1 Introduction

Figure 1 documents the relationship between household wealth and aggregate volatility in the United States. Volatility is measured as the standard deviation of the quarterly real GDP growth rate over a 10 years period (where the x axis in the graph denotes the end of that period), while wealth is measured as the average deviations from trend for net worth of households and non profit organization (from the Flow of Funds) over the same 10 years windows. The figure reveals that periods when average net worth is high relative to trend, reflecting high prices for housing and/or stocks, tend to be periods of 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 periods ending in late 70s and early 1980s wealth is at its historical low and volatility is at its historical high, while periods ending during the late 1990s and early 2000s wealth is at its highest and volatility is at its lowest.

Figure 2 presents another piece of evidence that relates economic volatility and wealth, showing that the three periods over the past century in which the US economy has been more unstable, namely the 30s, the late 70s early 80s and the late 00s are all characterized by household net worth below trend[1]

In this paper we argue that (exogenously given) fluctuations in wealth are an important factor in determining the volatility of business cycles. We make the argument by developing a micro-founded dynamic equilibrium model that contains elements of a traditional Keynesian framework in which economic fluctuations are driven by fluctuations in household optimism or pessimism. The novel feature is that the scope for equilibrium fluctuations due to "animal spirits" depends crucially on the value of wealth in the economy. When wealth is high the economy has a unique equilibrium and behaves neoclassically. When wealth is low, the economy becomes vulnerable to additional confidence-driven fluctuations and hence is, in general, more volatile. In this case, there is a potential role for public policies to stabilize demand.

Our model economy deviates from a standard representative agent economy in two ways: the first is that we introduce frictional labor markets, with allows equilibrium unemployment, the second is that we introduce uninsurable unemployment risk, which makes household demand sensitive to expectations about economic conditions. The economy is populated by a large number of identical households, each of which comprises many members. Competitive firms operate a linear technology

[1] Household net worth is from the Flow of Funds from 1945 onward and has been calculated using historical sources on stock values and housing prices for earlier periods, see the data appendix for more details

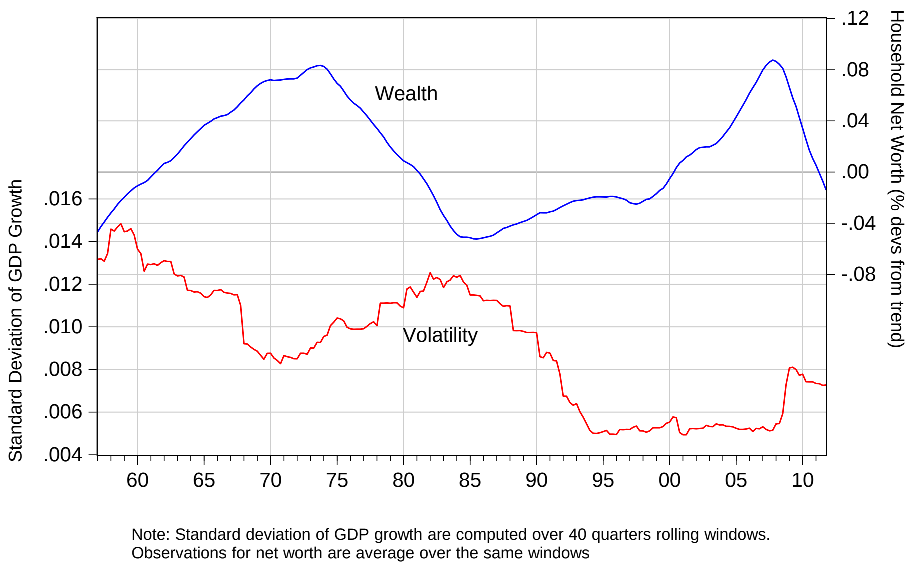

Figure 1: Wealth and volatility

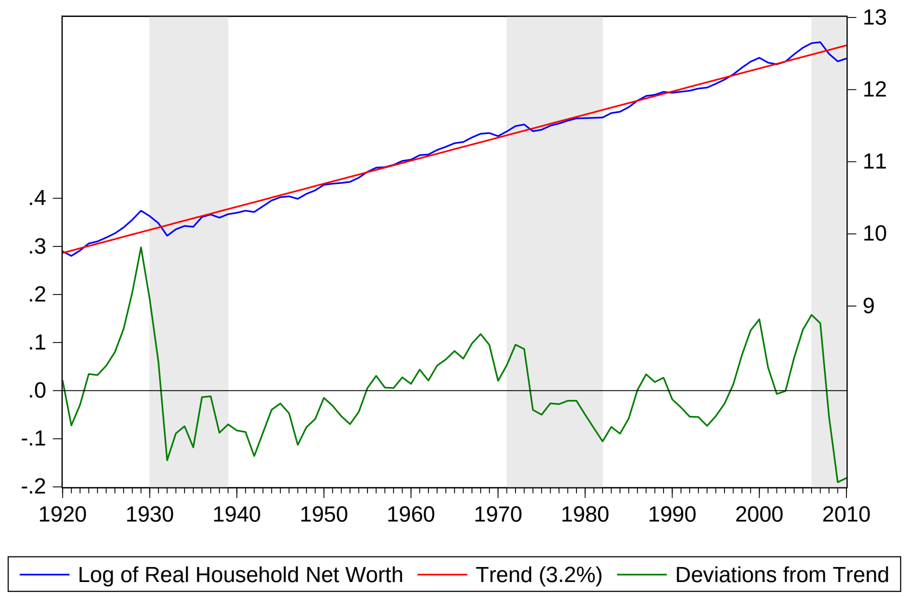

Figure 2: Household net worth in US in the long run

that use employed workers to produce a perishable consumption good. Households enjoy utility from non-durable consumption and from durable housing, which is in fixed supply. In each period, given current economic conditions and expectations, households submit consumption orders to firms. Given orders, firms hire the workers that are necessary to fulfill the orders. Then jobs are allocated by random matching in a decentralized frictional labor market. The key friction we introduce is that household cannot affect the probability of finding a job by asking a lower wage. risk of unempl The decentralized nature of the labor market is important because it means that equilibrium output will be determined by desired consumption demand, rather than by desired labor supply, and because it allows for the possibility of equilibrium unemployment.

Agents must finance their consumption orders using wage income, home equity, or non-collateralized borrowing. Unemployment expectations matters not only because the expected unemployment rate determines expected income, but also because if house prices are low the household anticipates that members who do not find jobs will have to use expensive credit. The fact that consumption for each member is committed prior to realization of the member's idiosyncratic employment status increases the precautionary motive associated with perceived unemployment risk.

Our first result is to show that this environment allows for multiple equilibria in which households can collectively co-ordinate on a range of expectations about unemployment, each of which turns out to be self-fulfilling. In particular, there is a range of values for house prices in which the model has two steady states (with the same house price in each). In the optimistic steady state, households expect low unemployment, are therefore not too concerned about credit costs for unemployed workers, and set consumption demand high. Facing high demand, firms employ a large fraction of workers, and the expectation of low unemployment is rationalized. In the pessimistic steady state, households expect high unemployment. Because they do not want to commit to high consumption given high idiosyncratic unemployment risk and costly credit, they set consumption demand low. Facing low demand, firms hire few workers, and unemployment is in fact high, as expected.

Precautionary saving in housing offers a way for households to self-insure against unemployment risk. The less wealth a household has, the more reliant the household will be on costly credit in the event of unemployment. Thus the lower is household wealth, the more sensitive is consumption demand to the expected unemployment rate. This increased sensitivity of demand to expectations increases the range of unemployment rates that can be supported in a rational expectations equilibrium. To see this consider the extreme case in which households have no wealth. Then, if they are maximally pessimistic and expect 100% unemployment they will set consumption to zero, and

100% unemployment can occur in equilibrium. But if households have positive wealth they will choose positive consumption even if they expect 100% unemployment. Firms must then hire a positive fraction of workers to fill these orders, and so 100% unemployment cannot be an equilibrium. Thus the maximum magnitude of sun-spot driven equilibrium fluctuations will vary inversely with the level of house prices.

Home values in the model are endogenous equilibrium objects, and reflect both the fundamental flow utility from home ownership and the liquidity value of being able to finance consumption out of home equity in the event of unemployment. Because this liquidity value is tied to the level of unemployment, house prices themselves are indeterminate, and like the unemployment rate, can potentially fluctuate in response to changes in expectations. However, for most of our analysis we will explore what dynamics for unemployment are possible for alternative constant values for equilibrium house prices. We do this because in the data a large share of house price volatility is at lower frequencies than typical business cycle fluctuations.

