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asset bubbles

by Christopher Phillip Reicher

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Keywords: Bubbles, fiscal theory of the price level, collateral constraints, neutrality, transversality conditions.

JEL classification: G12, E44, E51.

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On the neutrality of credit-driven asset bubbles

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Abstract:

This paper proposes and tests a theory of credit-driven asset bubbles which are neutral in their real effects. When a lender such as a government, central bank, or banking sector is willing to lend infinitely against collateral, explosive asset bubbles can form which exactly offset a bubble in household liabilities. Surprisingly, evidence from a VAR using long-run restrictions supports the idea that asset bubbles are approximately neutral in their real effects before 2007. The evidence becomes more ambiguous if one includes post-2007 data, hinting that the post-2007 degree of comovement between asset prices and output comes from an unusual regime.

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On the neutrality of credit-driven asset bubbles

1. Introduction

The major macroeconomic story of the past decade has been the worldwide housing bubble which peaked in 2006 and then crashed, the crash coinciding with a financial crisis and a large recession. Banks lent heavily to homeowners, who used their borrowings to bid up the price of real estate. This paper models rational explosive land bubbles as the counterpart of credit bubbles and shows that these bubbles should not affect economywide real wealth and therefore should be more or less neutral in their effects. Surprisingly, U.S. data before 2007 are broadly consistent with this story, while a sample which includes the post-2007 period shows an ambiguously positive relationship between long-run asset price appreciation and real activity. In other words, during normal times, asset bubbles are in fact neutral or close to neutral, while the late 2000s crisis seems to represent a departure from normal times. Something apart from the usual (non-)effects of asset price movements has led to the recent comovement between asset prices and real activity. These results lend support to the efforts by Kocherlakota (2009) and Wang and Wen (2009) to model financial distress during crises, though the mechanisms present in these models might not matter in more normal times.

There is already an extensive literature on rational explosive bubbles. Kocherlakota (1992) and Santos and Woodford (1997) discuss some of the conditions under which rational bubbles can form, where rational bubbles are defined as an expectation of continuing price rises into the infinite future. Abreu and Brunnermeier (2003), Kocherlakota (2008), and Hellwig and Lorenzoni (2009) have investigated the role of imperfect credit markets in allowing bubbles to form and persist. The problem with getting rational bubbles into standard equilibrium models with well-behaving credit markets is that people will try to arbitrage away bubbles by increasing the present value of their consumption and decreasing their asset holdings. Everybody cannot do this in the aggregate, so this should exert downward pressure on asset prices once a bubble forms, thus correcting the bubble. Introducing constraints on debt accumulation can make it impossible to arbitrage these bubbles away in those states where the bubble is at its most extreme, so rational bubbles can. There is also an active literature on rational nonexplosive bubbles in the presence of period-by-period collateral constraints following Kiyotaki and Moore (1997). This paper does not discuss those types of bubbles, which are interesting in their own right and might apply to crisis periods. Kocherlakota (2009) and Wang and Wen (2009) follow Kiyotaki and Moore's line of thinking.

This paper shows that it is in fact possible to get asset bubbles by throwing the "fiscal theory of the price level" into reverse even if credit markets are otherwise perfect. The logic is deceptively simple. Households borrow from the lending sector in order to finance consumption and land holdings, while

the lending sector does nothing but issue credit and pay dividends. When households can borrow against asset bubbles and lenders are willing to lend against them, then land may trade at a positive price. Households believe that the land could be sold for a higher value in the future, and they plan to use this land as collateral to borrow against. Since the rise in asset values is offset by an increase in household liabilities, the bubble does not affect total household wealth or relative prices and is thus neutral in its effects. Blanchard and Watson (1982) offer a good description of the behavior of these types of explosive bubbles in a partial equilibrium setting. This paper shows that these bubbles are an empirically relevant phenomenon in a general equilibrium setting, and it is difficult to reject the idea that asset bubbles are neutral during normal times. The rest of the paper lays out the basic model of bubbles and then discusses the empirical evidence supporting the claim that credit-driven bubbles are neutral.

2. Households in a simple model

Households belong to a continuum of households who can lend and borrow with each other and with the lending sector. They can do four things with their income: Buy land (L_{t+i}) which yields no dividends and is inelastically and exogenously supplied, buy nominally-indexed bonds (B_{t+i} for which positive values represent net lending by households and negative values represent net borrowing), eat a consumption good (C_t), and pay net lump-sum transfers to the lender (T_t) which would be analogous to taxes in a fiscal policy model. They fund these things through previous landholdings, previous bondholdings, and current income (Y_t) which is exogenous. All of the real allocations are bounded to grow at a rate less than the interest rate, thus ensuring finite asset prices.

