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Two Models of Land Overvaluation and Their Implications*

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1. Introduction

From early 1996 through mid-2006, the price of residential land (henceforth, land) nearly tripled in the United States. It has since fallen by over 60%. As of the fourth quarter of 2009, the price of land is not even 10% above its price in 2000.[1] These observations suggest to me, as they have to others, that in the mid-2000s, the price of land was *overvalued* (relative to the expected discounted value of future land rents). In this paper, I construct two distinct models of this overvaluation. In the first, the land overvaluation is due to government guarantees of bank debt. I examine the implications of this model for the regulation of banks and other financial institutions. In the second, the land overvaluation is due to an asset price bubble. I examine the implications of this model for fiscal policy.[2]

In the remainder of the introduction, I briefly lay out the arguments and conclusions described with greater detail and more technically in the two parts of the paper that follow. The first part of the paper constructs a simple model in which bank creditors (depositors and debtholders) receive implicit and explicit guarantees from the government.[3] The key to the model is that the markets for land, mortgage origination, and bank debt are all competitive. This assumption implies that the benefits from debt guarantees end up flowing to the owners of scarce factors in the economy. In the model, the only such scarce factor is land, and so the government guarantees impact the economy by increasing the value of land. I demonstrate that these guarantees can lead land to be overvalued. It is generally believed that the benefits of debt guarantees accrue to bank equityholders. However, they only do so if their bank enjoys

[1] Note that I'm talking about *land*, not housing. Theoretically, it is hard to motivate the existence of significant overvaluation in housing structures (they're readily replaceable). Empirically, there is considerably less evidence of overvaluation for structures than for land. Here, I refer to data from the Lincoln Institute of Land Policy that separates the price of housing into the price of structures and the price of land. The data were originally constructed by Davis and Heathcote (2005, 2007), and are derived from the Case-Shiller housing price index. These data indicate that the price of housing structures rose by less than 100% in nominal terms from 1996 to 2006, and has fallen by less than 10% since that date.

[2] The views expressed do not necessarily reflect those of others in the Federal Reserve System. Indeed, I would hesitate to say that the results in this paper represent my own view. There are many possible models of the behavior of land prices in the 2000s. My goal in this paper is only to describe the implications of two of them. I also make no claims to originality: I am sure that much of what I say is well-known to most macroeconomists and financial economists.

[3] I am primarily interested in the ex ante impact of the guarantees. What matters is whether creditors expect such guarantees, not whether they actually receive them.

market power in the mortgage origination process. The rents from government guarantees flow to the owners of scarce factors in the economy. In my model, the only scarce factor is land.

Interestingly, this overvaluation occurs even if bank debtholders are the only people in the economy who are actually aware of the guarantees. All other actors (including bank equityholders) simply respond to natural competitive pressures. Thus, landowners may have no idea why their buyers are willing to pay so much. Indeed, the buyers themselves have no idea why they are paying so much. All they know is that the banks are offering low mortgage rates. The banks are willing to offer these low mortgage rates because they are able to borrow at a low rate from debtors who believe themselves to be insured against loss.

I show that regulations like capital requirements and leverage restrictions can eliminate this overvaluation. However, to be effective, bank regulation must react to shifts in the probability distribution of future land values. In particular, a given capital requirement or leverage cap might successfully eliminate all pricing distortions associated with debt guarantees for a given probability distribution of future land values. However, suppose that the distribution changes so that its left tail becomes longer. Then, the debt guarantees will lead to land being overvalued. Intuitively, the debt guarantees imply that taxpayers make transfers to bank creditors when they suffer losses. To forestall losses to taxpayers, good regulation should require that bank equityholders or landowners hold as much of land's risk as possible. Such regulations must adjust to the underlying distribution of land values, and especially to changes in its left tail.

The second part of the paper models land overvaluation as being due to a *rational bubble*. What do I mean by a bubble? I mean that the asset's price is higher than the price that a buyer would be willing to pay if he were required to never resell it. I will refer to this "buy-and-hold-forever" price as the asset's fundamental. So, with a bubble, assets are overvalued relative to fundamentals. What do I mean by *rational*? I mean that the overvaluation is common knowledge among all people in the model economy, and so risk-adjusted returns are always equalized across assets.

At this point, the term "rational bubbles" may sound like an oxymoron. The key to this apparent contradiction is that returns are related to the *expected* rate of *growth* of prices, and not to the level of the price. Two prices might grow at the same rate, but have consistently different levels. Two prices might have the same expectation, but have different variances around their means. Hence, even if risk-adjusted returns are equalized across all assets, some asset prices may be elevated relative to fundamentals, and some asset prices might fluctuate more than fundamentals.[4]

Beginning with Samuelson (1958), there have been many years of research into rational bubbles.[5] In this literature, rational bubbles emerge as a response to a particular kind of friction in loan markets. In private credit markets, the real rate of interest adjusts so as to equalize the demand for savings by lenders with the supply of savings by borrowers. However, in many circumstances, borrowers face credit constraints, in that they are unable to fully capitalize their future income. In those settings, the supply of savings is restricted. The market for savings can only clear if the interest rate is low enough so as to reduce the demand for savings correspondingly.

If the credit constraints are sufficiently severe (so that they drive down the market interest rate sufficiently), equilibrium asset prices may exhibit bubbles. These bubbles have a benefit, in that they provide savers with a vehicle to store wealth for future consumption purposes. To understand how this works, suppose a parcel of land has a fundamental value

[4] How can I say that risk-adjusted land returns were equalized to those of other assets in the 2000s, when land prices were growing so fast? An asset's price may grow rapidly even if the asset's risk-adjusted return is the same as other assets' returns. However, in the equilibrium of an efficient market, an asset's price can only grow rapidly from one year to the next if there is a nontrivial probability that it might fall. In other words, a strong believer in efficient market theory who watched land appreciate rapidly in the 2000s would have said that there must be some probability of a big fall in land prices. An even more sophisticated believer in efficient markets might have speculated that land's high returns are only possible because land has a large beta. Such a true believer in efficiency would have predicted that a fall in land prices would take place simultaneously with a large stock market crash and/or a deep recession.

