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Bridging between policymakers' and economists' views on bubbles

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Introduction and summary[1]

The policy debate over bubbles concerns the question of what policymakers should do when faced with a rapid increase in asset prices that does not coincide with corresponding changes in the value of the dividends these assets are expected to pay out. Such scenarios alarm policymakers (and the public), because the rapid inexplicable increase in asset prices may indicate that asset prices are too high, leaving markets vulnerable to an equally rapid price decline. As the terminology used to describe these episodes suggests, the concern is that under these circumstances, asset prices are as fragile as a soap bubble that can burst at the slightest touch or as a bubble of air that rises in a flute of champagne until it reaches its peak and then pops. The economic fallout from a sharp fall in asset prices can be severe, as evident from the collapse of U.S. house prices in the mid-2000s.

One striking aspect of the debate over how to respond to bubbles is the way in which this debate has largely ignored the theoretical models economists have devised to study bubbles. For a variety of other economic questions, it is quite common for policymakers to seek guidance from economic models to help them formulate economic policy, much in the way that engineers consult models of the physical world when they design and build bridges. For example, central banks have long used macroeconomic models to guide them on what type of monetary policy would best allow them to meet their mandate to maintain a stable economy.[2] Similarly in the area of fiscal policy, the Congressional Budget Office uses economic models to capture how households respond to different policies that affect government revenues and expenditures. The results inform policymakers about the likely fiscal impacts of the various policy proposals they consider.[3]

When it comes to asset bubbles, however, the theoretical models economists have devised to study this very phenomenon have not been integrated into policy analysis. Here, I am specifically referring to a line of research that tries to be precise about what it means for an asset price to be too high and to explain when and why this might happen. To economists, the value of an asset derives from the dividends it pays out. By this logic, the price at which an asset should trade is the present discounted value of the dividends

it is expected to generate over its lifetime, also known as the asset's fundamental value. Ordinarily, people would be reluctant to pay more for an asset than the value of the dividends it is expected to yield. Likewise, if an asset sold for less than the value of the dividends it was expected to generate, investors should view it as a bargain and rush in to buy it, bidding up its price. And indeed, in many economic models, assets are predicted to trade at their fundamental values. Economists would, therefore, define a bubble as an asset that trades at a price that differs from its fundamental value.[4] And although many models predict that bubbles will not arise, economists have devised models in which an asset can trade at a price that is too high, in that it exceeds its fundamental value. These models can presumably speak to the concern that asset prices can sometimes be too high. Nevertheless, these models have not figured prominently in the discussion of how policymakers ought to respond if they suspect a bubble. To the contrary, it is not uncommon to hear policymakers dismiss such models as esoteric and of limited practical interest. When I first presented a version of this article in a panel session at an academic conference on the topic of asset bubbles, one conference participant volunteered that whenever they presented their theoretical work on asset bubbles at central banks, there was always a sharp contrast between the initial enthusiasm with which they were greeted before their presentation and the generally tepid response afterwards.

To be sure, models of bubbles are not the only types of models that can provide information about large asset price swings of the kind that worry policymakers. For example, Kiyotaki and Moore (1997) and Brunnermeier and Sannikov (2014) study economies with financial frictions in which asset prices are highly volatile. In these models, there are shocks that do not affect dividends directly but do affect which agents hold assets and, thus, how efficiently assets are allocated. When assets are allocated less efficiently, their price will drop. Related work by Fostel and Geanakoplos (2008) assumes agents value assets differently because they hold different beliefs or have different attitudes toward risk. In their model, a shock that induces a change in the identity of the marginal trader who holds the asset may lead to a big change in the price of the asset without any change in the underlying dividends. While these models can also explain why asset prices might be volatile, they do not imply that asset prices are excessive relative to the dividends they generate. The reason I restrict my attention to models of bubbles is that the debate about how policymakers should respond to asset prices is often framed in terms of bubbles, precisely because policymakers are worried that asset prices are somehow too high. While it is essentially impossible to measure the fundamental value of long-lived assets and definitively establish whether they are in fact overpriced, theoretical models in which a bubble can arise ought to be useful for developing insights on why overpricing might occur and what would be an appropriate policy response to it. Yet so far, policymakers have not relied on such models to guide their thinking about policy.