The period by period budget constraint of each household is the usual one, with stocks denoted as beginning-of-period values. Consumers are never satiated over consumption so the constraint holds with equality:

$$\frac{B_t}{P_t} + P_t^L L_t + Y_t = P_t^L L_{t+1} + C_t + T_t + \frac{B_{t+1}}{R_{t,t+1} P_t}, \quad (1)$$

where P_t is the current price level, P_t^L is the real price of land; and $R_{t,t+i}$ is the gross nominal interest rate from t through $t+i$.

In equilibrium, land and bond prices must be priced according to a stochastic discount factor $\Lambda_{t,t+i}$ such that:

$$P_t^L = E_t \Lambda_{t,t+1} P_{t+1}^L,$$

and

$$E_t \frac{\Lambda_{t,t+1} R_{t,t+1}}{\Pi_{t,t+1}} = 1,$$

where $\Pi_{t,t+i}$ is the gross inflation rate from t through $t+i$. The discount factor can come from a simple consumption-based asset pricing model, or it can come from a more complicated factor model. This is a very general formulation which does not depend too much on specific utility functions. See Cochrane (2001, page 64) for a discussion of the generality of this setup.

One can iterate through (1) to express the value of household balance sheets as the expected present value of net outlays plus a terminal condition:

$$\begin{aligned} \frac{B_t}{P_t} + P_t^L L_t &= \lim_{T \rightarrow \infty} E_t \sum_{i=t}^T \Lambda_{t,t+i} (C_{t+i} + T_{t+i} - Y_{t+i}) \\ &+ \lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} \left(\frac{B_{t+T+1}}{P_{t+T+1}} + P_{t+T+1}^L L_{t+T+1} \right). \end{aligned} \quad (2)$$

In plain language, what this says is that households' beginning wealth goes toward the present value of net outlays, plus terminal holdings of land and bonds.

In most normal models, the present value of net lending to and by households is constrained to equal zero in all terminal states, so both parts of terminal wealth are each zero. Such constraints are *not* the consequence of a competitive equilibrium. As Wright (1987) points out, this whole class of models has no competitive equilibrium when one lets consumers choose their terminal debt holdings. Consumers will always want to run a Ponzi scheme against lenders, sending the terminal value of net debt holdings as far down toward negative infinity as possible. Wright and others have discussed the consequences imposing no-Ponzi-scheme conditions, but these are additional constraints to these model and do not emerge naturally from Walrasian reasoning.

One path might be to relax this, to assume that terminal net borrowings must merely be collateralized by something such as land; this would be the case if people died at a far off terminal date and estates were liquidated to pay off creditors. In both of these cases the households will wish to consume all of their wealth subject to the terminal conditions; otherwise one could always improve welfare by

consuming more in the current period. Mathematically, collateralized lending leads to the transversality condition which sets the *total* value of terminal wealth to zero:

$$\lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} \left(\frac{B_{t+T+1}}{P_{t+T+1}} + P_{t+T+1}^L L_{t+T+1} \right) = 0. \quad (3)$$

Nothing in this transversality condition rules out a bubble in either land or credit; what matters to households and lenders is that these bubbles offset each other. If there is a land bubble (a positive terminal value for land), it requires a credit bubble to offset it, or else households will bid down the price of land to zero.

3. Lenders and market clearing in a simple model

Lenders have a debt transition equation which mirrors that of the government sector in most dynamic economic models. They issue nominal debt in reaction to the transfers which they receive or pay out. Their debt transition equation is as follows:

$$\frac{B_t}{P_t} - T_t = \frac{B_{t+1}}{R_{t,t+1} P_t}.$$

In the case of a fiscal authority, this equation would relate the evolution of government debt to primary surpluses. In the case of a foreign lender, this equation would relate the evolution of foreign debt to trade surpluses. In the case of the financial sector, this would represent the funds needed to engage in net lending. One can view the financial sector as engaging in a type of fiscal policy. In present value terms the lender's transition equation collapses down to the same debt valuation equation as used in the fiscal theory of the price level:

$$\frac{B_t}{P_t} = \lim_{T \rightarrow \infty} E_t \sum_{i=t}^T \Lambda_{t,t+i} T_{t+i} + \lim_{T \rightarrow \infty} E_t \frac{\Lambda_{t,t+T+1} B_{t+T+1}}{P_{t+T+1}}. \quad (4)$$

As with the fiscal theory of the price level, nothing directly constrains lenders to honor a transversality condition of their own.