We further limit the set of values for house prices we consider by introducing as an additional model element a fringe group of households that does not face unemployment risk. The presence of this group establishes a lower bound on housing demand and thus on equilibrium house prices. If this lower bound is sufficiently high, unemployed workers can finance consumption entirely out of home equity, and full employment is the only possible equilibrium.

We use the model to offer an interpretation of recent macroeconomic history. The Great Moderation was a time in which US house and stock prices were very high by historical standards. High household wealth levels in this period meant that the economy was robust in the sense that it was not subject to large recessions induced by declines in confidence. However, the sharp declines in house and stock prices between mid 2007 and mid 2009 left the economy fragile, and vulnerable to a confidence-driven recession. One possible "trigger" for a collective loss of confidence was the collapse of Lehman Brothers in the Fall of 2008. We show that following a transitory sunspot-induced recession, equilibrium dynamics imply a slow recovery, even though fundamentals remain unchanged. Of course, fluctuations in consumer confidence are only one source of business cycles, and over a longer history economic cycles in the United States likely have a number of causes above and beyond fluctuations in animal spirits.

The model has policy implications. We evaluate two specific policies. The first is a lump-sum unemployment benefit, financed by a proportional income tax. This policy makes unemployment less painful, and thereby reduces the sensitivity of demand to the expected unemployment rate.

A sufficiently generous benefit rules out sunspot-driven fluctuations and ensures full employment. The second policy we consider is government consumption financed by lump-sum taxation, in the spirit of the 2009 stimulus plan. This policy also makes aggregate (private plus public) demand less sensitive to expectations, and thereby rules out equilibria with very high unemployment rates. However, taxation also reduces asset values, which increases the sensitivity of demand to perceived unemployment risk. The two effects offset each-other and the end result is that fiscal policy can be very ineffective.

1.1 Related Literature

From a theoretical viewpoint, our paper is related to recent work by Guerrieri and Lorenzoni (2009), Chamley (2010), and Farmer (2010). In both our model and Farmer's output is demand-determined, and asset prices play a critical role in determining demand. One difference is that agents in our model face idiosyncratic risk and thus have a precautionary motive for saving, which is central to delivering a connection between the level of asset prices and the volatility of output. Guerrieri and Lorenzoni develop a model in which risk-averse agents trade in a decentralized fashion and face idiosyncratic risk. Their model recessions feature an increase in precautionary saving, as do ours, but in their model an endogenous increase in precaution amplifies a fundamental aggregate productivity shock, while in ours it is a self-fulfilling prophecy.

Other recent models that argue for multiple equilibria as a source of aggregate fluctuations include Kaplan and Menzio (2013) where multiplicity is driven by a shopping externality, and Martin and Ventura (2012), where there are multiple possible prices of collateral.

A challenge in constructing models in which demand-side factors play an important role in that many forces that tend to reduce desired consumption demand (e.g. lower asset values, greater idiosyncratic risk) also tend to increase desired household labor supply. Hall (2005), Michaillat (2010) and Shimer (2012) have developed models with decentralized labor markets in which they assume that the real wage does not fall (much) in response to a negative productivity shock, leading to a large fall in vacancy posting and a surge in involuntary unemployment. These models lack clear microfoundations for wage formation. On the other hand, they offer a natural resolution to the longstanding discrepancy between small microeconomic estimates for labor supply elasticities, and the large macro elasticities implicit in the large movements in aggregate hours over the business cycle (see, for example, Chetty et al., 2011). The resolution is simply that large falls in aggregate hours during recessions do not reflect an unwillingness to supply labor, but instead indicate that wages are "stuck" at too-high levels. In our model, the household is assumed to first choose a reservation wage, and then the firm only gets to decide whether or not to accept or reject a potential match. Workers then always extract all the surplus from a firm-worker match and, given a linear technology, firms are always indifferent about how many workers to hire. The level of demand then effectively selects a particular employment rate.

We are not the first to argue for a link between asset values and volatility, but our mechanism reverses the usual direction of causation. Others (see Lettau et al. 2008) have pointed out that higher aggregate risk should drive up the risk premium on risky assets relative to safe assets. Lower prices for risky assets like housing and equity then just reflect higher expected future returns on these assets. 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.

2 Model

There are two goods in the economy: a perishable consumption good, produced by a continuum of identical competitive firms using labor, and an durable asset, which is in fixed supply and which we label housing. There are two types of households in the model, and a continuum of identical households of each type. These types share common preferences, but differ with respect to the risk they face: income for the first type is risky, while income for the second is not.

Each household of the first "risky" type contains a continuum of measure one of individuals. The measure of firms is equal to the measure of risky households. Thus we can envision a representative firm interacting with mass one members of a representative risky household. The price of the consumption good is normalized to one in each period. The quantity of housing is normalized to one. The riskless type of household is measure zero, but its presence will establish a floor for asset prices. The economy is closed.

Let s_t denote the current state of the economy, and s^t denote the history up to date t. In each period, households of the risky type send out members to buy consumption and to look for jobs. Employment opportunities are randomly allocated across household members, but assets must be allocated across members before labor market outcomes are realized. It is therefore optimal to give each member an equal fraction $h(s^{t-1})$ of the assets the household carries in the period. The household can give its members consumption and savings instructions that are contingent on their labor market outcomes. The fraction $1 - u(s^t)$ of household members who find a job are paid a wage $w(s^t)$ and use wage income and asset holdings to pay for consumption $c^w(s^t)$. The fraction $u(s^t)$ who are unemployed can only use wealth and (potentially) unemployment benefits to pay for consumption $c^u(s^t)$.

At the end of the period the household regroups and pools resources, which determines the quantity of the asset carried into the next period $h(s^t)$. 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.

At the start of each period t households observe s_t, update s^t, and assign probabilities to future sequences $\{s_\tau\}_{\tau=t+1}^{\infty}$. We assume that all households form the same expectations.

Preferences for a household are given by

$$\sum_{t=0}^{\infty} \beta^t \sum_{s^t} \pi(s^t) \left[(1-u(s^t)) \log c^w(s^t) + u(s^t) \log c^u(s^t) + \phi h(s^{t-1}) \right].$$

where β is the discount factor, $\pi(s^t)$ is the probability of history s^t as of date 0, and ϕ is a parameter determining the utility from housing.

The household budget constraints for a risky household have the form:

$$\left[1-u(s^t)\right] c^w(s^t) + u(s^t) c^u(s^t) + p(s^t) \left[h(s^t) - h(s^{t-1})\right] \leq \left[1-u(s^t)\right] \left[w(s^t) - T(s^t)\right] + u(s^t) b \quad (1)$$

$$c^u(s^t) \leq p(s^t) h(s^{t-1}) + b \quad (2)$$

$$c^w(s^t) \leq p(s^t) h(s^{t-1}) + w(s^t) - T(s^t) \quad (3)$$

$$c(s^t), h(s^t) \geq 0$$

The left hand side of 1 captures total household consumption and the cost of net asset purchases. The first term on the right hand side is earnings for workers $w(s^t)$ less payroll taxes $T(s^t)$, while the second is unemployment benefits members who do not find a job. Note that $h(s^{t-1})$ was effectively chosen in the previous period. In the current period, given aggregate variables $u(s^t)$, $w(s^t)$ and $p(s^t)$, the choices for $c^w(s^t)$ and $c^u(s^t)$ implicitly define the quantity of wealth carried into the next period $h(s^t)$. Equation 2 is the constraint that limits consumption of unemployment members to wealth plus unemployment benefits. Equation 3 is the analogous constraint for workers.

The budget constraint for the riskless household is identical, except that unemployment and transfers for this type are equal to zero.

The government balances its budget period by period, using payroll taxes on workers to finance unemployment benefits b and (possibly) government spending G :

$$\left[1-u(s^t)\right]T(s^t)=u(s^t)b+G.$$

2.1 Household's problem

Consider the problem for the type that faces unemployment risk. Let $\mu(s^t)$ denote the multiplier on 1 and let $\lambda(s^t)$ denote the multiplier on 2. We conjecture and later verify that the other constraints do not bind in equilibrium.

