular, as $\bar{M} \rightarrow 0$, and the economy converges to the cashless limit, allocations in the economy with money will converge to those in the economy without money.

Even if \bar{M} is small, however, hitting the zero lower bound does not necessarily mean the central bank is out of ammunition. In particular, it can still increase the money supply, and at a zero nominal rate households may be willing to hold large real balances even if the marginal utility from additional money is zero. Moreover, such policies could be effective in stimulating demand by improving insurance, and reducing precautionary saving. Thus, the model with money could be used to explore unconventional monetary policies that temporarily expand the money supply when the economy is at the zero lower bound. This is something we leave for future work.

Appendix C. Empirical Analysis

Total Household Net Worth

Total net worth of U.S. households is computed as the sum of the following components of the Financial Accounts of the United States (Z1 release): (i) Households and nonprofit organizations; real estate at market value minus home and commercial mortgages, (ii) Households and nonprofit organizations; corporate equities, (iii) Households and nonprofit organizations; treasury securities, including U.S. savings bonds. For the period 1920-1944, these series are not available from the source above so we extend them as follows. The value of real estate is backcast using the growth rate of the value of total residential non-farm wealth in Grebler et al. (1956). Home mortgages are backcast using the growth rate of nonfarm residential mortgage debt from Grebler et al. (1956) and commercial mortgages are backcast using the growth rate of nonfarm commercial mortgage debt from the same source. The value of Treasury securities is backcast using the growth rate of the amount of public debt outstanding from the Treasury Department, and finally the value of

²⁵Absent a sticky nominal wage, a higher money supply would pass through one-for-one to nominal wages and prices, and would not affect real allocations.

corporate equities is backcast using the historical growth of the S&P 500 price index.

Micro Data

For each data set our key variables are net worth, disposable income and consumption expenditures. Below we first briefly describe the data sets, and then discuss the construction of these variables. The micro data used for the analysis are available on the authors' websites.

The Panel Study of Income Dynamics (PSID) is a panel of U.S. households, selected to be representative of the U.S. population, collected (from 1997) at a bi-annual frequency. Starting in 2004 the PSID reports, for every household in the panel, comprehensive consumption expenditure information, alongside information on income and wealth. Our panel includes all households which have at least one member aged between 22 and 60, which report yearly consumption expenditure of at least \$1,000, and which are in the panel for at least two consecutive interviews.

The Consumer Expenditure Survey (CES) is a rotating panel of U.S. households, selected to be representative of the U.S. population, collected at a quarterly frequency. Households in the CES report information for a maximum of four consecutive quarters. Households report consumption expenditures in all four interviews, income information in the first and last interview, and wealth information in the last interview only. We use CES data from the first quarter of 2004 to the last quarter of 2013, and include all households which have at least one member aged between 22 and 60, which report yearly consumption expenditure of at least \$1,000, and which report consumption and income in the first and last interviews.

The Survey of Consumer Finance (SCF) is triennial survey of U.S. households. The survey collects information on household income but focuses primarily on detailed information about household financial and non-financial assets and debts.

Net Worth In all three data sets we construct net worth by summing all categories of financial wealth (i.e. bank accounts, bonds, stocks) plus real estate wealth minus the value of any household debt (including mortgages, home equity loans and other debts). The PSID and SCF have a more accurate record of wealth, and report also the values of individual retirement accounts (IRAs), of family businesses, and of vehicles. Our measure of net worth in PSID and SCF includes these variables.

Disposable Income In both the PSID and the CES data sets we construct disposable income by summing all money income received by all members of the household, including transfers, and then subtracting taxes. In the PSID we compute taxes using the NBER TAXSIM utility, while in the CES we use taxes paid as reported by the household.

Consumption Expenditure In both data sets we construct expenditure by summing the value of the purchases of: new/used cars and other vehicles, household equipment (including major appliances), goods and services used for entertainment purposes, food and beverages (at home and out), clothing and apparel (including jewelry), transportation services (including gasoline and public transportation), household utilities (including communication services such as telephone and cable services), education, and child care services. The two major categories that are excluded from our analysis are health expenditures and housing services. We exclude these categories to enable better comparison with NIPA data. Our key result regarding the differential behavior of

consumption rates between rich and poor (shown in Figure 10) survives with consumption measures that include these two categories. We also experimented with a narrower consumption measure which excludes food, transportation services and utilities. The reason to consider excluding these categories is that households in the PSID are asked how much they spent on these in a typical week and not explicitly for the whole year (as for the other consumption categories). For this narrower consumption definition the discrepancy between aggregate consumption expenditures in the PSID and the other two data sources (Panel A of Figure 13) is much smaller. We have also reproduced Figure 10 with this narrower consumption measure, and found that the patterns of changes in saving rates are very similar.