In this article, I offer some thoughts on why there is such a gap between policymakers and researchers when it comes to asset bubbles. I argue that existing theoretical models of bubbles have yet to effectively address the questions that policymakers are most interested in. I go on to discuss how existing theories can potentially be used to address these questions in the future. The message I wish to convey is that even if policymakers find little in existing work on bubbles that can illuminate the questions they find important, there is scope for theoretical work on bubbles to either address these questions going forward or to convince policymakers that the answers it already does provide are useful. It should, therefore, be possible to bridge the gap between the theoretical literature on bubbles and the types of issues policymakers care most about. In what follows, I first describe the key questions that occupy policymakers who are concerned about the prospect of asset bubbles. I then discuss what the existing theoretical literature has to say about these key questions and how these models might eventually be used to shed light on the questions policymakers care most about.

Policymakers' views on bubbles

Prior to the global financial crisis that started in 2007, the debate over how policymakers ought to respond to asset bubbles focused largely on two particular policies. One of these calls for a central bank to raise interest rates when it suspects a bubble has developed in order to dampen it. The other calls for a central bank to wait and see what happens to the prices of assets suspected to be bubbles, then intervene if necessary if and when prices fall. According to this view, a central bank should intervene only if asset prices collapse, and then only if there is reason to intervene to avoid negative fallout from the crash.

The first option, raising rates in the face of a potential bubble, has come to be known as "leaning against the wind." Trichet (2005) offers a nice explanation of what this approach entails:

> The leaning against the wind principle describes a tendency to cautiously raise interest rates even beyond the level necessary to maintain price stability over the short to medium term when a potentially detrimental asset price boom is identified. ... The central bank conducts a slightly tighter policy in order to better ensure price stability over extended horizons by possibly containing the future growth of the bubble—or at least not to accommodate it—than it would otherwise if confronted with a similar macroeconomic outlook under more normal market conditions.

Even before the financial crisis, papers such as Borio and Lowe (2002) were arguing that the historical evidence suggests that periods of rapid asset price growth are often followed by recessions and financial crises, especially if the rise in asset prices is accompanied by a rapid growth in credit. On the basis of these patterns, they argue that central banks facing a rapid increase in asset prices should actively try to dampen asset prices by raising interest rates, even if it is unclear whether the increase in the price of assets corresponds to an asset bubble as economists would define it.

An alternative policy option, articulated in Bernanke and Gertler (1999), argues that central banks should hold off on responding to rapid asset price increases and intervene only if asset prices collapse in a way that endangers economic activity. This is the wait-and-see approach. The key point Bernanke and Gertler emphasize is that raising interest rates represents a blunt intervention that affects not only asset prices but also economic activity and inflation. Thus, they argue that acting to stabilize asset prices can interfere with a central bank's mandate for macroeconomic stability. If the surge in asset prices itself contributes to inflation and economic overheating, a central bank committed to stabilizing output and prices should certainly respond to make sure the economy doesn't overheat and that inflation doesn't rise above its target rate. But, they argue, a central bank should not intervene if asset prices rise without overheating. Indeed, a central bank should not intervene even if a surge in asset prices is likely to result in an eventual fall in asset prices that could threaten economic activity. The reason is that a central bank should in principle be able to shield the economy from such fallout by lowering interest rates after asset prices fall to keep the economy growing at its natural rate. This response to asset bubbles has sometimes been described as waiting to "mop up" the mess after the crash, which is why the debate over bubbles has at times been described as the "lean versus clean" debate.