The first order conditions for $h(s^t)$, $c^w(s^t)$ and $c^u(s^t)$ are respectively

$$\begin{aligned}
p(s^t)\mu(s^t) &= \beta\sum_{s^{t+1}}\pi(s^{t+1}|s^t)\left[p(s^{t+1})\mu(s^{t+1})+p(s^{t+1})\lambda(s^{t+1})\right]+\beta\phi \\
\frac{1}{c^w(s^t)} &= \mu(s^t) \\
\frac{u(s^t)}{c^u(s^t)} &= \mu(s^t)u(s^t)+\lambda(s^t)
\end{aligned}$$

Combining these gives

$$\frac{p(s^t)}{c^w(s^t)}=\beta\sum_{s^{t+1}}\pi(s^{t+1}|s^t)\left[\frac{p(s^{t+1})}{c^w(s^{t+1})}+p(s^{t+1})\left(\frac{1}{c^u(s^{t+1})}-\frac{1}{c^w(s^{t+1})}\right)u(s^{t+1})\right]+\beta\phi$$

where

$$c^u(s^{t+1})=\begin{cases} c^w(s^{t+1}) & \text{if } \; c^w(s^{t+1})\le p(s^{t+1})h(s^t)+b \\ p(s^{t+1})h(s^t)+b & \text{if } \; c^w(s^{t+1})> p(s^{t+1})h(s^t)+b \end{cases}$$

Alternatively,

$$\frac{p(s^t)}{c^w(s^t)}=\beta\sum_{s_{t+1}}\pi(s_{t+1}|s^t)\left[\frac{p(s^{t+1})}{c^w(s^{t+1})}\left(1+\frac{u(s^{t+1})\max\left\{c^w(s^{t+1})-\left[p(s^{t+1})h(s^t)+b\right],0\right\}}{p(s^{t+1})h(s^t)+b}\right)\right]+\beta\phi$$

This first order condition can be interpreted as follows. The cost of buying an additional unit of housing is the price times the marginal utility of consumption for a worker. The return is the discounted utility flow $\beta\phi$ plus the next period price times next period marginal utility plus an additional term that regulates the liquidity value of additional wealth in the next period. This liquidity value is proportional to the unemployment rate – which captures the number of household members who will value extra liquidity – times the difference in consumption for employed versus unemployed workers – which captures the value of being to allocate consumption more evenly across household members. When either the unemployment rate is zero, or when the borrowing constraint is non binding for unemployed workers – so that employed and unemployed members enjoy equal consumption – this liqudity term drops out, and the inter-temporal first-order condition takes the usual representative agent form. Conversely, when there is a positive probability of unemployment at $t+1$ and when workers consume more than the unemployed, the incentive to save is larger the higher are expected unemployment rates, and the lower is household wealth.

The analogous first order condition for the type that does not face unemployment risk is

$$\frac{p(s^t)}{\hat{c}^w(s^t)} \geq \beta \sum_{s_{t+1}} \pi(s_{t+1}|s^t) \frac{p(s^{t+1})}{\hat{c}^w(s^{t+1})} + \beta\phi$$

where hats denote allocations for this type. The inequality here reflects the fact that, given the preferences we will assume below, the type facing no unemployment risk will be at a corner in equilibrium, with zero housing.

2.2 Production and Labor Markets

Each representative firm produces according the following linear technology:

$$y(s^t) = n(s^t)$$

where $n(s^t)$ is the mass of workers employed by the representative firm. In equilibrium $u(s^t) = 1 - n(s^t)$. We now describe how equilibrium employment is determined.

Households first observe the aggregate state s_t and then give workers instructions about what wages to accept, i.e. they specify a reservation wage $w^*(s^t)$. Firms and workers meet in a decentralized labor market. A unit mass of workers meets each firm, where these meetings occur in a random sequence throughout the period. Each firm takes as given the wage $w^*(s^t)$, the price at which it can sell output (normalized to one), and decides whether or not to hire each successive worker it meets. When a firm hires a worker it produces and sells the resulting output immediately.

The optimal strategy for the firm in this environment is to employ a worker if and only if the worker's reservation wage $w^*(s^t)$ is less than or equal to the worker's marginal product $z(s^t)$. Understanding the firms' incentives, a representative household will optimally assign its members a reservation wage $w^*(s^t) = 1$. Recall that a lower reservation wage does not increase the probability that a given household member will find a job, while a higher reservation wage would guarantee non-employment.

Note that households make consumption decisions and firms make production plans given the same information set and identical expectations.

2.3 Equilibrium

In some versions of the model, the (constant) preference for housing ϕ will be sufficient statistics for all aggregate variables. In other versions, sunspot-driven fluctuations in expectations will generate non-fundamental driven movements in consumption and house prices. Thus we define the current aggregate state of the economy $s_t = (z_t, \phi_t, c_t, p_t)$. [REVISIT THIS] The distribution of housing wealth does not appear because we will focus on equilibria in which all housing is owned by the risky household type, and in which each risky household is representative. (In Section XX we will consider an example in which the distribution of wealth between types is allowed to vary). A symmetric equilibrium in this model is a pair of policy parameters (G, b), a process for s_t and associated decision rules and prices $n(s^t)$, $u(s^t)$, $c^w(s^t)$, $c^u(s^t)$, $w(s^t)$, $h(s^t)$, $p(s^t)$, $T(s^t)$ that satisfy, for all t and for all s_t :

1.
$$w(s^t) = w^*(s^t) = 1$$

2.
$$n(s^t) = 1 - u(s^t)$$

3.
$$h(s^t) = 1$$

4.
$$[1 - u(s^t)]c^w(s^t) + u(s^t)c^u(s^t) + G = 1 - u(s^t)$$

5.
$$\left[1 - u(s^t)\right] T(s^t) = u(s^t)b + G.$$

6.
$$c^u(s^t) = \min\left\{c^w(s^t), p(s^t)h(s^{t-1}) + b\right\}$$

7.
$$\frac{p(s^t)}{c^w(s^t)} = \beta \sum_{s_{t+1}} \pi(s_{t+1}|s^t) \left[\frac{p(s^{t+1})}{c^w(s^{t+1})} \left(1 + \frac{u(s^{t+1}) \max\left\{c^w(s^{t+1}) - \left[p(s^{t+1})h(s^t) + b\right], 0\right\}}{p(s^{t+1})h(s^t) + b}\right)\right] + \beta\phi$$

8.

$$\frac{p(s^t)}{1-T(s^t)} \geq \beta \sum_{s^{t+1}} \pi(s^{t+1}|s^t) \frac{p(s^{t+1})}{1-T(s^{t+1})} + \beta\phi$$

2.4 Discussion

In a symmetric equilibrium, each firm employs sufficient workers to satisfy demand: $n(s^t) = c(s^t)$. Thus, in this environment, the consumption order $c(s^t)$ determines employment $n(s^t)$ and unemployment $u(s^t) = 1 - n(s^t)$. If orders fall short of potential output, i.e., if $c(s^t) < 1$, then labor supply will exceed labor demand, in the sense that all measure 1 of workers in each household are willing to work at any positive wage, while employment is determined by labor demand $n(s^t) = c(s^t) < 1$.

In this environment, firms are on their labor demand curve. However, no single atomistic household has an incentive to choose a lower reservation wage, because a lower wage will not increase the probability of its members forming successful matches. Thus unemployment does not exert downward pressure on wages, breaking the standard Walrasian adjustment process that ultimately equates labor demand and labor supply in models with frictionless labor markets.

Equation (8) indicates that the presence of the riskless type whose consumption is $\hat{c}(s^t) = 1 - T(s^t)$ puts a floor under house prices.[2]

3 Steady States

We begin by considering a version of the model in which the government plays no role, so that $b = G = T(s^t) = 0$.

Steady states are solutions (c^w, c^u, u, p) to the following equations

$$\frac{p}{c^w} = \beta \left[\frac{p}{c^w} \left(1 + \frac{u \max\{c^w - p, 0\}}{p} \right) \right] + \beta\phi$$

$$[1-u]c^w + uc^u = 1 - u$$

$$c^u = \min\{c^w, p\}$$

$$p \geq \underline{p} = \frac{\beta}{1-\beta}\phi$$

[2]Note that with $h(s^t) = 1$ the inter-temporal first order condition for the risky household type (equation 7) would be identical if preferences were given by $u(c, h, \phi) = \log c + \phi \log h$. Thus it is sufficient to assume linearity in preferences for the riskless type.

where the last expression is the asset price floor established by the presence of the riskless household type.

Proposition: Any steady state with positive unemployment must feature limited risk sharing: $u > 0 \Longrightarrow c^w > c^u$.

Proof: Suppose, contrary to the claim, that $u > 0$ and $c^w = c^u$. Then the price that solves the inter-temporal FOC would be

$$p = p_F(u) = \frac{\beta\phi}{1-\beta}(1-u) < \underline{p} \tag{4}$$

where $p_F(u)$ is the "fundamental" steady state price given u. But $p < \underline{p}$ contradicts $p \geq \underline{p}$ which must hold in any steady state.