Imposing market clearing in debt by combining (2) and (4) yields the economywide budget constraint:

$$P_t^L L_t = \lim_{T \rightarrow \infty} E_t \sum_{i=t}^T \Lambda_{t,t+i} (C_{t+i} - Y_{t+i}) + \lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} P_{t+T+1}^L L_{t+T+1}.$$

Imposing market clearing in product markets such that consumption equals output and that the demand for land equals the supply (normalized to one), yields the land pricing equation:

$$P_t^L = \lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} P_{t+T+1}^L.$$

Combining the land pricing equation with the transversality condition (3) yields the current price of land as a function of the debt bubble:

$$P_t^L = - \lim_{T \rightarrow \infty} E_t \frac{\Lambda_{t,t+T+1} B_{t+T+1}}{P_{t+T+1}}. \quad (5)$$

In this economy, land can have value if and only if some lender is willing to lend infinitely using land as collateral. Otherwise, once a bubble hits, households bid land prices down to zero in order to consume as much as possible in present value terms.

4. A more complex model with a financial sector

It is possible to extend the analysis above to include a financial sector which both issues equity and lends to households but does not engage in production. The financial sector, unlike a government, issues equity, and financial firms wish to maximize the value of their equity. The household's period-by-period budget constraint now contains a term for equity purchases:

$$\frac{B_t}{P_t} + P_t^L L_t + P_t^X Q_t + Y_t = P_t^L L_{t+1} + P_t^X Q_{t+1} + C_t + T_t + \frac{B_{t+1}}{R_{t,t+1} P_t}, \quad (6)$$

where P_t^Q is the cum-dividend equity price of the financial firm, P_t^X the ex-dividend equity price at which new shares are issued, and Q_{t+1} is the number of shares issued by the firm at time t . Using the pricing kernel and iterating forward, the budget constraint now becomes:

$$\frac{B_t}{P_t} + P_t^L L_t + P_t^Q Q_t = \lim_{T \rightarrow \infty} E_t \sum_{i=t}^T \Lambda_{t,t+i} (C_{t+i} - Y_{t+i})$$

$$+ \lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} \left(P_{t+T+1}^L L_{t+T+1} + \frac{B_{t+T+1}}{P_{t+T+1}} + P_{t+T+1}^Q Q_{t+T+1} \right). \quad (7)$$

Under the same collateral constraints as before, the transversality condition becomes:

$$\lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} \left(\frac{B_{t+T+1}}{P_{t+T+1}} + P_{t+T+1}^L L_{t+T+1} + P_{t+T+1}^Q Q_{t+T+1} \right) = 0. \quad (8)$$

The financial sector's balance sheet now evolves according to the law of motion:

$$\frac{B_t}{P_t} - P_t^X (Q_{t+1} - Q_t) - T_t = \frac{B_{t+1}}{R_{t,t+1} P_t},$$

The sequence T_t is the negative stream of dividends distributed to the old shareholders of the financial firm. This notation is used to keep notation consistent across sections and to emphasize the idea that the financial sector can engage in fiscal policy in reverse.

Shares are valued in the market according to the same stochastic discount factor as before:

$$P_t^Q Q_t = P_t^X Q_t - T_t = E_t \Lambda_{t,t+1} P_{t+1}^Q Q_{t+1} - T_t, \quad (9)$$

and the financial firm wishes to maximize its cum-dividend value which is obtained by iterating the asset pricing equation forward:

$$P_t^Q Q_t = - \lim_{T \rightarrow \infty} E_t \sum_{i=t}^T \Lambda_{t,t+i} T_{t+i} + \lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} P_{t+T+1}^Q Q_{t+T+1}. \quad (10)$$

Combining the equity valuation equation with the debt accumulation equation yields:

$$\frac{B_t}{P_t} + P_t^Q Q_t = E_t \Lambda_{t,t+1} \left(\frac{B_{t+1}}{P_{t+1}} + P_{t+1}^Q Q_{t+1} \right).$$

Iterating forward yields the value of the financial firm as simply the value of a financial bubble, since each financial firm's fundamental value is zero:

$$\frac{B_t}{P_t} + P_t^Q Q_t = \lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} \left(\frac{B_{t+T+1}}{P_{t+T+1}} + P_{t+T+1}^Q Q_{t+T+1} \right). \quad (11)$$

Nothing has to prevent an incumbent financial firm from being willing to hoard assets in the long run, since its period by period budget constraint and asset pricing conditions are satisfied. This is not possible with new entrants who have a zero starting debt position; as Blanchard (1982) notes, the bubble has to have existed since the beginning of time. Since households can now each individually use stock bubbles as collateral on the right hand side of (7), they are indifferent to whether or not that bubble exists or is paid out in the form of dividends. What matters is that the total net asset position of the financial sector explode, lumping financial sector equity in with liabilities.