Aggregates

Panel A of Figure 13 shows the dynamics of average per capita expenditures in the PSID and the CES against the equivalent measure in the National Income and Product Accounts (NIPA). Panel B shows average per capita disposable income in the PSID and the CES versus NIPA personal disposable income. Panel C shows median household net worth in the PSID and the CES versus median net worth in the SCF. Our consumption concept includes all categories except expenditure on housing and on health. Net worth includes net financial wealth plus housing wealth net of all mortgages (including home equity loans).²⁶ The key message from the figure is that the dynamics of consumption, income and wealth are broadly comparable across data sets. In particular, both micro data sets exhibit a marked reduction in consumption expenditure during the recession.²⁷

Measuring changes in saving rates in the PSID and the CES

We now specify the details of the the procedure used to produce Figure 10.

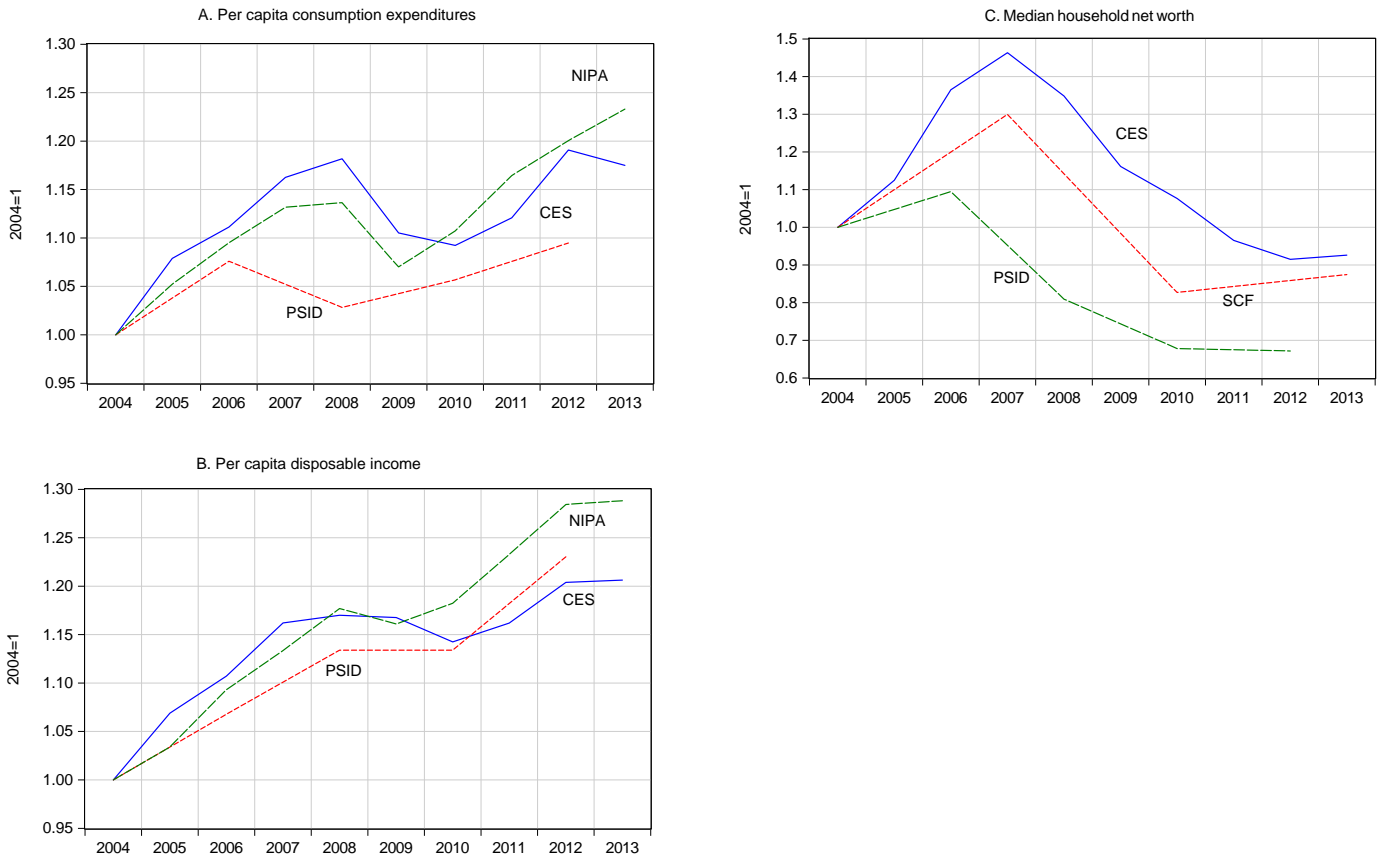
PSID (Panels A and B)