The logic for this result is that in any steady state with positive unemployment, expected individual consumption is less than one. If each household member consumed expected individual consumption, the equilibrium price of housing would fall below the price the riskless household is willing to pay (whose expected consumption is higher). It must therefore be that housing has additional value as a source of liquidity for the risky household type. This in turn implies that in steady state unemployed agents must be consuming less than employed households, so that the additional liquidity associated with housing wealth is priced.

Proposition: If $\phi \geq \tilde{\phi} \equiv \frac{1}{2}\sqrt{\left(\frac{4}{\beta} - 3\right)} - \frac{1}{2}$, then the only possible steady state is $p = \underline{p}$, $u = 0$. If $\phi < \tilde{\phi}$ then there exists a range of values for $p \geq \underline{p}$ such that for any p in this range there are two steady state values for u. For $p = \underline{p}$ one of these steady states features positive unemployment. For $p > \underline{p}$ both of these steady states feature positive unemployment.

Proof:

From the pricing equation for the riskless type, $p \geq \underline{p} = \frac{\beta\phi}{1-\beta}$. Thus there can be no steady states with $p < \underline{p}$.

From the previous proposition, if there is an equilibrium with $u > 0$, then unemployed agents are constrained. Thus $c^u = p$ and $c^w = 1 - \frac{u}{1-u}p$.

The first order condition for the risky household is therefore

$$\frac{p}{1-\frac{u}{1-u}p} = \beta\frac{p}{1-\frac{u}{1-u}p}\left[1 + \frac{u\left(1-\frac{u}{1-u}p - p\right)}{p}\right] + \beta\phi$$

which simplifies to deliver the following equilibrium relation between steady state u and p :

$$p(u) = \frac{\beta\left(u+\phi\right)}{(1-\beta)+\frac{\beta u(1+\phi)}{1-u}} \tag{5}$$

Note that at $u=0$, this relation implies $p=\underline{p}$, so that is always a steady state.

Using the expression above, we can explore how p varies with u.

$$\frac{\partial p}{\partial u} \propto -\left(2u+\beta-2u\beta+\beta\phi+2u^2\beta+\beta\phi^2-u^2+u^2\beta\phi-1\right)$$

Now it is immediate that at $u=0$

$$\left(\frac{\partial p}{\partial u}\right)_{|\ u=0} = \begin{cases} >0 & \text{for} \quad \phi<\tilde{\phi} \\ 0 & \text{at} \quad \phi=\tilde{\phi} \\ <0 & \text{for} \quad \phi>\tilde{\phi} \end{cases}$$

Now turn to the second derivative:

$$\frac{\partial^2 p}{\partial u^2} \propto u+\beta-2u\beta-u\beta\phi-1$$

It is immediate that $\beta>0.5$ is a sufficient condition for the second derivative to be negative, and thus for p to be a concave function of u.

Combining these two results, it follows that for $\beta>0.5$ and $\phi\geq\tilde{\phi}$, the value for p that satisfies the risky type's first-order condition is decreasing in u. Thus $p\leq\underline{p}$

But then for $\phi\geq\tilde{\phi}$, we have $p\geq\underline{p}$ (from the FOC for the riskless type) and $p\leq\underline{p}$ (from the FOC for the risky type). It follows that $p=\underline{p}$ and $u=0$ is the only steady state.

If $\phi<\tilde{\phi}$ then $\frac{\partial p}{\partial u}>0$ at $u=0$. Since p is a continuous and concave function of u, and since $p=0$ at $u=1$ there must be a second steady state at $p=\underline{p}$ with $u>0$.

This unemployment rate is given by

$$u^{+} = 1-\frac{\beta}{1-\beta}\phi(1+\phi) \tag{6}$$

By similar reasoning, there is a range of values for $p>\underline{p}$ such that given $\phi<\tilde{\phi}$ there are two steady states with positive unemployment.

Note that the uniqueness result with $\phi\geq\tilde{\phi}$ hinges on the presence of the riskless household type. Without this type, there would be a continuum of steady states with unemployment rates

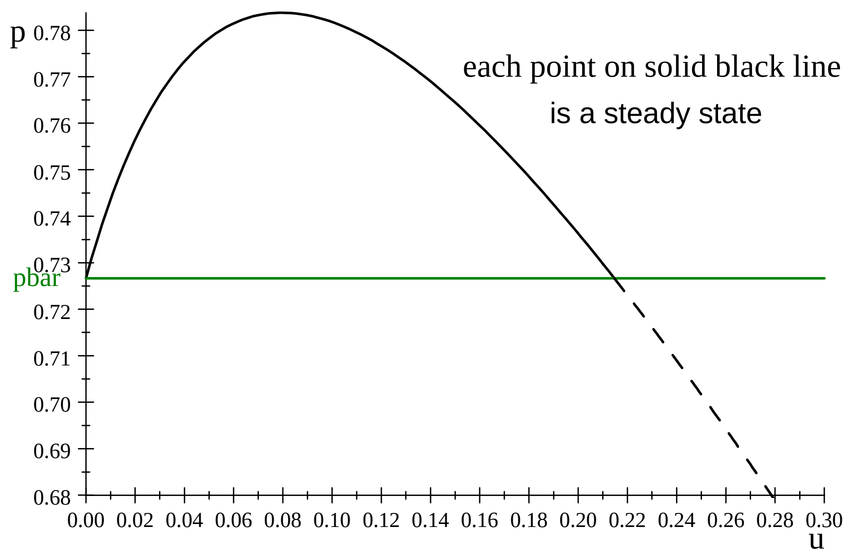

Figure 3: Steady states for $\beta = 0.9$, $\phi = 0.8 \times \tilde{\phi}$.

between zero and one, with each unemployment rate corresponding to a different steady state asset price as given by eq. 4 (see Farmer 2010). The presence of the riskless type puts a floor on the asset price, which effectively establishes a floor for steady state consumption demand and output.

Example Figure 3 describes the set of steady states for a particular parameterization of the model. In this example $\beta = 0.9$ and $\phi = 0.8 \times \tilde{\phi}$. Thus $\phi < \tilde{\phi}$ ensuring, by virtue of Proposition 2 that there are multiple states. In this example, at $p = \underline{p}$ there are two possible steady state unemployment rates: $u = 0$ and (from eq. 6) $u = 0.215$.

The green horizontal line in Figure 3 is $p = \bar{p}$, and each point on the hump-shaped solid black line is a steady state. Points on the dashed black line are not steady states, because they correspond to values for p below the lower bound $\bar{p}$ established by the marginal investor. Note that for $p > \bar{p}$, if steady states exist, the two steady state unemployment rates are closer together the larger is p.

Note that it is straightforward to decompose steady state house prices into fundamental and liquidity components. In particular, the liquidity value of housing, given a steady state unemployment rate u can be defined as the equilibrium price (eq. 5) minus the fundamental component (eq.

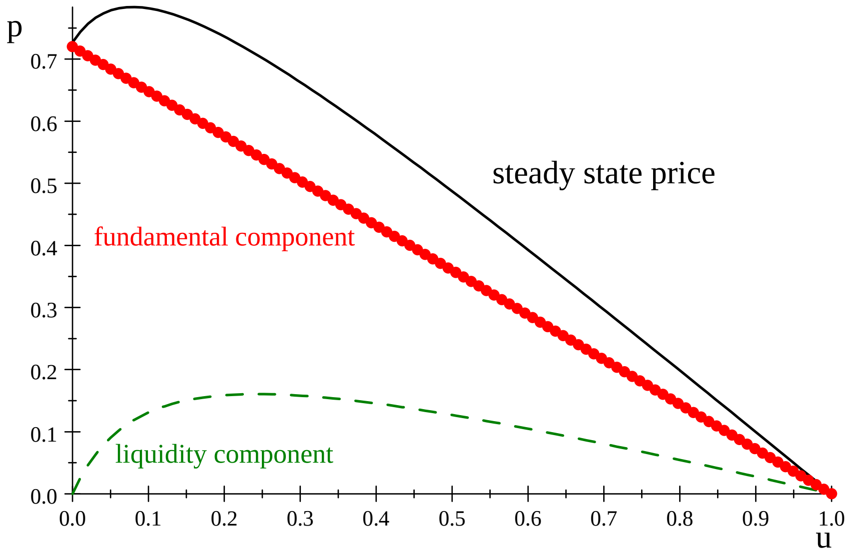

Figure 4: Steady State Price Decomposition

??):

$$p_L(u) = \frac{\beta\,(u+\phi)}{(1-\beta)+\frac{\beta u(1+\phi)}{1-u}} - \frac{\beta\phi}{1-\beta}(1-u) \tag{7}$$

It is straightforward to verify that at $u = 0$, the liquidity value for housing is increasing in the unemployment rate, given $\phi \leq \tilde{\phi}$. It is also clear that the liquidity value shrinks to zero as $u \to 1$.