Substituting the financial sector valuation equation (11) into the transversality condition (8) and then imposing market clearing yields the familiar land bubble condition, whereby land prices equal their terminal value, which in turn equals the terminal value of the financial sector, which now also equals the market value of the financial sector's overall balance sheet:

$$\begin{aligned} P_t^L &= \lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} P_{t+T+1}^L \\ &= - \lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} \left(\frac{B_{t+T+1}}{P_{t+T+1}} + P_{t+T+1}^Q Q_{t+T+1} \right) \\ &= - \frac{B_t}{P_t} - P_t^Q Q_t. \end{aligned} \quad (12)$$

The new equilibrium conditions merely generalize (5) to include financial sector equity as a form of lending. Since the Modigliani-Miller Theorem and the usual asset pricing conditions hold, the mix of financial sector equity and debt is not important, so long as households are net debtors to the financial sector and this net debt explodes.

5. Welfare implications: The surprising macroeconomic neutrality of bubbles

Kocherlakota (2008) provides a formal proof of the possible neutrality of bubbles in a production economy where bubbles arise through the imposition of period-by-period solvency constraints. This section proves a similar result in the economy with credit-driven asset bubbles, even when land is a factor of production. The economy is a standard representative-agent macroeconomy. Capital K_t has an ex-post rental rate (gross of depreciation) r_t^K . Land has a rental rate r_t^K and labor has a return W_t which is paid according to hours of work H_t . As in the previous section, assets are priced cum-

dividend when there is no subscript on the price. Capital is supplied elastically so its real price is one, and it depreciates at rate δ . It is possible to extend the logic of this proof to an economy with many goods, assets, and agents using the same intuition.

Households seek to maximize the discounted utility of consumption subject to a modified version of their budget constraint (6) and transversality condition (7). The household objective function takes the form

$$V_t = E_t \sum_{i=0}^{\infty} \beta^i u(C_{t+i}, H_{t+i}) - E_t \sum_{i=0}^{\infty} \beta^i \lambda_{t+i} \left[P_t^{LX} L_{t+1} + P_t^X Q_{t+1} + C_t + T_t + K_{t+1} + \frac{B_{t+1}}{R_{t,t+1} P_t} \right] \\ + E_t \sum_{i=0}^{\infty} \beta^i \lambda_{t+i} [P_t^{LX} L_t + P_t^X Q_t + W_t H_t + r_t^L L_t + (1 + r_t^K - \delta) K_t],$$

where asset prices with a superscript X are ex-dividend. Utility maximization results in the first-order conditions:

$$-u_H(C_t, H_t) = W_t \lambda_t,$$

$$u_C(C_t, H_t) = \lambda_t,$$

and the asset pricing relationships:

$$P_t^L = E_t \Lambda_{t,t+1} P_{t+1}^L,$$

and:

$$E_t \frac{\Lambda_{t,t+1} R_{t,t+1}}{\Pi_{t,t+1}} = 1,$$

where the stochastic discount factor equals $\Lambda_{t,t+i} = \beta^i \lambda_{t+i} / \lambda_t$ as before.

Producers produce according to a constant returns production function and have the three intratemporal first order conditions:

$$Y_K(K_t, H_t, L_t) = r_t^K,$$

$$Y_H(K_t, H_t, L_t) = W_t,$$

and

$$Y_L(K_t, H_t, L_t) = r_t^L.$$

The asset pricing equation for land (cum-dividend) now contains a fundamental component:

$$P_t^L = E_t \Lambda_{t,t+1} P_{t+1}^L + r_t^L = \lim_{T \rightarrow \infty} E_t \sum_{i=0}^T \Lambda_{t,t+i} r_{t+i}^L + \lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} P_{t+T+1}^L. \quad (13)$$

After pricing every asset, the household budget constraint becomes:

$$\begin{aligned} \frac{B_t}{P_t} + P_t^L L_t + P_t^Q Q_t + W_t H_t + (1 + r_t^K - \delta) K_t \\ = E_t \Lambda_{t+1,t} P_{t+1}^L L_{t+1} + E_t \Lambda_{t+1,t} P_{t+1}^Q Q_{t+1} + C_t + K_{t+1} + \frac{B_{t+1}}{R_{t,t+1} P_t}. \end{aligned}$$

Iterating the budget constraint forward and imposing that real income payments and allocations are well behaved (growing at less than the rate of interest) gives the following condition:

$$\begin{aligned} \frac{B_t}{P_t} + P_t^L L_t + P_t^Q Q_t = \lim_{T \rightarrow \infty} E_t \sum_{i=t}^T \Lambda_{t,i} (C_{t+i} - W_{t+i} H_{t+i} + K_{t+i+1} - (1 + r_{t+i}^K - \delta) K_{t+i}) \\ + \lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} \left(P_{t+T+1}^L L_{t+T+1} + \frac{B_{t+T+1}}{P_{t+T+1}} + P_{t+T+1}^Q Q_{t+T+1} \right). \end{aligned}$$