Although the relative merits of these two approaches were actively debated before the financial crisis, policymakers largely tended to take the wait-and-see approach. This may be due in part to the U.S. experience with the boom and bust in technology stocks in the late 1990s, an episode often referred to as the dot-com bubble. As the share prices of companies specializing in information technology shot up, the Fed refrained from responding by raising interest rates. Then-Fed Chairman Alan Greenspan did publicly question how policymakers would know if high asset valuations were driven by irrational exuberance, comments that attracted considerable attention at the time and were widely interpreted as concern about the rise in the

price of equities (Greenspan, 1996). But beyond Greenspan's speech, the Fed did not signal any inclination to use interest rate policy to respond to what some had decried as a potential bubble. After the price of technology stocks collapsed and economic activity began to contract, the Fed proceeded to cut interest rates aggressively. The fact that the 2001 recession proved to be rather mild was taken by many as evidence that the wait-and-see approach could work well in practice, and that waiting to intervene could still be effective in limiting the fallout from an asset price collapse.[5]

However, the global financial crisis that started six years later led many policymakers to reassess the merits of the wait-and-see approach. In contrast to the mild 2001 recession that followed the collapse of dot-com stocks, the recession that followed the fall in U.S. house prices in the mid-2000s was severe and prolonged. Central bankers came to view the wait-and-see approach as potentially costly. First, it became clear that a failure to intervene while asset prices are rising may allow risks to accumulate and expose financial intermediaries to larger losses that leave the financial system vulnerable to a systemic crisis. Second, the severity of the recession following the collapse in house prices exposed the limits of central banks in stimulating economies hit by especially large shocks, due to the effective lower bound on the nominal interest rates central banks could set. Although central banks did develop new tools to get around constraints on interest rates, such as quantitative easing, forward guidance, and negative interest rates, most policymakers viewed having to resort to these tools instead of traditional monetary policy tools as an undesirable position for a central bank to be in. The prevailing view in policy circles on how to deal with bubbles thus shifted away from the wait-and-see approach and toward a view that policymakers confronted with a potential asset bubble should move in some way to contain it. The question now was what the best way to contain a growing asset bubble might be.

From "lean versus clean" to "lean versus screen"

Even as policymakers began to view the wait-and-see approach as too costly in the wake of the global financial crisis, they remained troubled by the original critiques of the lean-against-the-wind approach.

The resulting shift in thinking led to a view in which some sort of action by central banks in the face of rapidly rising asset prices was probably called for, but not necessarily one that involves an increase in interest rates. One alternative approach to reining in potential bubbles that gained popularity in policy circles focused on macroprudential policies. This approach argues that central banks should supervise and regulate banks in a way designed to safeguard the financial system as a whole rather than to ensure the health of individual banks. The two might conflict if the decisions that improve the outlook of an individual bank, such as liquidating risky assets or buying up certain assets in an attempt to diversify a given bank's holdings, may imperil the banking sector as a whole.[6] Rather than raising interest rates when asset prices rise, this approach argues, central banks should closely monitor how exposed financial intermediaries are to asset bubbles and whether these intermediaries are contributing to the growth of these bubbles. Central banks should then intervene to restrict the type of lending banks can do or the terms at which they lend in an effort to either dampen the bubble or potentially mitigate the fallout if asset prices crash. For example, central banks could move to restrict the type of lending that pushes up asset prices or the use of contracts that facilitate speculative trading.[7]

The view that macroprudential policies can serve as an alternative tool against asset bubbles relies on the idea that credit is an important driving force behind asset bubbles, or at least the type of asset bubbles that policymakers are most concerned about. For example, Mishkin (2011) makes a distinction between what he calls irrational-exuberance bubbles and credit-driven bubbles. He views the boom and bust in the price of technology stocks in the late 1990s as an example of the former and argues that these do not have a

profound impact on the economy. By contrast, he argues that bubbles in which credit plays a key role should be viewed as a particular source of concern for policymakers. He writes:

> [N]ot all asset price bubbles are alike. Financial history and the financial crisis of 2007–2009 indicates that one type of bubble, which is best referred to as a credit-driven bubble, can be highly dangerous. With this type of bubble, there is the following typical chain of events: Because of either exuberant expectations about economic prospects or structural changes in financial markets, a credit boom begins, increasing the demand for some assets and thereby raising their prices. ... At some point, however, the bubble bursts. The collapse in asset prices then leads to a reversal of the feedback loop in which loans go sour, lenders cut back on credit supply, the demand for the assets declines further, and prices drop even more.