Figure **??** shows the steady state house price along with its fundamental (red) and liquidity (green) components, for the parameterization described above.

It is straightforward to explain the logic for the existence of multiple steady states with these figures in hand. Suppose we start with $p = \underline{p}$ and $u = 0$, and consider how the steady state asset price changes in response to a marginal increase in unemployment. On the one hand, higher unemployment reduces expected income, reducing fundamental housing demand and the fundamental component of the price $p_F(u)$. On the other hand, increasing unemployment raises the liquidity value, $p_L(u)$, since the household has a stronger incentive to accumulate housing as an asset that members can use to consumption smooth through unemployment spells. For $\phi < \tilde{\phi}$, the liquidity effect initially dominates, and a marginal increase in unemployment (starting from $u = 0$) necessitates an increase in the steady state asset price. But for high enough unemployment rates, the fundamental effect comes to dominate, so that the steady state price becomes a declining function of u, and there is a second equilibrium at $p = \underline{p}$ with $u > 0$.

In the no unemployment steady state wealth is low relative to consumption, but the household does not want to increase saving because there is no unemployment risk – and thus no precautionary motive to save. In the high unemployment equilibrium, unemployment risk is high, but the household does not want to increase saving further because wealth is already high relative to consumption.

For $p > \underline{p}$, if steady states exist, then in the low unemployment equilibrium the fundamental share of house value is higher (and the liquidity share lower) than in the high unemployment equilibrium.

4 Dynamics

We now want to consider dynamics. Suppose that $p(s^t) = p > \underline{p}$. We will maintain the assumptions $b = G = T(s^t) = 0$.

The resource constraint at s^t is

$$[1 - u(s^t)]c^w(s^t) + u(s^t)c^u(s^t) = 1 - u(s^t)$$

To maximize risk-sharing within the household, the household will set

$$c^u(s^t) = \min\left\{c^w(s^t), p\right\}$$

so

$$[1 - u(s^t)]c^w(s^t) + u(s^t)\min\left\{c^w(s^t), p\right\} = 1 - u(s^t)$$

$$u(s^t) = \frac{1 - c^w(s^t)}{\min\left\{c^w(s^t), p\right\} + 1 - c^w(s^t)}$$

The inter-temporal FOC is (imposing $p(s^t) = p$ and $h(s^t) = 1$)

$$\frac{p}{c^w(s^t)} = \beta \sum_{s_{t+1}} \pi(s_{t+1}|s^t)\left[\frac{p}{c^w(s^{t+1})}\left(1 + \frac{u(s^{t+1})\max\left\{c^w(s^{t+1}) - p, 0\right\}}{p}\right)\right] + \beta\phi$$

If unemployed workers are always wealth-constrained, so that $c^w(s^t) > c^u(s^t) = p$, then the

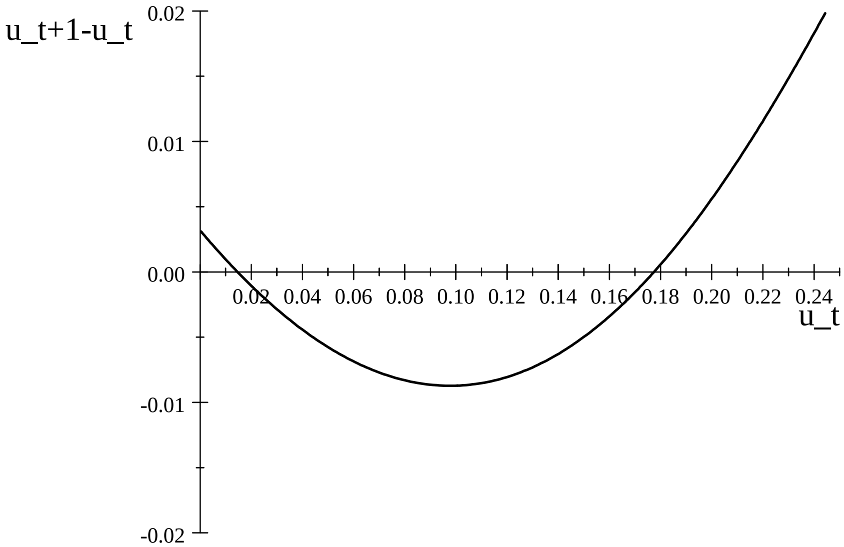

Figure 5: Deterministic Dynamics

first-order condition simplifes to

$$\frac{p}{c^w(s^t)} = \beta \sum_{s_{t+1}} \pi(s_{t+1}|s^t) \left[\frac{p}{c^w(s^{t+1})} \left(1 + \frac{u(s^{t+1})\left(c^w(s^{t+1}) - p\right)}{p} \right) \right] + \beta\phi$$

where

$$c^w(s^t) = 1 - \frac{u(s^t)p}{1 - u(s^t)}$$

Deterministic Dynamics We now plot the dynamics for unemployment given a particular initial condition, assuming no uncertainty, and assuming $\beta = 0.9$, $\phi = 0.8\tilde{\phi}$ and $p = 0.75$.

Figure 5 plots the change in the unemployment rate $u_{t+1} - u_t$ against the unemployment rate u_t. The two points at which the change in the unemployment rate is zero correspond to the two steady state unemployment rates at $p = 0.75$. Denote these rates $u_L(p)$ and $u_H(p)$. The figure indicates that for any initial unemployment rate below the high unemployment steady state, unemployment will gradually converge, over time, to the low unemployment rate steady state. Thus the low unemployment steady state is locally dynamically stable: if unemployment starts out below u_L, unemployment will rise, while if it starts above u_L (but below u_H) unemployment will fall. Because this steady state is dynamically stable, we can introduce sunspot shocks that will generate fluctuations in the neighborhood of u_L.

The high unemployment steady state is not stable. If unemployment starts above u_H, it will increase towards maximum unemployment, in expected terms. Note that any such paths are not equilibria, because in the limit they imply that households will end up with zero income and consumption, which cannot be optimal given positive wealth.

Two State Sunspot Equilibra We now construct two-state Markov sunspot equilibrium, in which asset prices are constant, and the unemployment rate bounces between zero and a positive value. We assume a symmetric process, so that the probability of unemployment being low (high) in the next period given that it is low (high) today is λ. Thus this is now a three parameter model, where the parameters are β, ϕ and λ. Let u_R denote the unemployment rate in the bad (recession) state. In the good (boom) state, $c_R^w = 1$. In the bad state, $c^w = c_R$ where c_R denotes workers' consumption in the recession state.

Given (β, ϕ, λ) these are three equations in three unknowns (p, c_R, u_R). There is a two state sunspot equilibrium with the desired properties if there is a solution to this system of equations that satisfies $u_R \in (0, 1]$, $p \geq \underline{p}$ and $c_R > p$.

We start by fixing β and ϕ, and asking: for what values for λ does a sunspot equilibrium exist.

The inter-temporal first-order conditions in the good and bad states are, respectively,

$$\begin{aligned} p &= \beta\lambda p + \beta(1-\lambda)\left(\frac{(1-u_R)p}{c_R} + u_R\right) + \beta\phi \\ \frac{p}{c_R} &= \beta\lambda\left(\frac{(1-u_R)p}{c_R} + u_R\right) + \beta(1-\lambda)p + \beta\phi \end{aligned}$$

Worker's consumption in the recession state are given by

$$u_R = \frac{1-c_R}{1-c_R+p}$$

Solving this system of equations gives the following relationship between the persistence parameter λ, and the unemployment rate in the recession state.