Substituting the financial sector valuation equation (11) cleans things up a bit:

$$\begin{aligned} P_t^L L_t = \lim_{T \rightarrow \infty} E_t \sum_{i=t}^T \Lambda_{t,i} (C_{t+i} - W_{t+i} H_{t+i} + K_{t+i+1} - (1 + r_{t+i}^K - \delta) K_{t+i}) \\ + \lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} P_{t+T+1}^L L_{t+T+1}. \end{aligned} \quad (14)$$

To see that bubbles are neutral in this model, one can look at a ‘star’ economy as sequence of real aggregates where there are no bubbles; all first order conditions hold, and markets clear. Land is then priced according to (14):

$$P_t^{*L} L_t = \lim_{T \rightarrow \infty} E_t \sum_{i=t}^T \Lambda_{t,t+i}^* (C_{t+i}^* - W_{t+i}^* H_{t+i}^* + K_{t+i}^* - (1 + r_{t+i}^{K*} - \delta) K_{t+i}^*). \quad (14^*)$$

Market clearing implies that income equals expenditure:

$$r_t^{*L} L_t + r_{t+i}^{K*} K_{t+i}^* + W_{t+i}^* H_{t+i}^* = C_{t+i}^* + K_{t+i+1}^* - (1 - \delta) K_{t+i}^*.$$

Land markets also clear, and substituting land’s factor payments into (14*) ensures that land is priced at its fundamental value:

$$P_t^{*L} L_t = \lim_{T \rightarrow \infty} E_t \sum_{i=t}^T \Lambda_{t,t+i}^* r_{t+i}^{L*} L_{t+i}.$$

One can show that there is an equivalent economy where the land price differs and satisfies its asset pricing relationship while real allocations are the same as in the star economy. Land prices would take the form:

$$\begin{aligned} P_t^L L_t &= \lim_{T \rightarrow \infty} E_t \sum_{i=t}^T \Lambda_{t,t+i}^* (C_{t+i}^* - W_{t+i}^* H_{t+i}^* + K_{t+i}^* - (1 + r_{t+i}^{K*} - \delta) K_{t+i}^*) + b_t^L L_t \\ &= \lim_{T \rightarrow \infty} E_t \sum_{i=t}^T \Lambda_{t,t+i}^* r_{t+i}^{L*} L_{t+i} + b_t^L L_t, \end{aligned}$$

where the bubble is purely speculative, based on expectations of future price increases:

$$b_t^L = E_t \Lambda_{t+1,t} b_{t+1}^L = \lim_{T \rightarrow \infty} E_t \Lambda_{t,t+T+1} P_{t+T+1}^L L_{t+T+1}.$$

One can see by inspection that this economy satisfies (13), (14), and all of the same first order and market clearing conditions as the ‘star’ economy. Bubbles are neutral because land prices are additively separable between the fundamental component and bubble component, so the bubble component does not affect fundamentals or any other relative price. Furthermore, an offsetting credit bubble (an increase in household liabilities) exactly neutralizes the wealth effect from the land bubble,

so consumption decisions also do not change in equilibrium. Outside lenders end up absorbing all of the increase in land prices, and land prices absorb all of the increase in outside lending. In order to get real effects from this type of land bubble (or the destruction of one), one must introduce some other features such as time-varying credit market imperfections into the economy.

6. Empirical evidence on neutrality from macroeconomic data

The Fed publishes balance sheet data for certain sectors of the US economy, with certain assets valued at market prices. Figure 1 shows the estimated net claims on real assets for different sectors of the US economy from 1952 through 2010 as a share of the CBO's estimate of potential real GDP inflated by the GDP deflator. Net claims on real assets consist of the replacement cost or market value of tangible assets plus net holdings of corporate equities. The personal sector consists of households and nonprofit institutions serving households (Tables B.100 and B.100e) consolidated with nonfarm noncorporate business (Table B.103). The private nonfinancial sector consists of the personal sector consolidated with nonfarm nonfinancial corporate business (Table B.102). To avoid double-counting the value of corporate equity held by households, the market value of corporate equity outstanding (Line 35 of Table B.102) is treated like a negative claim on assets for the corporate sector. The corporate equity portion of mutual fund shares held by nonfarm nonfinancial corporate business (Line 19, which is rather small in magnitude) is approximated using the proportion of corporate equities in mutual funds from the household balance sheets. As a look at Figure 1 shows, the assets of the personal sector fluctuate in the medium run according to the value of the stock market; the drastic runup in real estate prices in the 2000s also shows up. The value of the assets of the private nonfinancial sector, by contrast, fluctuates mostly according to the value of real estate. The real estate booms and busts of the 1970s, 1980s, and 2000s are strongly visible to the naked eye in the second series.