[5] Along with many others, Diamond (1965), Tirole (1985), Kocherlakota (1992), Santos and Woodford (1997), and Hellwig and Lorenzoni (2009) provide theoretical treatments of rational bubbles. As I do in this paper, Caballero (2006), Caballero and Krishnamurthy (2006), Kraay and Ventura (2007), and Farhi and Tirole (2010) analyze policy interventions in the context of models in which bubbles emerge in response to financing frictions.

of $200,000. Without a bubble, person A can buy the land, using a down payment of $40,000 and a nonrecourse mortgage from bank B for the remaining $160,000. But suppose the land has a bubble of $100,000, with the same risk-adjusted return as the fundamental. Now person A can buy the land using a down payment of $60,000 and a mortgage from bank B for $240,000. A pays more—but gets the same expected return. The bubble in the land price does not necessarily give either A or B a higher risk-adjusted return on their portfolios. However, it does allow A to save an additional $20,000 in the form of land and the owners of B to save an additional $80,000 in the form of land.

Thus, bubbles enhance the ability of savers to save. At the same time, though, bubbles are intrinsically unstable because they rely on a fragile chain of mutual understanding. (I'm willing to pay too much for land today because someone else will pay too much and so on.) Changes in people's beliefs in the viability of this chain can have big effects on the size of the bubble and on asset prices themselves.

I use this framework to discuss useful fiscal policy responses to the emergence of bubbles. My basic argument is that, while they have some benefits, bubbles introduce instability into the economy. It *may* be possible for the government to avoid this possibility by using appropriate debt management, but only at some risk and cost. I then discuss optimal policy responses to the collapse of bubbles. A bubble collapse introduces two distinct problems into the economy.

- The real interest rate has fallen (below the growth rate of the economy), because the supply of savings has contracted. This problem is necessarily highly persistent.
- The distribution of wealth has shifted, as those who owned the bubbly asset lose, and those who did not have the bubbly asset would gain. This problem may be (relatively) transitory.

A government can fix the first problem by committing to borrow at a higher fixed real interest rate that is lower than the growth rate in the economy. Because the real interest rate is lower than the growth rate of the economy, these loans are essentially a free lunch. The government raises funds in the first period and then rolls over the debt perpetually. Fixing the second problem, wealth redistribution, is more challenging. The government needs to be able to target the proceeds of the debt issue to the right people in the economy. It may well be difficult to figure out, from an economic standpoint, who should receive a transfer and who should not.

My discussion of optimal policy responses to the emergence and collapse of bubbles is contingent on the validity of the rational bubble framework. I close with some admittedly speculative suggestions about how to use the policy prescriptions in this paper as a benchmark for a more general class of models.

There has been a great deal of discussion about how monetary policy should respond to bubbles. I will have nothing to say on this issue. In the United States, monetary policy generally takes the form of open market operations. In an open market operation, the Federal Reserve exchanges some govenment liabilities (reserves) for other government liabilities (Treasuries or securities issued by govenment-sponsored enteprises) of equal market value. In this way, the Federal Reserve can influence the *composition* of outstanding government liabilities, but not the *total value* of outstanding government liabilities. (The latter is shaped by Congress.)

As we will see, in the rational bubble framework, the time path of the total value of government liabilities matters a great deal for economic outcomes. However, the composition of those liabilities is, at a minimum, less essential. Hence, I abstract from the latter consideration entirely—and, in doing so, I abstract from monetary policy.

2. Debt Guarantees and Land Overvaluation

In this section, I consider the impact of bank debt guarantees on land prices. By "bank debt guarantees," I mean to include guarantees for creditors of so-called too-big-to-fail institutions and guarantees of depositors. My discussion in the text is verbal. The interested reader is referred to Appendix 1 for mathematical details.

A. Model and Equilibrium

I begin by describing a simple abstract two-period model. The key feature of the model is that bank creditors—both depositors and debtholders—have debt guarantees provided by the government. In equilibrium, these debt guarantees drive up the price of assets that are in fixed supply.

In the model, there are equal numbers of four types of economic actors: landowners, land buyers, bank equityholders, and bank debtholders. (Implicitly, there is a fifth type—taxpayers—but I treat them as being outside the model.) All people are risk-neutral, and they do not discount between the two periods. The owners each own a unit of land. Land pays off V units of consumption in period 2. Here, V is random, with cumulative distribution function Φ and probability density function ϕ. V has support $[V_{\min}, V_{\max}]$. All land payoffs are always equal to one another, because I want to focus on aggregate risk. The owners don't desire consumption in period 2, but do desire consumption in period 1, and so are willing to sell to the buyers.

The buyers buy land from the owners at an endogenous price p. The buyers are required to put down a down payment of αp, where α is exogenous. They borrow the remaining $(1-\alpha)p$ from the banks, using debt with an endogenous face value F_{land}. The loan is nonrecourse, except for the underlying land itself, and so the buyers get a random payoff equal to

$$\max(V - F_{land}, 0)$$

from their purchase.

I assume that the bank faces an exogenous restriction κ on its debt/equity ratio (this is supposed to stand in for capital requirements or, more meaningfully, for leverage caps). Bank debtholders make a loan with an endogenous face value F_{bank} to the bank equityholders.

The equityholders face limited liability, and so they receive a payoff equal to

$$\max(\min(V, F_{land}) - F_{bank}, 0).$$

The bank's debtholders are fully guaranteed against any losses from fluctuations in V. Hence, their payoff in period 2 is simply the loan amount F_{bank}.

Trade is competitive within the model. The price of land p, the face value of bank debt F_{land}, and the face value of land loans F_{bank} adjust so that debtholders, equityholders, and land buyers earn zero economic profit in equilibrium. Without debt guarantees, the price p equals the expected value $E(V)$. However, with debt guarantees, the price of land may be larger than $E(V)$. Define

$$\lambda = (1 - \alpha)/(1 + 1/\kappa).$$

This is the key regulatory parameter. It ranges between 0 and 1, is decreasing in the down payment α, and is increasing in the leverage restriction κ. When α is high, landowners hold much of the land risk. When κ is low, equityholders hold much of the land risk. But when λ is high, much of the land risk is held by guaranteed bank debtholders—and therefore by taxpayers.