1. For any year t (e.g. 2006), select households that (i) contain a head or spouse aged between 22 and 60, (ii) report disposable income and consumption expenditures and net worth in year t and year $t + 2$.
2. Rank households by net worth in year t relative to the average of consumption expenditures in years t and $t + 2$. We then divide the sample into 2 (for panel A) or 5 (for panel B) equal size (weighted) groups, where the dividing lines between groups are the (weighted) quantiles of the empirical distribution of net worth relative to consumption expenditure.
3. For each group, compute the change in saving rates between years t and $t + 2$, where the change is defined in equation 18 in the text. Note that the identity of households in a group does not change when we compute changes in saving rates between year t and $t + 2$.

²⁶We do not impose any sample selection when constructing the PSID, CES and SCF series in Figure 13. All data are nominal and in levels (relative to 2004).

²⁷One discrepancy is that consumption expenditures decline somewhat earlier in the PSID than in the CES or the NIPA. Note, however, that due to the bi-annual nature of the PSID we have no observation for 2007. In addition, it is difficult to date consumption precisely in the PSID because some of the survey questions ask explicitly about spending in the previous year – the year to which we attribute consumption – while others ask about current consumption. Excluding the latter consumption categories narrows the gap between the PSID and the other two sources.

Figure 13: Comparing aggregates across micro data sets



4. Move to year $t + 2$ and repeat to steps 1 through 3. Note that when we move to a new year and re-define rich and poor the identity of the households in each group changes. Households which have, for example, low net worth in 2006 do not necessarily have low net worth in 2008.

CES (Panels C and D)

1. For any year t (e.g. 2006), select households that (i) contain a head or spouse aged between 22 and 60, (ii) are interviewed for the first time in year t (e.g. the first year in the sample), and (iii) report annual disposable income and quarterly consumption expenditures in their first and last interviews, and report net worth in their last interview.
2. Rank these households by net worth in their last interview (the only time wealth is reported) relative to the average of consumption reported in the first and last interview. Then divide the sample into two (for panel C) or 5 (for panel D) equal size (weighted) subgroups, where the dividing lines between groups are the (weighted) quantiles of the empirical distribution of net worth relative to consumption expenditure.
3. For each group, compute change in saving rates between the first and last interview, where the

change is defined in equation 18 in the text. Note that because the first and last interviews are 9 months apart, for some households the last interview is at the end of year t while for the rest it is in year $t + 1$. Also since consumption expenditures are quarterly and income is yearly we annualize consumption expenditures.

4. Move to year $t + 1$, and repeat steps 1 through 3.

To produce Figure 10, Panel D, we follow the same procedure, except that to compute saving rate changes over a two-year window, for a given wealth quintile, we add together the quintile-specific changes in the saving rate over each of the two years in the window. In all figures data are nominal and in levels.

Alternative Wealth Definition

In our baseline empirical analysis, we define our rich and poor groups based on the ratio of net worth to consumption, to get a sense of wealth relative to permanent income, which in turn ought to be a good proxy for the strength of a household's precautionary motive. If we were to group based on wealth in year t relative to consumption in year t , the low wealth group would mechanically have low wealth and/or high consumption. However, both household consumption and household wealth have a mean-reverting component. Thus, looking forward, the low wealth group based on this definition would tend to have rapid wealth and/or slow consumption growth between t and $t + 1$. If we were instead to group based on wealth in year t relative to consumption in $t + 1$, the low wealth group would tend to have high consumption in $t + 1$ and thus rapid consumption growth between t and $t + 1$. When we define wealth as net worth at t relative to the average of consumption at t and $t + 1$, there is no obvious mechanical bias in implied consumption growth either direction.

In any case, in order to check that our results on saving rates are not driven by mean reversion, we have experimented with a wide range of alternative ways to split the sample. We have found that our results are not driven by the particular definition of wealth chosen. Changing the date at which we measure consumption in the net worth to consumption ratio does affect average differences between consumption growth and saving rates of rich and poor, but it does not have much of an effect on how the behavior of the two groups diverges as the U.S. economy enters the Great Recession. The simplest and starkest way to make this point is to consider what happens if we do not normalize by consumption at all. Figure 14 shows that when we simply define wealth as net worth, the result that, during the recession, the wealth poor increase their saving rate more than the wealth rich is still present.²⁸

²⁸The rich versus poor difference is now slightly muted, which is what one might expect given that this measure of wealth is less ideal from the standpoint of capturing differential strength of the precautionary motive.

Figure 14: Changes in saving rates for rich and poor under alternative definition of wealth