Figures 2a and 2b show the impulse responses to an asset price shock in a bivariate Bayesian VAR using long-run restrictions, using eight lags and a diffuse normal conjugate prior. To allow for potentially explosive asset prices over the long run, the first variable is the log first difference of claims on real assets relative to GDP.¹ The second variable is the output gap, in natural logs. Asset price shocks are defined as those shocks which have a long-run effect on the log of asset prices relative to the size of the economy. Figures 2a and 2b show the posterior median impulse responses to a one standard deviation asset price shock from this exercise for 1955 through the end of 2006 for the

¹ There is of course a large empirical literature on the effects of asset price shocks. Lettau and Ludvigson (2004) assume cointegration and thus eliminate the bubble component of wealth, which this paper analyzes. The system as estimated through 2006, in levels, has one unstable root corresponding with the real estate bubble. To date, no analysis has used long-run restrictions in a VAR to tease out the effect of a change in bubbles versus a change in fundamentals.

personal and nonfinancial private sectors, along with posterior 95% and 90% confidence bands. Table 1 shows some summary statistics. These are the result of a Markov Chain Monte Carlo with 75,001 draws, after discarding the first 10,000 draws. Before 2007, asset price fluctuations were in fact neutral or close to neutral. A long-run rise in asset prices statistically had little to do with the output gap. The largest posterior probabilities that asset price shocks have a positive effect are 0.74 for the personal sector and 0.80 for the private sector, 7 quarters after the initial shock. Peak median posterior effects on output are 0.17% and 0.23%, respectively, also 7 quarters after the initial one-standard-deviation shock. The data from before the financial crisis broadly support the neutrality result shown in the previous sections. During normal times, the claim that asset bubbles have a major effect on macroeconomic aggregates is tenuous at best.

Estimating the system using the full sample from 1955 through the second quarter of 2010 changes things somewhat. Figures 3a and 3b show the posterior impulse responses. For the personal sector, the posterior probability of a positive effect peaks 7 quarters after the initial shock at 0.9330, which is still less than the value of 0.975 typically used for classical statistical significance tests. For the private sector, the posterior probability of a positive effect peaks at 8 quarters with a value of 0.9715, which is still “statistically insignificant” by the Bayesian counterpart of the traditional significance test but noteworthy compared with the earlier results. The median effects are much larger using the longer sample, at 0.46% and 0.56%, respectively. These effects occur 7 quarters out. Using traditional criteria, it is still not possible to reject neutrality, but the evidence against neutrality becomes more tenuous. It is probably fair to conclude that while asset prices are more or less neutral during normal times, the post-2007 crisis represents an unusual regime asset prices are both very volatile and strongly nonneutral. The models of asset price nonneutrality based on credit constraints, such as those developed by Kocherlakota (2009) and Wang and Wen (2009), are probably best understood as applying not to normal times but to a special regime where credit markets are unusually fragile.

Unfortunately, it would require several more years of data to be able to see whether a break has occurred in the transmission of asset prices to economic aggregates, or whether the financial crisis was a unique event. Putting nonlinearity aside, the sample is so far too short to include an indicator for the meltdown in the banking sector in late 2008, and the results from including an indicator for the onset of the financial crisis in 2007 are not robust. An exploratory trivariate VAR which includes an indicator for the onset of the financial crisis in the third quarter of 2007 broadly confirms the full-sample results when that indicator is ordered third in the VAR. Ordering the indicator first gives results more similar to that of the shorter sample. No purely statistical method exists to choose between the orderings, to say whether falling asset prices caused the financial crisis or the financial crisis caused falling asset prices. An alternative approach would be to include a continuous indicator of financial-sector stress as an endogenous variable in the VAR to see if asset prices usually affect

financial sector stress; unfortunately, no such indicator (such as the TED spread or an indicator of banking stress which encompasses the shadow banking sector) exists throughout the entire sample.

7. Conclusion

Credit-backed land bubbles can appear when lenders (such as a domestic or foreign fiscal authority or a financial sector) are freely willing to lend against assets and households buy these assets, leaving net household wealth unchanged. Basically, the increase in liabilities by households exactly neutralizes the wealth effect from the bubble, and relative prices are left unchanged. Bubbles in this context are neutral or close to neutral; they should not affect real allocations. This is possible even when the bubble asset, such as land, is a factor in production, since the price component attributable to bubbles is separable from the fundamental component. Data generated during normal times, that is, the postwar period before 2007, broadly support that view. Including the post-2007 period has significantly weakened the case for asset price neutrality but not completely overturned it. The instability of econometric estimates suggests that the latter period represents a different regime with a different structure that is best explored as a special case rather than a general case.

The normally weak statistical relationship between asset price fluctuations and output fluctuations indicates that during normal times, authorities may not wish to concern themselves too much with attacking asset bubbles if to do so has a negative effect on the economy. The instability of estimates further suggests that the late-2000s financial crisis has seen an unusual degree of linkage between asset prices and real aggregates, though pending a few more years of data, no formal statistical test of that proposition is yet possible. Exploratory evidence does statistically tie the financial crisis to a fall in asset prices (particularly in real estate) but it cannot attribute causation in either direction.