Given a value of λ, the land price is determined as follows.[6]

$$E(V)\lambda \leq V_{\min} \Longrightarrow p = E(V).$$

$$E(V)\lambda > V_{\min} \Longrightarrow p = E\{V \mid V \leq \lambda p\}\Phi(\lambda p) + E(V).$$

If $\lambda E(V) \leq V_{\min}$, then bank equityholders or land buyers hold all of the land risk. The probability of taxpayers making transfers to creditors is zero, and land is not overvalued. If $\lambda E(V) > V_{\min}$, then the bank and land buyers are jointly sufficiently leveraged so that bank

[6] See Appendix 1 for the full mathematical analysis.

debt is risky. There is a positive probability of taxpayers making transfers to creditors, and land is overvalued. Intuitively, the amount of the overvaluation exactly equals the expected value of the transfers from taxpayers to bank creditors.

B. Lessons of the Model

In this section, I draw out some simple implications of the model for bank regulation.

Implications for Leverage

I've treated both the leverage restriction κ and the down payment α as being exogenous variables (implicitly under the control of bank regulators). Together, these two parameters combine to form the key regulatory parameter λ, which ranges between 0 and 1.

In this model, bank regulation eliminates all pricing distortions caused by government guarantees if λ is less than $E(V)/V_{\min}$. Bankers and policymakers have long debated the merits and costs of having more stringent capital requirements when banks are doing well. In this model, the cutoff value for λ does not change if the distribution of land values is scaled up or down proportionately. Instead, the requisite regulation has more to do with the left tail of the probability density of asset (here, land) values. If that tail becomes long, then bank regulation needs to be tight. If the left tail is shorter, then bank regulation can be more relaxed.

Lesson: Bank leverage restrictions should become tighter if the left tail of the probability density of future land values becomes longer.

Implications for Down Payments

I have treated the down payment requirement α as being exogenous. Suppose $E(V)(1+\kappa^{-1}) \leq V_{\min}$. Then, for any specification of α, $\lambda E(V) \leq V_{\min}$ and $p = E(V)$. Hence, the price of land is independent of the down payment α, and there are no competitive pressures on its level.

In contrast, if $E(V)/(1+\kappa^{-1}) > V_{\min}$, then the price of land is decreasing in α. Banks will compete to make α as low as is possible.

Lesson: Bank leverage restrictions should become tighter when banks are actively competing with one another by lowering down payment requirements.

Implications for the Distribution of Rents and Knowledge

In this model, landowners receive all of the rents from debt guarantees. Nonetheless, only bank creditors need to know about the guarantees.

In equilibrium, the guarantees imply that bank debtholders make loans at a low rate, given their risk, to bank equityholders. The equityholders don't care why bank debtholders are willing to do so. The bank equityholders respond by being willing to make cheap loans, given the underlying risk, to land buyers. Again, the land buyers don't care why their loans have such a low interest rate.

Finally, because their loans are nonrecourse and have such a low interest rate, the land buyers are willing to borrow a lot to finance their land purchases. In fact, they find that to buy land at all, they must be willing to borrow a lot and bid high. The landowners are of course delighted to get such a high price and, again, don't care why buyers are willing to pay so much.

This chain of reasoning points out how competition spreads rents around in an economy. There are ex ante rents due to ex post debt guarantees. But debt markets are competitive, and so the actual recipients of debt guarantees compete away those rents. The ex ante owners of scarce factors are the ones who get the rents, without necessarily knowing their source.

Lesson: Insufficiently stringent bank regulation may have relatively little impact on bank profits, but nonetheless lead scarce factors (finance talent, land) to be overvalued.

Summary

This simple model shows how ex post debt guarantees for bank creditors can lead to the overvaluation of land. It indicates how optimal bank regulation needs to respond to changes in the shape of the probability distribution of future land values. In this discussion, I have treated the probability distribution of future land values as exogenous. The distribution may change for demographic, technological, or much less fundamental reasons. Bank regulation should respond in the same way to these changes, regardless of their source.

3. Rational Bubbles in Land Prices

In this section, I describe the basics of rational bubble models. I then discuss the implications of these models for optimal fiscal policy. As I mention in the introduction, I abstract completely from monetary policy.

There are many kinds of models with rational bubbles: overlapping generations models, models with exogenous borrowing constraints, and models with endogenous borrowing constraints. My discussion attempts to treat all at once. In Appendix 2, readers can find an explicit mathematical framework that illustrates the verbal points made in the text.

A. Rational Bubble Basics

This treatment draws upon Tirole (1985), Kocherlakota (1992), and Santos and Woodford (1997). The discussion is designed to apply to a model with a large number of infinitely lived households or to an overlapping generations model. In either case, I assume that all households are symmetrically informed at all dates.

Definition and Equilibrium Restrictions

I begin by defining a bubble.

Definition 1. *In a given equilibrium, an asset's price has a* bubble *if the price exceeds the asset's buy-and-hold-forever value (which is, again, the price that a buyer would be willing to pay if he were required to never resell it).*

In what follows, I will assume that there are no aggregate fluctuations in the economy. This assumption means that all assets earn the same constant rate of return r. This assumption can be relaxed, but only at a nontrivial notational cost.

Suppose an asset's price has a bubble. By assumption, the asset's expected return is constant over time and equal to r. Hence, by the definition of expected return, the asset's price and dividend satisfy the restriction

$$(1) \quad P_t = E_t\{P_{t+1} + D_{t+1}\}/(1+r)$$

where E_t is the conditional expectation, based on information available at date t. I can roll this first-order difference equation forward to conclude that

$$(2) \quad P_t = EDV_t + \eta_t.$$

Here, EDV stands for expected discounted value of future dividends (discounted at rate r) and is the buy-and-hold-forever value of the asset. The random variable η_t is the bubble; it is necessarily nonnegative and satisfies the restriction

$$(3) \quad \eta_t = E_t \eta_{t+1}/(1+r).$$

The asset has a bubble if $\eta_t > 0$. Note that equation (3) implies that an asset that has a bubble currently must have had one in the past. However, the size of the bubble may fluctuate over time.