Three points to make from the theory section

1. You can only get sunspot driven fluctuations when the value of wealth is low
2. All sunspot type recessions must be pretty persistent in expected terms
3. Within the class of sunspot recessions, the worse the recession, the more persistent it will be
4. Two states sunspot cycles that are arise with low prices (low wealth) are more volatile (Wealth and Volatility)

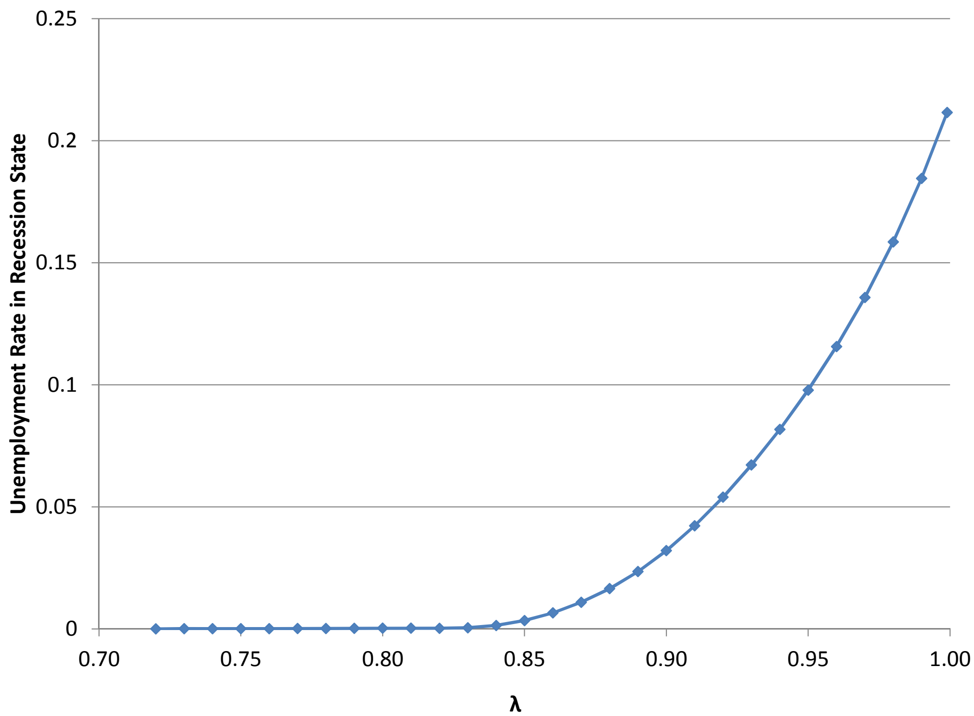

Figure 6: Larger Recessions are More Persistent

5 Review: Asset Prices and Volatility

Recall that the starting point for this paper is the strong positive empirical correlation between the level of US household wealth and US macroeconomic volatility. We now collect together the various theoretical results we have established corresponding to the relationship between asset prices and output:

1. First, if the taste for housing is strong ($\phi \geq \bar{\phi}$) or if credit is cheap ($\psi \leq \bar{\psi}$) then the only equilibrium is permanent full employment.

2. Second, if the taste for housing is weak ($\phi < \bar{\phi}$) so that home equity is inadequate to finance consumption of the unemployed and if, in addition, credit is expensive ($\psi > \bar{\psi}$) then the model has two steady states for the same house price p. The unemployment rate in the high unemployment steady state u_H is decreasing in p.

3. Third, given low house prices and expensive credit, and absent expectational errors, for any possible steady state price $p \geq \underline{p}$, the set of equilibria is as follows. First, for any initial unemployment rate $u_0 \in [0, u_H)$ there is an equilibrium path in which the unemployment rate steadily converges to u_L. Second, there is an equilibrium in which the unemployment rate is initially u_H and remains always at u_H.

4. Fourth, because the low unemployment steady state is dynamically stable, non-fundamental sunspot shocks can generate fluctuations in unemployment. Thus for any $p \geq \underline{p}$ and any $u_t \in [0, u_H)$ sunspot shocks can move the economy to any $u_{t+1} \in [0, u_H)$ (in expected terms unemployment evolves according to **??**).

5. Finally, combining points 1, 2 and 4 and assuming costly credit, the range of equilibrium unemployment rates $[0, u_H)$ is decreasing in the steady state house price p. For high enough p (i.e. $\phi \geq \bar{\phi}$) the only possible unemployment rate is $u = 0$. For lower values for p (i.e. $\phi < \bar{\phi}$) unemployment can fluctuate between 0 and u_H. Moreover, since u_H is declining in p the range of equilibrium unemployment rates and thus the maximum size of sunspot shocks, is decreasing in p.

6 Microeconomic evidence

As discussed above, when wealth is low demand (and hence output) in our model can fall in response to a negative shock to expectations. Low wealth implies a strong precautionary motive and this leads to a large consumption fall in response to higher perceived unemployment risk, thereby making the expectation of higher unemployment self-fulfilling.

Consider in particular two households, one with low wealth and the other with high wealth, which face the same increase in unemployment/income risk. Our theory suggests that the low wealth household should decrease its consumption more than the high wealth household.

In this section we present some direct evidence for the first part of this mechanism using micro data from the Consumer Expenditure (CE) Survey and the Panel Study of Income Dynamics (PSID).

6.1 Consumer Expenditure Survey

The CE Survey contains information on household-level wealth, expenditures and income. Households in the CE survey are interviewed for a maximum of four consecutive quarters. Households report consumption expenditures in all four interviews, report income information in the first and last interview, and report wealth information in the last interview only. We use CE data from the first quarter of 2005 to the first quarter of 2011 and we select households for which we have four consumption expenditure observations, two income observations and one wealth observation.

The goal is to compare changes in consumption expenditures during the course of the Great Recession for wealth rich versus poor households, controlling for potentially different income trends across the groups. It is important that we measure changes in expenditures using the same households, rather than comparing the average consumption of different sections of the wealth distribution at different points of time, as changes in moments of the cross sectional distribution might reflect changes in composition of the cross-sections and not actual changes in expenditures. To measure actual expenditure changes we exploit the limited panel dimension of the CE survey.

In particular, we first rank households in each survey quarter by net worth relative to average quarterly consumption expenditure, which we use as a proxy for permanent income. Net worth here includes net financial wealth plus housing wealth net of all mortgages (including home equity loans). We then construct two wealth groups in each month of the survey, using the median as the break-point. We compute aggregate nine-month consumption (income) growth for each

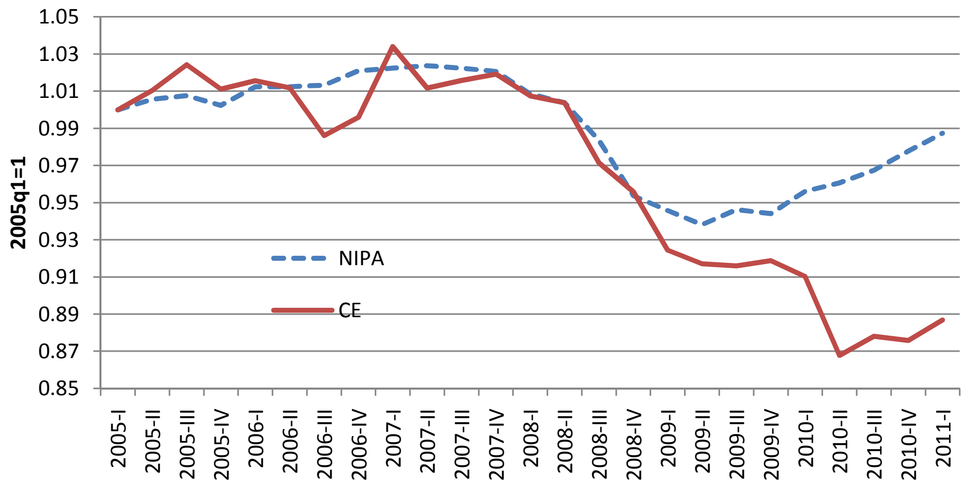

Figure 7: Aggregate real consumption expenditures per capita

group as the difference between aggregate 4th interview consumption (income) less aggregate 1st interview consumption (income). Note that we are using the exact same set of households to measure consumption and income growth. Finally we using a standard weighting scheme to convert these observations on monthly growth rates to a quarterly frequency, assuming constant growth between interview dates.

Before comparing changes in expenditures across groups, we compare aggregate consumption in our CE sample to a conceptually-similar definition of consumption from the National Income and Product Accounts (NIPA). In particular we take aggregate NIPA consumption expenditure minus the following categories: housing and utilities, health care, and financial services.[3]. Figure 7 compares the CE and NIPA series, both of which are real, per-capita measures. The timing and depth of the Great Recession are broadly similar across the two measures, although the extent of the recovery in expenditures is much weaker in the CE than in NIPA.

Table 1 reports some characteristics of the two groups. First the table indicates that with respect to demographics the wealth poor group appears to be composed by younger, less educated and poorer (in terms of income) households. The table also shows that the differences in average net worth across the different groups are large: the median per capita household wealth in the poorest group is close to 0 while the corresponding value for the rich group quartile exceeds 60000 2005 dollars.

[3]We exclude the categories for which the matching of the CE with NIPA is particularly poor

Most important though, for our purposes, is the comparison of income and consumption growth for the groups. The table shows that although the wealth poor experience a slightly stronger income growth than the wealth rich, they experience a substantially stronger reduction in consumption expenditures (-5.6% v/s -3.1%). We view this as *prima-facie* evidence that the level of wealth is a major factor, independent from income, in determining demand response in a turbulent time.