If the trading of bubble assets is financed by credit, then an intervention that limits the amount that financial intermediaries can lend against bubble assets may be an effective way to rein in bubbles without requiring an increase in interest rates. The lean versus clean debate from the period before the financial crisis thus evolved into a lean versus screen debate in the wake of the crisis, or a debate between raising rates to stem a bubble and using oversight and regulation to curb resources from flowing into overheated asset markets.

One advantage of the macroprudential approach over interest rate policy is that it can potentially be targeted toward particular financial institutions and particular assets without affecting macroeconomic outcomes more broadly. This has certainly increased the appeal of this approach among policymakers who were already concerned about using blunt tools to combat asset bubbles. However, others have argued that a regulatory approach will only invite innovation to circumvent whatever regulations central banks can come up with. As Stein (2013) puts it, raising rates "has one important advantage relative to supervision and regulation—namely that it gets in all of the cracks." That is, although financial intermediaries may be able to get around restrictions on what assets they can lend and at what terms, they cannot avoid competing with the short-term nominal interest rate set by the central bank. As policymakers have shifted to favoring a more proactive stance against bubbles, the policy debate has focused on a choice between interest rates and regulation as the right tool for fighting bubbles.

Are policies designed to fight bubbles effective?

Whereas Stein (2013) argued that monetary policy is likely to be more effective in reining in bubbles than macroprudential policy given that it is harder to circumvent, some recent work has argued that, for quite different reasons, raising rates may be ineffective or counterproductive at reining in bubbles. An example of this critique is the debate about the move by the Riksbank to raise short-term interest rates in Sweden in 2010 out of concern about a potential bubble in housing markets. This move was highly criticized both at the time and subsequently by Lars Svensson, who was deputy governor at the Riksbank at the time of the rate increase. The fact that the Riksbank later reversed course and lowered interest rates starting in late 2011, eventually setting negative rates, helped strengthen the impression that the original decision to raise rates out of a concern about a potential bubble was a mistake.

Svensson (2014) lays out his case against leaning against the wind, which he further elaborates in Svensson (2017). Part of his case mirrors the original critique by advocates of the wait-and-see approach that interest rates are too blunt an instrument and can work against the central bank's goals for macroeconomic stability. To make this point, Svensson uses a dynamic stochastic general equilibrium model of the Swedish economy maintained by the Riksbank to analyze what would have happened had the Riksbank kept the nominal interest rate unchanged rather than increasing it as it did. He finds that by moving to raise rates, the Riksbank increased unemployment above what would have prevailed had it kept the nominal interest

rate unchanged. He also finds that the Riksbank lowered the inflation rate to below its desired target of 2 percent. Although a central bank might be willing to trade off missing on its macroeconomic targets in order to reduce the probability of a financial crisis, Svensson points out that the Riksbank's own calculations suggest a miniscule reduction in this probability. In particular, the Riksbank used the work of Schularick and Taylor (2012) to estimate the probability of a financial crisis as a function of the growth rate of real debt. But Svensson argues that the decline in the probability of a financial crisis using the Riksbank's own calculations is insignificant, only 0.02 percentage points. Thus, he argues that the Riksbank effectively sacrificed its macroeconomic goals without getting much in return.

Moreover, Svensson goes on to argue that raising rates may well have been counterproductive and increased the likelihood of a financial crisis rather than slightly decreasing it. In particular, he posits that the probability of a crisis depends not on the growth of real debt but on the ratio of household debt to income. This is arguably a better measure of how financially stressed households are, since it compares their obligations with the resources they have to repay them. Using the same model of the Swedish economy maintained by the Riksbank, he computes the ratio of household debt to income in the counterfactual scenario in which the Riksbank had kept the nominal interest rate unchanged. He finds that according to the model, raising the interest rate increased the ratio of household debt to income. That is, even though raising rates slowed down the growth rate of debt, it slowed income even more. Thus, Svensson concludes, leaning against the wind in the case of Sweden "made any problem and risks with household indebtedness worse." The effective message of Svensson's paper is that even if raising rates is successful at dampening the bubble and reducing the growth of debt, it might be counterproductive by increasing stress on households and increasing the chance of a crisis.