Equation (3) immediately implies that there is a sample path along which the asset price grows at rate r. But the asset price cannot grow faster than the economy. Hence, if the economy grows at g, then $r \leq g$. In other words: **If the asset has a bubble, the equilibrium rate of return r cannot exceed the growth rate of the economy g.**[7] Note that this requirement is a long-run restriction. Over short periods of time, an asset's price could grow more rapidly than the economy—but this trend cannot continue forever.

There is an immediate implication from this result: At any point in time, current

[7] This condition applies in deterministic settings. In stochastic settings, the appropriate generalization is that if a bubble exists, then the expected discounted value of GDP, using the appropriate risk-adjusted discount rate, is infinite.

investors must face restrictions on their ability to borrow against the future income of the society. The discount rate r is no larger than g. Hence, the present value of the future income of the economy is infinite. If people could fully capitalize all of this future wealth, they could buy an infinite amount of goods. It follows that **if some asset's price has a bubble, then, at any date, everyone faces borrowing constraints that bind currently or at some point in the future.**

These borrowing constraints can take a number of forms. They could be purely exogenous limits on people's debt positions. Or they could be endogenous restrictions, as in Kehoe and Levine (1993). Or they could represent the inability of parents to borrow against their children's incomes (as in an overlapping generations economy).

For similar reasons, no currently traded asset with rate of return r can have an underlying dividend stream that grows at the same rate as the economy. It follows that growth in a bubbly economy occurs through the addition of assets, not through growth in the payoff streams of a currently available asset.

Low Interest Rates and Mutual Trust

Suppose a household has a temporarily low income in a given year, compared to its average income realization. There are two ways for that household to smooth its consumption over that temporary downward blip in income: It can have saved from the past, or it can borrow from the future. In a well-functioning loan market, some households save and some borrow.

But now suppose borrowers become more tightly *constrained* in their ability to borrow. There are many ways to think about such frictions, but at their heart, they all represent an erosion of interpersonal trust. Suppose everyone knows, with certainty, that I will have $\$X$ next year. In principle, I should be able to borrow $\$X$. A borrowing constraint means that I cannot borrow the full $\$X$, even though everyone knows that I will have $\$X$. I am not *trusted* to fulfill my obligation—because of my personal characteristics, because of legal institutions, or both.

More severe borrowing constraints mean that more households will try to smooth their consumption by saving, and fewer by borrowing. In terms of basic economics, the supply of savings has fallen relative to the demand, and the market for savings can only be equilibrated by the interest rate r falling. It is when the supply of savings is so small that r falls below g that bubbles can occur.

To understand why bubbles occur, it is useful to think through why people save. Savers defer consumption from the current period to some future date, when it is more valuable to them. For example, in a model with incomplete markets, a saver gives up current consumption in order to have more consumption at some later date when his income will be low. In an overlapping generations economy, the saver gives up consumption today for consumption when he is older. Borrowing constraints make it hard for savers to accomplish this deferral of consumption. The saver simply cannot trust borrowers to make repayments when needed.

Bubbles allow savers to defer consumption without the aid of individual borrowers. The saver buys the bubbly asset at an elevated price today and then sells it when he needs consumption. The key is that he anticipates (with reasonable confidence) that there will be a buyer willing to buy the bubbly asset at that critical point in the future. In this sense, a bubble is a form of collective trust. Savers are unwilling to lend $\$X$ to a given borrower, because the borrower may not repay the loan. However, savers are willing to invest $\$X$ in a bubbly asset, because they feel confident that they can sell the asset for an elevated price in the future. Bubbles substitute collective trust for individual trust.

In this sense, bubbles expand the range of what people can accomplish. The problem is that arrangements based on mutual trust are intrinsically unstable. In the future, buyers of the asset may have considerably more doubt in their ability to resell. This doubt can lower the future price of the asset and potentially eliminate the bubble permanently. Thus, fluctuations in the mutual trust that underlies the bubble can lead to fluctuations in a bubbly asset's value and the ability of people in the society to effectively transfer wealth across periods.

B. Macroeconomics of Bubbles

In this section, I turn to the consideration of optimal fiscal policy in the context of a bubble.

Responding to Ongoing Bubbles

I begin with the first question that arises in any discussion of bubbles: How can governments "pop" bubbles? I've argued that bubbles represent a form of collective trust. Person A is willing to pay a price above fundamentals for land because he believes that the bubble component of the price will grow at the rate of return. That belief relies on person A's trust that someone else will be willing to pay that higher price at some point in the future.

Of course, I say collective trust—others might say collective delusion. Whatever one might call it, though, I see no easy way to end it. On the one hand, it is not clear if private citizens will be greatly influenced by government statements about land or other assets being overvalued. On the other hand, as I will show in the next section, the consequences of a bubble suddenly bursting can be extremely adverse. Even if a government has the ability to reduce a bubble, it would prefer to do so only gradually—deflate it rather than pop it.

The government can attempt to replace a *private sector* land bubble with a *public secto*r bubble in its debt. Suppose that the government gauges that the total bubble across all private sector assets is $\$Y$. The government can try to siphon off this bubble by offering Y dollars of debt for sale, where the debt pays real interest rate r. Because there is a bubble, the real interest rate is no larger than g, and so the government can then roll this debt over perpetually. Under this policy, there is an equilibrium in which the price of the private sector assets reverts to fundamentals and the bubble is transferred to government debt.

This kind of shift is attractive in some ways if the public debt bubble is regarded as being more stable than the private sector's bubble. However, the shift will make some agents worse off, and the bubble in public debt may also be unstable.[8]

[8] Because of the government's ability to tax, public sector bubbles may be more stable than private sector bubbles. See Caballero and Krishnamurthy (2006) for a full discussion.