Table 1. Characteristics of two wealth groups, 2005.1-2011.1

	Wealth Group	
	0-50	50-100
Sample size	8864	8873
Average age of head	41.4	46.9
Percent of heads with college	25.7	40.5
Average household size	2.9	2.8
Per capita real net wealth (2005$)		
Mean	1498	119796
Median	238	63162
Average per capita after tax income (2005$)		
Level	22117	32811
Growth rate	-0.3%	-1.0%
Average per capita consumption expenditures (2005$)		
Level	9353	11252
Growth rate	-5.6%	-3.1%

We analyze the issue in more detail as figure 8 plots (annualized) growth rates of per capita real consumption for each of our four wealth groups from the 4th quarter of 2005 through the 1th quarter of 2011 while figure 9 plots the change in consumption rates (i.e. consumption expenditure over after tax total income) for the two groups. These 2 figures tell a clear story. The first suggests that the the wealth-poor group reduced consumption sooner and most periods more sharply than the wealth rich. The second suggests that the relative reduction in consumption expenditures of the wealth poor throughout the recession is not just driven by a poor relative income growth by the wealth poor but rather by an increasing saving (reduced consumption rate). Our theory suggests that this increase in relative saving rate of the wealth poor is the result of the strengthening of their precautionary motive to save, in response to higher unemployment risk.

6.2 Panel Study of Income Dynamics

The PSID is a panel of US households, selected to be representative of the US population, collected at a bi-annual frequency. Most importantly for our purposes starting in 2004 the PSID report, for every household in the panel information on income, wealth and comprehensive consumption

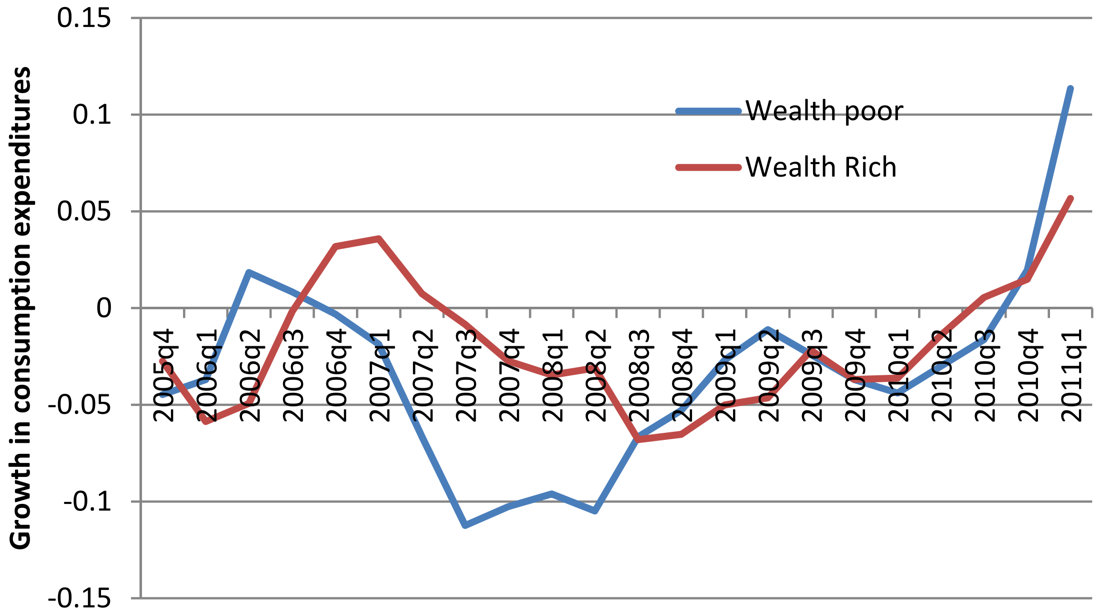

Figure 8: Growth in consumption expenditures for rich and poor

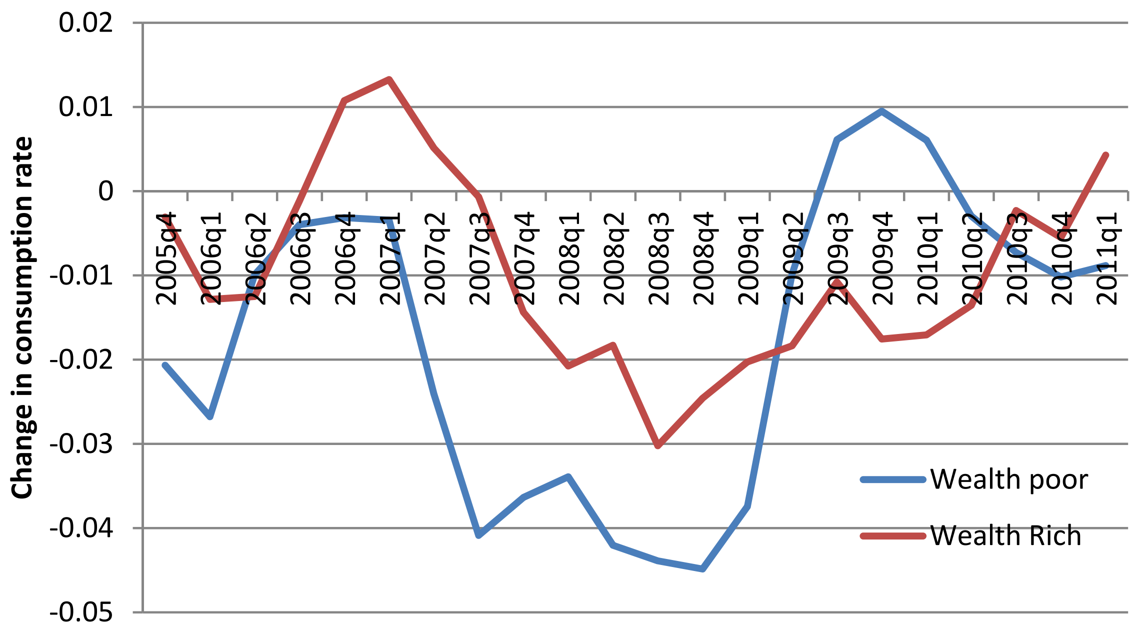

Figure 9: Changes in consumption rates for rich and poor

expenditures. Our panel includes all households which have at least one member aged between 22 and 60, which report yearly consumption expenditures of at least $ 1000, and which are in the panel continuously from 2004 to 2010. In table 2 we report the statistics of interest for the Great recession period. In particular in 2006 and in 2008 we divide all households in the PSID sample in two groups, those with wealth to consumption ratio above the median and those with wealth to consumption ratio below it. The table shows that the differences in consumption behavior between the two groups are even more starker than in the CE. Over the period 2006-2008 the low wealth group reduced its consumption from 68% of its disposable income to 52%. By comparison the high wealth group only reduced from 46% to 43%.

	Low Wealth		High Wealth	
	2006	2006-2008	2006	2006-2008
Disposable Income	36600	+15%	73600	+6%
Consumption	24800	-13%	33600	-2%
Consumption Ratio	68%	-16%	46%	-3%
	2008	2008-2010	2008	2008-2010
Disposable Income	41200	+2%	77800	-2%
Consumption	22600	+3%	31600	+10%
Consumption Ratio	55%	+1%	41%	+5%

7 The Great Recession

The key characteristics of the Great Recession were a sharp fall in asset prices, accompanied by a sharp fall in spending, and a rise in unemployment. Since the recession officially ended in mid 2009, the subsequent recovery has been slow.

Figure 10 shows timepaths for (i) the price of net worth, (ii) durable consumption, and (iii) the unemployment rate over a five year period between the first quarter of 2007 and the last quarter of 2011.[4] Asset prices fall 30% relative to trend in the first two years of the sample, while durables consumption falls around 20%. Note that the fall in asset prices precedes the fall in consumer spending, which in turn leads the fall in the unemployment rate. Figure 11 shows price series for the two key components of net worth: house prices and stock prices. This figure shows that throughout 2007 house prices were already falling steadily relative to trend. In contrast, the fall in

[4] A nominal net return series for net worth is constructed from the Flow of Funds as household and non-profit sector holding gains on assets stated at market value (Table R100, line 9) divided by previous quarter net worth (Table B100, line 43). A price index is created from this series by deflating by the GDP deflator. The series plotted for the real price of net worth and real per-capita durable consumption are deviations from a constant 2.1% trend, the average growth rate of GDP per capita in the 1947-2007 period.