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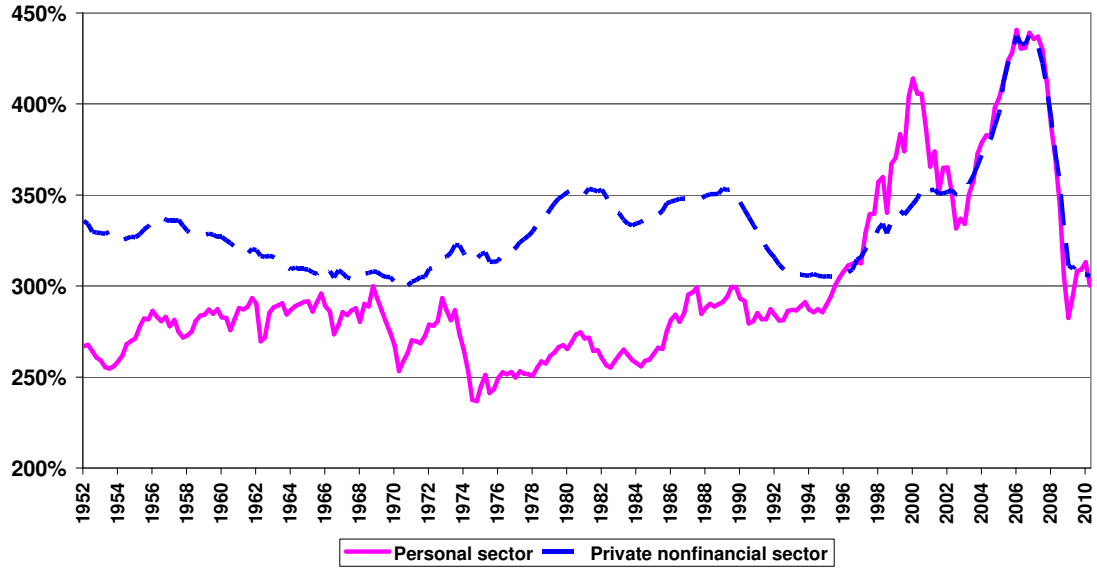
Table 1: Posterior statistics for impulse responses

Period	Sector	Posterior Max	Value (%)	Quarter
1955.I - 2006.IV	Personal	Median effect	0.1686	7
		Probability > 0	0.7416	7
	Private	Median effect	0.2346	7
		Probability > 0	0.8026	7
1955.I - 2010.II	Personal	Median effect	0.4599	7
		Probability > 0	0.9330	7
	Private	Median effect	0.5641	7
		Probability > 0	0.9715	8

This table shows posterior statistics for the impulse responses after 75,001 MCMC draws, discarding the first 10,000.

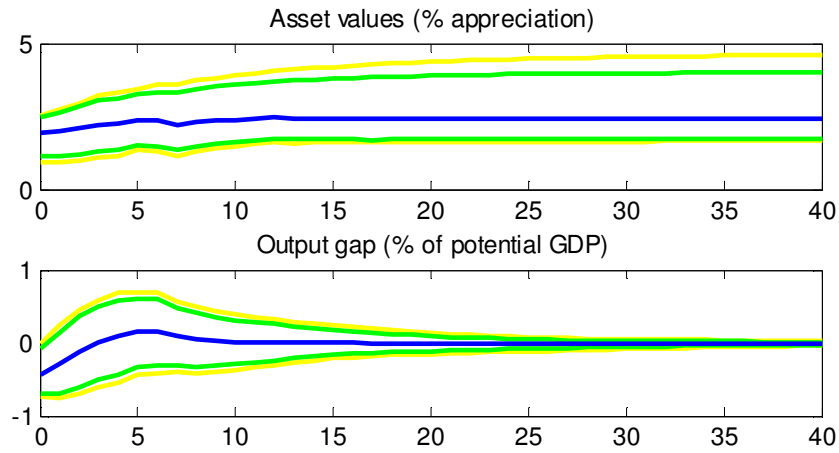
Figure 1: Asset values for the personal and private nonfinancial sectors

Net claims on real assets in the US economy (% of potential GDP)
Source: Federal Reserve Flow of Funds, CBO, NIPA.



See Section 6 for a description of the data sources and the author's calculations.