The Consequences of a Bursting Bubble

With any bubble, there is some probability that it will fall in size—possibly greatly. This shrinkage in the size of the bubble can have significant effects on an economy. As I've argued earlier, bubbles emerge in response to significant borrowing frictions. Bubbles insulate economies against the impact of these frictions by providing savers a vehicle with which to transfer current resources into the future. A fall in the bubble's size reduces the ability of savers to save.

With that in mind, the exact impact of the bubble's collapse depends on the role of asset accumulation in the economy. However, a bubble bursting generally has two key consequences. First, because the bubble contributed to the supply of savings in the economy, its collapse means that the supply of savings has fallen, and so the real interest rate should fall. Moreover, a burst bubble has a low or zero value today because people expect its value to be low or zero in the future. The fall in the real interest rate is therefore likely to be persistent.

Second, some agents held bubbly assets and others did not. The fall in the value of the bubbly asset redistributes wealth from the bubbly asset holders to the nonholders. The persistence of this effect depends on the law of motion of the distribution of wealth in the society. In many models with borrowing constraints, the long-run distribution of wealth is invariant to shocks. In such models, this latter effect will be transitory.

The fall in the real interest rate and the redistribution of wealth can impact the economy in a number of ways. I'll focus on the implications for labor supply[9] and investment. Bubbly asset holders are less wealthy after the bubble's collapse, and so are more willing to supply labor, while nonholders are less willing to do so. At the same time, the fall in the real interest rate retards labor supply for everyone. Overall, the impact of the bubble's collapse on aggregate labor supply, and on aggregate output, depends critically on the joint distribution of labor productivities and asset holdings in the economy. If the holders of a bubbly asset

[9]This discussion is reminiscent of the behavior of the equilibrium described in Scheinkman and Weiss (1986).

have high labor productivities, then the bubble's collapse may actually increase output as asset holders supply more labor.

The fall in the real interest rate after a bubble bursts will increase the demand for investment goods. Firms and others with nonbubbly sources of resources should engage in more investment. However, a bubbly economy is an economy with significant credit constraints. When the bubble is large, it is likely to be entrepreneurs and firms who anticipate having good investment projects who are holding the bubbly assets.[10] If the bubble bursts, they lose that source of funds. Given the credit constraints that generated the bubble in the first place, they will be unable to take advantage of desirable projects.

What Should Be Done After a Bubble Bursts?

As I described above, the bursting of the bubble has two consequences for an economy: a fall in the real interest rate and a redistribution of wealth. The government can potentially fix both problems.

To fix the first problem, it can issue one-period debt with real interest rate r, where r was the real interest rate before the bubble burst. It can then commit to roll that debt over forever. If credible, this commitment will serve to raise the real interest rate permanently. The fresh debt gives savers the needed vehicle for savings.

Since the bubbly interest rate r was less than or equal to the growth rate g, this perpetual rollover plan is feasible without any extra taxes ever being collected. However, it does rely on the same kind of mutual trust that supported the bubble. At any date, people are willing to buy the debt today only because they believe that the government will be able to pay it off with a future sale of debt. Instability in this chain of beliefs may lead to the government having to raise taxes or default.

The debt rollover plan provides the government with extra resources. As well, the increase in the interest rate generates more labor supply and more output. The government can generate even higher levels of output after the bubble's collapse by allocating these funds

[10] This discussion is reminiscent of that in Kiyotaki and Moore (2008).

in an appropriate way. For example, it can target the funds to people with relatively low labor productivities. Given the usual wealth effects on labor supply, this shift in the distribution of wealth from highly productive to less productive workers will generate higher output.[11] Similarly, the government could generate higher output by targeting funds to entrepreneurs with highly productive investment projects. It may be hard for the government to identify the relevant targets in the above scheme. A more feasible option might be to allocate government funds so as to re-create the distribution of wealth that existed under the bubble. By doing so, the government can also re-create the higher levels of output that existed under the bubble.

This distribution of funds can work in many ways. Consider a person A who has a mortgage from bank B with principal \$200,000. A's property was worth \$300,000 at the peak of the bubble and is now worth \$150,000. How should the government allocate the proceeds of its new debt issue between A and B? There are many ways to proceed, but my favorite is that the government pays B \$150,000 to write down the value of the mortgage to \$50,000. I like this approach because A keeps her property and again has \$100,000 of equity in her property. In addition, B has a (presumably viable) debt worth \$50,000 from A and has received \$150,000 from the government.

This strategy is reminiscent of many suggested foreclosure mitigation plans. However, within the context of the model, the government can only recapture the bubbly distribution of wealth by using the same strategy regardless of when A bought her property or how she financed it. For example, suppose A bought the property for \$100,000 cash in 1995, its value rose to \$300,000 in 2006, and after the bubble burst, the property is now worth \$150,000. To restore the bubbly distribution of wealth, the government should simply give A \$50,000 to replace the lost bubbly wealth.

[11] These same wealth effects imply that the government could also generate higher output by spending its new resources on public goods. The welfare consequences of such an approach depend on the details of how those public goods affect private agents.

C. But Is It a Bubble?

I've described how a government should use debt management to respond to the emergence of, and the collapse of, a bubble in land prices. I've done so in the context of models in which everyone agrees that there is a bubble in land prices. In reality, we always face the question: How do we know if a given run-up in land prices is due to a bubble or due to fundamentals? Answering this question is always hard.

However, the above discussion suggests that it is better to ask a different—perhaps easier—question. In the models that I consider, the desirable interventions involve the government raising interest rates and then raising revenue through a debt issue. Because $r \leq g$ in the bubbly economies, the government can plan on rolling the debt over perpetually. In this way, the interventions can raise resources today without requiring new taxes in the future.[12]

Of course, the models in this paper are artificially deterministic. In reality, these interventions always run the risk of requiring the government to raise taxes in the future if interest rates move in the wrong direction. For example, the 10-year real yield on indexed TIPS bonds is currently less than 1%. The government could issue more of these bonds. However, in 10 years, it will need to pay the principal on these bonds, and it does not know what the real interest rate (or expected growth rate) will be then.