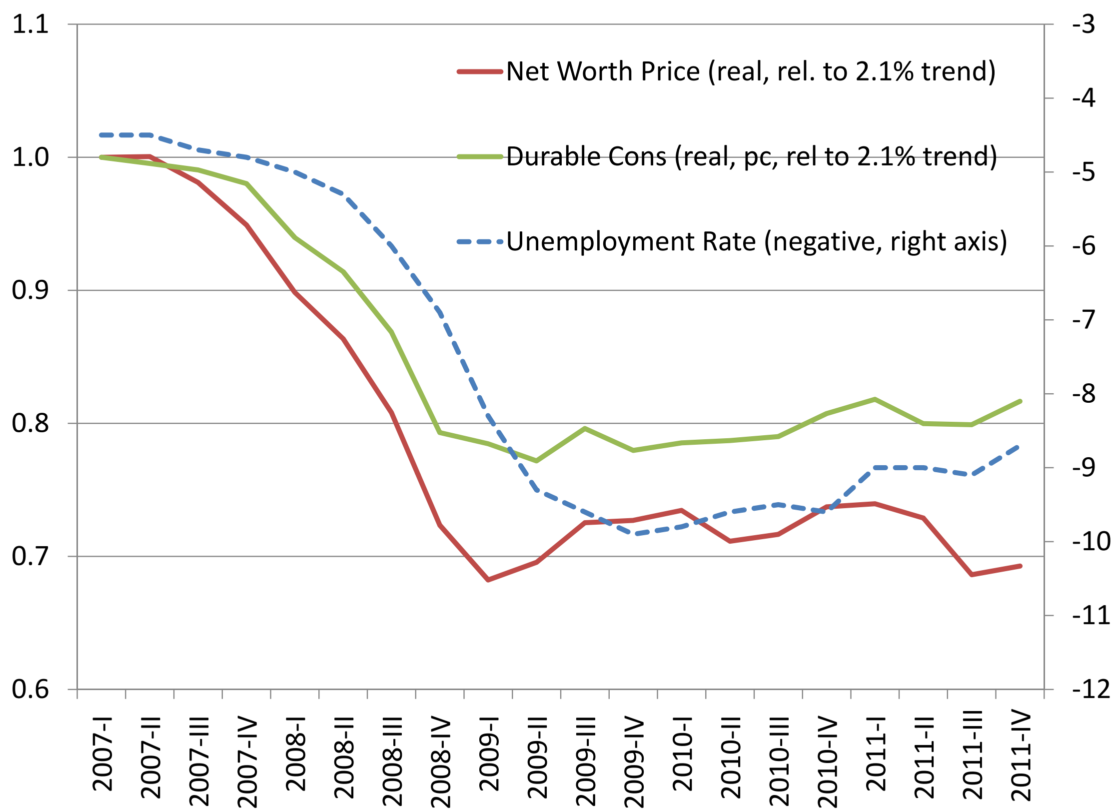

Figure 10: Asset prices, Consumption and Unemployment

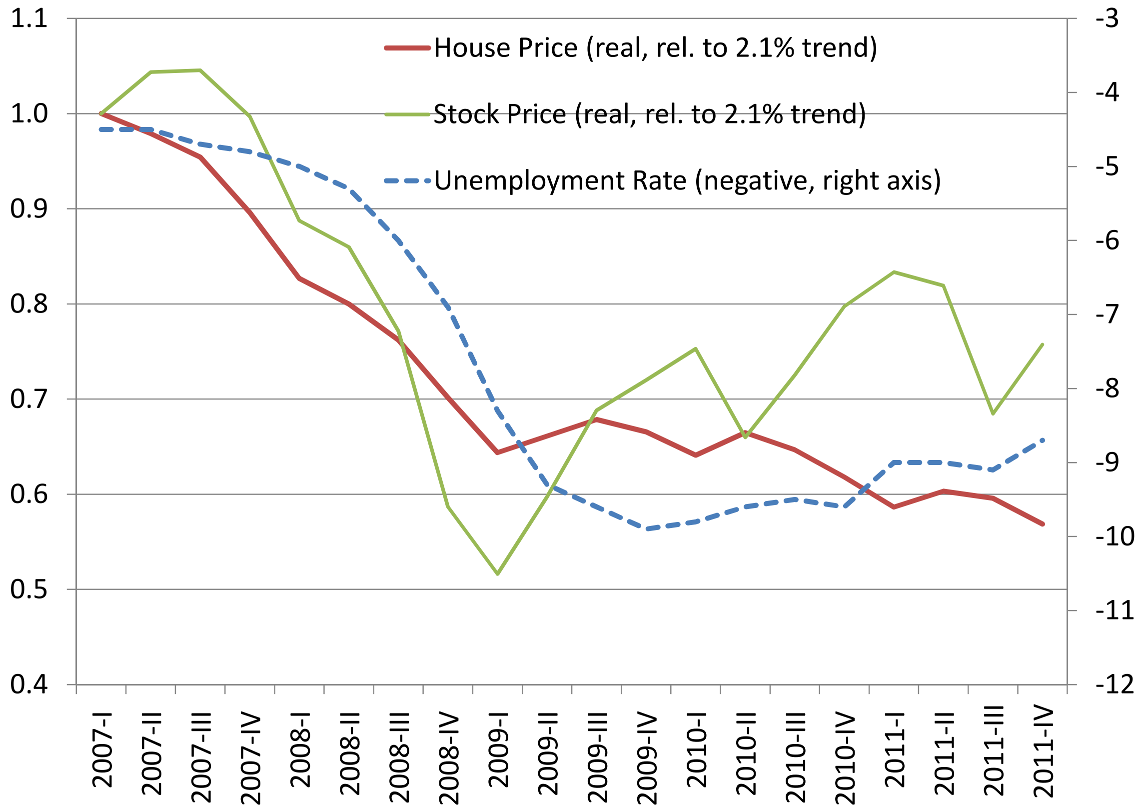

Figure 11: Housing prices, stock prices and unemployment

stock prices was concentrated in 2008, and the rise in unemployment between mid 2008 and mid 2009. Thus a sharp fall in house prices precedes the falls in consumer spending and the rise in unemployment. This fall in house prices drove the ratio of per capita home equity to per capita annual disposable income from a post-War high of 1.61 in the first quarter of 2006 to 1.19 by the fourth quarter of 2007, and to a post-War low of 0.70 by the end of 2011.

We now show that our model can generate dynamics that qualitatively resemble those described above. In the context of the model we interpret the events of the Great Recession as follows. Before 2006 the economy was robust in that the demand for housing was strong ($\phi > \bar{\phi}$) and thus there was no scope for expectations-driven cycles. Then, during 2006 and 2007, there was a fall in ϕ, the preference weight on housing, that left the economy fragile and vulnerable to a confidence-driven recession. In 2008 a negative aggregate confidence shock, perhaps triggered by the collapse of Lehman Brothers then led to a severe recession.

Figure 12: Model's prediction

Figure 11 shows the dynamics for a simulation of the model along the lines just described. At date $t = -6$ there is a permanent shock to preferences that reduces ϕ from its initial high value $\phi_0 > \bar{\phi}$ to a new lower value $\phi_1 = 0.05 < \bar{\phi}$. All other parameters are set to the same values as in the previous figures. From $t = -6$ onwards, we assume the equilibrium house price is constant at $p = 0.6$. Recall that at this price, instead of a unique full employment steady state, the model has two steady states, both with positive unemployment. To construct the figure, we assume that prior to date $t = 0$, the economy converges, with no surprises, towards the low unemployment steady state. Then, at $t = 0$, a one-off expectational shock generates a sharp fall in spending and an associated sharp rise in unemployment. Fearing high unemployment, households expect higher borrowing costs, and cut consumption orders to reduce credit costs. In aggregate this decline in demand does indeed translate into higher unemployment. After $t = 0$ the economy is hit by no further shocks, and the path for unemployment (the blue line) traces out the dynamics implied by Figure **??** below.

Note that in response to the negative sunspot shock, households cut back consumption, even though they expect positive income and consumption growth looking forward. Moreover, households have not experienced any loss in wealth (by assumption p is held fixed). The reason they nonetheless cut consumption is that higher unemployment risk generates a stronger precautionary motive to save. In fact this precautionary motive is so strong that positive expected consumption growth and an associated inter-temporal motive to dis-save is required to prevent a rise in house prices. After the sharp initial contraction, the economy gradually converges back towards the low unemployment steady state. In this recovery phase, the precautionary motive to save gradually declines, and so does expected income and consumption growth, such that the desired amount of household saving remains constant and equal to p.

8 Policy

TO BE ADDED

9 Conclusions

TO BE ADDED

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