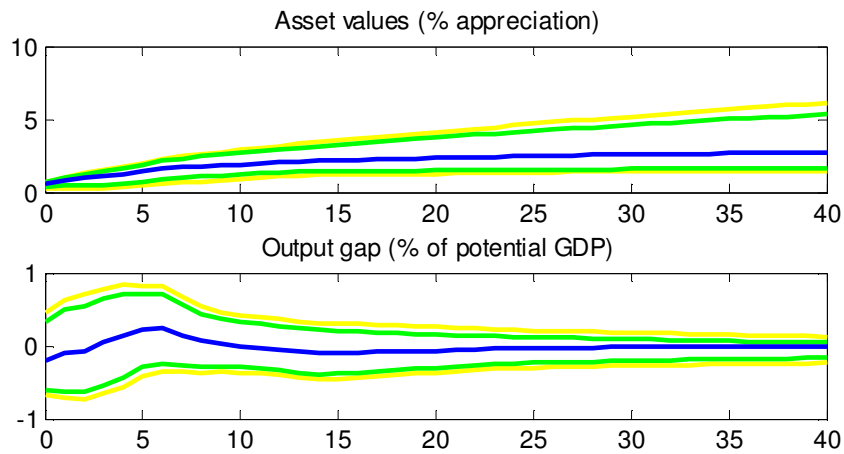
**Figure 2a: Impulse responses to a +1 S.D. long-run asset price shock
(Personal sector, 1955.I-2006.IV, time in quarters)**



Bands show 95% and 90% Bayesian posterior confidence intervals and the posterior median.

These shocks include stock market wealth.

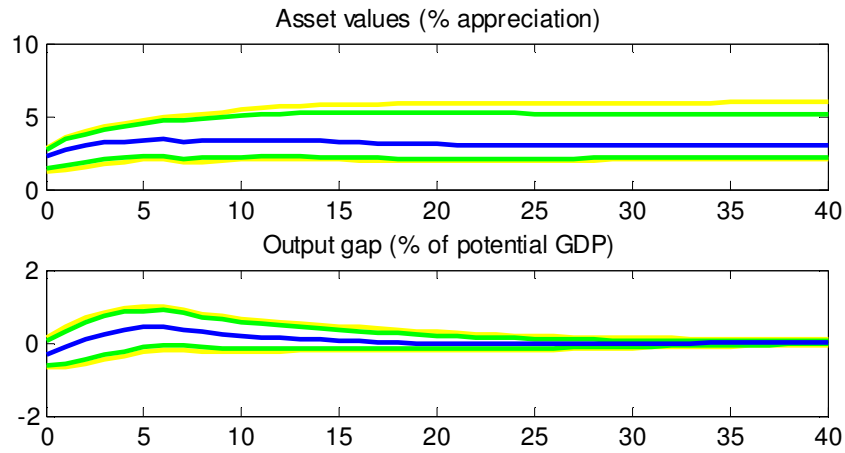
**Figure 2b: Impulse responses to a +1 S.D. long-run asset price shock
(Private nonfinancial sector, 1955.I-2006.IV, time in quarters)**



Bands show 95% and 90% Bayesian posterior confidence intervals and the posterior median.

These shocks net out most stock market wealth and are heavily affected by land prices.

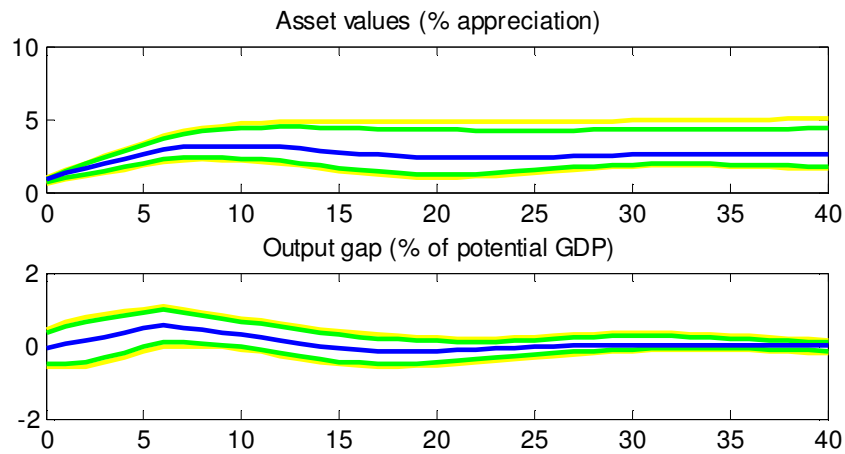
**Figure 3a: Impulse responses to a +1 S.D. long-run asset price shock
(Personal sector, 1955.I-2010.II, time in quarters)**



Bands show 95% and 90% Bayesian posterior confidence intervals and the posterior median.

These shocks include stock market wealth.

**Figure 3b: Impulse responses to a +1 S.D. long-run asset price shock
(Private nonfinancial sector, 1955.I-2010.II, time in quarters)**



Bands show 95% and 90% Bayesian posterior confidence intervals and the posterior median.

These shocks net out most stock market wealth and are heavily affected by land prices.