So, in the models that I use in this paper, the government can construct a costless intervention that makes everyone better off after a bubble bursts. In alternative models, the intervention may have costs. Nonetheless, I conjecture that there are many models in which large falls in asset prices would prompt governments to *contemplate* fiscal interventions. The point is that in any model with borrowing constraints, large asset price run-ups—whatever their source—provide agents with a larger supply of savings. If the asset's price falls, the pool of savings shrinks, and the real interest rate will fall. In reaction, just as in the model

[12] Abel, Mankiw, Summers, and Zeckhauser (1989) consider dynamic efficiency in overlapping generations economies with aggregate shocks. They show that in these models, one cannot reliably evaluate dynamic efficiency by comparing average risk-free interest rates to average growth rates. This conclusion applies to my model as well. Their solution is to use the sign of net inflows into firms. This solution is valid in their context, but does not work in my model with financial constraints. (Kraay and Ventura (2007) make a similar point.)

in this paper, the government can sell more of its own debt and make well-chosen transfers.[13] In the models in this paper, this intervention could be done without any costs to anyone. In a broader class of models without bubbles, the government's intervention would necessarily expose some taxpayers—maybe in the future—to some loss of income. These potential losses mean that the government must face hard distributional questions about the optimality of intervention.

4. Conclusions

Many observers have characterized land as having been overvalued in the 2000s relative to fundamentals. In this paper, I have explored two distinct models of that overvaluation. In the first, overvaluation emerges as a result of implicit guarantees for bank creditors (depositors and debtholders). In the second, overvaluation is a consequence of a rational bubble. I've described appropriate regulatory and fiscal responses in these models.

It should go without saying that these analyses are contingent on particular models. An important topic for future research is the evaluation of the robustness of the results in this paper to other modeling approaches.

[13] These kinds of interventions are studied by Aiyagari and McGrattan (1998).

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Appendix 1

I'll describe a simple abstract two-period model. The key feature of the model is that bank debtholders have debt guarantees. These debt guarantees drive up the price of an asset that is in fixed supply.

There are equal numbers of four types of economic actors: owners, buyers, bank equityholders, and bank debtholders. (Actually, there is a fifth type of actor—taxpayer—who exists outside the model.) All people are risk-neutral, and they do not discount between the two periods. The owners each own an asset that pays off V units of consumption in period 2. Here, V is random, with cdf Φ and density ϕ over support $[V_{\min}, V_{\max}]$. The assets' payoffs are always equal to one another, because I want to focus on aggregate risk. The owners don't desire consumption in period 2, but do desire consumption in period 1, and so are willing to sell to the buyers.

The buyers buy the assets from the owners at an endogenous price p. The buyers are required to put down a down payment of αp, where α is exogenous. They borrow the remaining $(1-\alpha)p$ from the banks using debt with an endogenous face value F_{land} (to match up with the notation in the paper). The loan is collateralized only by the asset itself. Hence, the buyers get a random payoff equal to

$$\max(V - F_{land}, 0)$$

from their purchase.

I assume that the bank faces an exogenous restriction κ on its debt/equity ratio. (This is supposed to stand in for capital requirements or, more meaningfully, for leverage caps.) Bank debtholders make a loan with an endogenous face value F_{bank} to the bank equityholders. The equityholders enjoy limited liability, and so they receive a payoff equal to

$$\max(\min(V, F_{land}) - F_{bank}, 0).$$

The bank's debtholders are fully guaranteed by the government against any losses from fluctuations in V. Hence, their payoff in period 2 is simply the loan amount F_{bank}.

Trade is competitive within the model.[14] It follows that the buyers' down payment must equal the period 1 expected value of their period 2 payoff:

$$\alpha p = \int_{V_{\min}}^{V_{\max}} \max(V - F_{land}, 0)\phi(V)dV$$

As well, the bank owners' payment to the buyers must equal the expected value of their period 2 payoffs:

$$(1-\alpha)p = F_{bank} + \int_{V_{\min}}^{V_{\max}} \{\max(\min(V, F_{land}) - F_{bank}, 0)\}\phi(V)dV$$

Finally, the leverage restriction implies that:

$$\kappa \int_{V_{\min}}^{V_{\max}} \{\max(\min(V, F_{land}) - F_{bank}, 0)\}\phi(V)dV = F_{bank}$$

so that the debt/equity ratio equals κ. (I'm requiring the bank to issue as much debt as possible. However, given the existence of the bailouts, the bank will find this behavior at least weakly optimal.) We can find the endogenous asset price p, asset loan face value F_{land}, and bank loan face value F_{bank} by solving the above three equations (given the down payment α and the leverage cap κ).

Without debt guarantees, the risk neutrality of the people in the model implies that the asset price $p = E(V)$. However, the presence of the debt guarantees can make the asset price higher than $E(V)$.

Proposition 1. *If* $(1-\alpha)E(V)/(1+1/\kappa) \leq V_{\min}$, *then* $p = E(V)$. *If* $(1-\alpha)E(V)/(1+1/\kappa) >$

[14] There are a variety of ways that trade could be structured. The only requirement is that, in equilibrium, the buyers, bank equity-holders, and bank lenders compete among themselves so as to maximize the price p that buyers bid for a given piece of land, given the zero economic profit constraints described below.

$V_{\min}$, *then* $p > E(V)$, *and* p *is the unique solution to the equation*

$$p = \int_{V_{\min}}^{(1-\alpha)p/(1+1/\kappa)} [(1-\alpha)p/(1+1/\kappa) - V]\phi(V)dV + E(V).$$

Proof. Note that $\min(x, c) + \max(x, c) = c + x$, and so $\min(x, c) + \max(x - c, 0) = x$. This simple mathematical relationship plays a key role in what follows. Consider the zero profit conditions for the banks and the asset buyers

$$\begin{aligned}
(1-\alpha)p &= \int_{V_{\min}}^{V_{\max}} \max(\min(V, F_{land}) - F_{bank}, 0)\phi(V)dV + F_{bank} \\
&= \int_{V_{\min}}^{V_{\max}} \min(V, F_{land})\phi(V)dV + \int_{V_{\min}}^{V_{\max}} (F_{bank} - \min(\min(F_{land}, V), F_{bank})\phi(V)dV
\end{aligned}$$

$$\alpha p = \int_{V_{\min}}^{V_{\max}} \max(V - F_{land}, 0)\phi(V)dV.$$

Adding these together, I get

$$p = E(V) + \int_{V_{\min}}^{V_{\max}} (F_{bank} - \min(\min(F_{land,} V), F_{bank})\phi(V)dV.$$

The leverage restriction says that

$$\kappa \int_{V_{\min}}^{V_{\max}} \{\max(\min(V, F_{land}) - F_{bank}, 0)\}\phi(V)dV = F_{bank}.$$

If $F_{land} \leq F_{bank}$, then $F_{bank} = F_{land} = 0$. Hence $F_{bank} < F_{land}$. It follows that

$$p = E(V) + \int_{V_{\min}}^{V_{\max}} [F_{bank} - \min(F_{bank}, V)]\phi(V)dV.$$

The leverage restriction implies that

$$F_{bank}(1 + \kappa^{-1}) = (1-\alpha)p$$

and so

$$
\begin{aligned}
p &= E(V) + \int_{V_{\min}}^{V_{\max}} [(1-\alpha)p/(1+\kappa^{-1}) - \min((1-\alpha)p/(1+\kappa^{-1}), V)]\phi(V)dV \\
&= E(V) + \int_{V_{\min}}^{(1-\alpha)p/(1+\kappa^{-1})} [(1-\alpha)p/(1+\kappa^{-1}) - V]\phi(V)dV. \qquad (4)
\end{aligned}
$$

If I set $p = E(V)$, the LHS is no larger than the RHS. If I set $p = V_{\max}(1+\kappa^{-1})/(1-\alpha)$, then the LHS is larger than the RHS. Hence, there exists a solution. The derivative of the LHS of the equation (4) with respect to p is 1. The derivative of the RHS is

$$
(1-\alpha)\Phi((1-\alpha)p/(1+\kappa^{-1}))/(1+\kappa^{-1}) < 1.
$$

It follows that there is a unique solution to (4).

If $E(V)(1-\alpha)/(1+\kappa^{-1}) \leq V_{\min}$, then $p = E(V)$ satisfies this equation. If $E(V)(1-\alpha)/(1+\kappa^{-1}) > V_{\min}$, then $p = E(V)$ does not solve this equation, because the right-hand side is larger than the left-hand side. It follows that $p > E(V)$ and solves the equation in the proposition. □

If the down payment requirement α is sufficiently small or the leverage cap κ is sufficiently large, then debt guarantees lead the asset's price to be larger than its fundamental value $E(V)$. The degree of "mispricing" is decreasing in α and increasing in κ.

Here, I've treated the down payment requirement α as exogenous. It is worth noting that if $E(V)/(1+1/\kappa) \leq V_{\min}$, the banks are indifferent across the choice of down payment requirement, because $p = E(V)$ regardless of the down payment requirement. However, if $E(V)/(1+1/\kappa) > V_{\min}$, the price of the asset is a strictly decreasing function of α. Under this condition, if banks are allowed to choose their own α and F_b, they will compete the down payment requirement down to whatever minimum regulators might allow.

In the same vein, if banks can choose their debt/equity ratio, they will compete κ up to infinity. If $\alpha = 0$ and $\kappa = \infty$, then $p = V_{\max}$. The bank is fully debt-financed. Its debt has a face value of $V_{\max}$, and the loan to the asset-buyer also has a face value of $V_{\max}$. The asset-buyer defaults almost always, and the bank defaults almost always on its obligation to its debtor. As a result, the government is forced to pay the debtor $V_{\max} - V$ when the value of the asset is V.

Appendix 2

Consider an economy with equal measures of infinitely lived odd and even agents. Odd agents are productive in odd periods; they produce n_t units of consumption by exerting n_t units of effort in those periods. They are unproductive in even periods. Even agents are productive in even periods; they produce n_t units of consumption by exerting n_t units of effort in those periods. They are unproductive in odd periods.

Agents have a momentary utility function

$$\ln(c_t) - n_t$$

and a discount factor equal to β, where $0 < \beta < 1$.

Suppose agents are able to borrow and lend with one another using one-period bonds, subject to a borrowing constraint of the form that requires their bond holdings to be larger than $-B$

$$b_{t+1} \geq -B.$$

This means that their flow constraint looks like

$$c_t + b_{t+1} \leq w_t n_t + b_t(1 + R_t)$$

where $w_t = 1$ when the agent is productive and 0 when the agent is unproductive.

A. Borrowing Constraints and Interest Rates

For the moment, I focus on stationary equilibria in which R is constant. This means that I'm assuming that the initial asset position of the odd agents equals $-B(1+R)$ and the initial asset position of the even agents equals B.

The equilibrium consumptions, effort, and interest rate satisfy

$$c_{prod} + B = n - B(1 + R)$$

$$c_{unprod} - B = B(1 + R)$$

$$\beta c_{prod}(1 + R)/c_{unprod} = 1$$

$$1/c_{prod} = 1.$$

I can solve these equations to get[15]

$$\begin{aligned} (5) \quad (1 + R) &= (B^{-1}\beta - 1)^{-1} \\ c_{unprod} &= B(2 + R) \\ c_{prod} &= 1 \\ n &= 1 + B(2 + R). \end{aligned}$$

It follows that R **is an increasing function of** B. As B falls, so does the equilibrium interest rate.

B. Bubbles

The equilibrium interest rate is less than 0 iff

$$B < \beta/2.$$

I claim that, for any such B, I can construct an equilibrium with a bubble. In particular, endow each of the even agents with a unit of land that pays no dividend. Suppose that agents can trade land and one-period debt in each period. They cannot short-sell land, and

[15] I'm assuming that B is sufficiently low that

$$1/c_{unprod} - \beta(1 + R) > 0$$

so that the unproductive agents have binding borrowing constraints. This is true for an interval of B that is bounded from above by $\beta/(1 + \beta)$.

they cannot borrow more than B in each period. Then, their budget sets are defined by the constraints

$$c_t + b_{t+1} + L_{t+1}p_t = w_t n_t + b_t(1+R) + L_t p_t$$

$$L_t \geq 0$$

$$b_t \geq -B$$

where L_t is the agent's landholdings at the beginning of period t and p_t is the price of land in period t.

There is an equilibrium (as defined above) in which $R < 0$ and land has no value. But there is also an equilibrium in which R is constant at 0 and land has constant value p

$$c_{prod} = 1$$

$$c_{unprod} = \beta$$

$$n = 1 + \beta$$

$$p = \beta - 2B.$$

The bubble in land allows agents to engage in more effective intertemporal trades. **Output is higher with the bubble, the unproductive agents consume more, and the productive agents consume the same.**

C. Crowding Out Bubbles

I've described two possible equilibria in the economy with land. There are a host of others that feature stochastic fluctuations in land prices over time. A government may wish to implement policies that remove this source of instability from the economy.

Suppose that the economy is in the bubbly equilibrium described above. In a given period t, the government in period t offers $\beta - 2B$ units of one-period debt for sale, with a commitment to keeping the real interest rate at $R = 0$ forever. (I assume that this offer was unanticipated in earlier periods.) The government uses the proceeds of the sale to buy goods from the productive agent. It repays the debt by rolling it over in perpetuity.

There are many equilibria in this economy. The government's interest rate offer is no different from that in the private market. Hence, agents may simply ignore the government's debt offer in every period. In this case, the bubbly equilibrium is unaffected by the government's policy.

However, there is also an equilibrium in which the price of land immediately falls to zero in period t. In that period, the productive agents produce $1 + \beta$ units of consumption. The government gets $\beta - 2B$ of that production, though, and the unproductive agents get only $2B$ units of consumption. In period $(t + 1)$, the economy returns to the bubbly equilibrium.

The government may be able to substitute a perpetual rollover in its own debt for a land bubble. However, the substitution may not work. If it does work, then owners of the private sector bubble will be made worse off.

D. Aftermath of a Bubble Collapse

As I indicated above, there is a continuum of stochastic equilibria in this economy. Consider, for example, that there is an equilibrium in which the price of land is positive and constant but may fall to zero with a small probability. (In terms of quantities, the aftermath of a "wholly unanticipated" bursting of the bubble is a good approximation to its bursting with a low but positive probability.) In the first period after the bubble bursts, the productive agents produce $1 + 2B$ units of consumption. The unproductive agents consume $2B$ units of consumption. Then, the agents live in the nonbubbly equilibrium (with the lower interest rate R defined by (1)) after the bubble bursts. From a macroeconomic point of view, there is a gradual (two-period) fall to a permanently new level of output.[16]

What is an appropriate response to the bursting of the bubble? I will think about

[16] In the wake of the bubble's collapse, the labor wedge grows. Labor productivity is unaffected by the fall in the bubble. However, the amount of labor falls. Through the lens of a representative household model, it would appear that there has been a shock that reduces the household's marginal utility of consumption.

three distinct policies. I will only consider their ex post consequences.

In all three policies, the government commits to sell an arbitrary amount of one-period debt with real return 0. **This part of the policy fixes the problem that the real interest rate is too low.** The government commits to collecting no new taxes. Hence, the government plans to repay the debt issue by rolling over the debt in each period.

Any debt rollover plan of this kind allows the government to generate extra resources in the first period after the bubble collapses. They differ in how the government spends those extra resources.

E. Public Investment

Consider a policy in which the government uses the resources from its debt issue to fund public projects that are additively separable from the private economy. Then, in the first period after the bubble collapses, the productive agents produce $1 + \beta$, and there is no recession at all. Nonetheless, unproductive agents do suffer a loss relative to the bubbly equilibrium, because they only consume $2B$, rather than β. The government gets the other resources $(\beta - 2B)$ from its debt issue.

In the second period after the bubble's collapse, the economy reverts to the bubbly outcome (because $R = 0$). This longer-run effect is a consequence of any of the three policies.

F. Uniform Transfer

Suppose next that the government spreads the proceeds of the debt issue evenly across all agents. (Somewhat unrealistically, I think about this redistribution as happening in the first period after the bubble collapses. Thus, the government is redistributing the results of the debt issue simultaneously with actually doing the debt issue.)

Then, in the first period after the bubble collapses, the productive agents produce $1+\beta/2+B$. They spend $\beta-2B$ on the government's debt issue, receive $(\beta-2B)/2$ back as a transfer, repay their debt of B units of consumption to the unproductive agents, and lend B units of consumption to the unproductive agents. Unproductive agents consume $\beta/2+B$.

There is a one-period recession. In this sense, the fiscal multiplier associated with transfers is lower than that associated with public goods expenditures. The lower fiscal multiplier is generated by a wealth effect: Giving resources to productive agents leads them to work less hard.

G. Directed Transfer

Finally, suppose the government gives out the proceeds of the debt issue only to unproductive agents (again as the debt issue is taking place). Now, the distribution of wealth is the same as in the bubbly economy and the equilibrium interest rates are the same. The equilibrium from this policy exactly mimics the bubbly equilibrium outcome.

H. Intuition

Intuitively, there are two effects from a bubble collapse. First, the real interest rate falls permanently because there are fewer vehicles for saving. Second, there is a redistribution of wealth from bubble owners to nonowners. The impact of the first effect is a permanent one, while the impact of the second effect is transient. It is relatively easy to solve the first problem, using appropriate fiscal policy. It is harder to fix the second, because it requires targeted transfers.