The broader question that Svensson's analysis raises is what indicators a central bank can turn to if it wants to gauge whether its policy is working. Since it is typically impossible to determine the fundamental value of an asset, policymakers will be unable to directly observe whether their intervention is successful in dampening a bubble. What other measures could a central bank look at to infer that it is achieving its goals? Svensson suggests the ratio of household debt to income is the relevant indicator to gauge the probability of a potential crisis, as opposed to data on asset prices or the change in the amount of debt. Is this indeed the right measure or are there additional indicators that a central bank should look at? As policymakers shift toward favoring some sort of response to evidence of a potential bubble, these questions will become more pressing.

Summary of the questions policymakers care about

My review of the historical debate over the best way to respond to potential asset bubbles reveals several key themes and questions that policymakers have focused on. First, rightly or not, the policy debate is built on the premise that asset bubbles are destabilizing and distortionary. The various policy options that have been debated all focus on how policymakers can either eliminate bubbles altogether, rein them in, or minimize the harm they cause. At the same time, policymakers appear to be most concerned with the implications of a bubble bursting rather than the distortions that might occur when the asset is overvalued. Although the global financial crisis shifted the balance of opinion toward some type of response in the face of a potential bubble, policymakers continue to debate whether central banks should intervene early or wait. Given the uncertainty about whether interventions to combat bubbles are effective, this debate is likely to continue.

Another theme that emerges is that policymakers seem to be particularly alarmed by bubbles that are financed by credit and whose collapse may lead to financial distress both for households and for financial intermediaries that borrowed to purchase these assets and may default. If the lenders that ultimately financed the purchase of the bubble assets experience significant losses, they may not be able to continue their lending activities in the future at the same pace. This may have devastating consequences for a modern economy

in which credit is essential for economic activity. In addition, households that are unable to borrow may curb their spending, leading to a contraction in economic activity even if producers remain able to borrow. But if policymakers are particularly keen on reining in bubbles that are financed by credit, they can potentially move against such bubbles by restricting credit rather than by raising rates—the essence of the lean versus screen debate. However, not all of the historical episodes believed to be bubbles feature the same prominent role for credit. Policymakers have been worried about bubbles in the past even when credit did not play a major role and may return to worrying about such bubbles in the future if the next crisis involves bubbles that are largely self-financed.

One last theme that emerges from the historical debate is that policymakers need some way to figure out whether their policy is effective. This issue is particularly acute given the difficulty in measuring the fundamental value of an asset and ascertaining the extent to which it is or may have been overvalued. In his critique of the lean-against-the-wind approach in Sweden, Svensson argued that the ratio of household debt to income is one relevant metric for the likelihood of a financial crisis. Is this the metric that theory implies policymakers should focus on? Or are there other variables and outcomes that policymakers can look at to determine whether their actions may reduce the likelihood of a crash or the severity of a crash if it occurs? If a central bank intervenes in a way that drives down the price of assets suspected to be bubbles, how will policymakers know if the central bank simply precipitated the crisis it was trying to avoid or if the outcome would have been worse without intervention?

These are the types of questions that policymakers would presumably want theoretical models of bubbles to answer. But I will argue next that existing models of bubbles either fail to shed light on these questions or have failed to convince policymakers to heed the answers they do provide. If economists want to contribute to and influence policymaking, they either need to convince policymakers to think differently about bubbles or address the questions that policymakers care about more effectively.

What do theoretical models of bubbles say?

To get a sense of whether and how existing theoretical models of bubbles can contribute to policy, I first need to explain how economists define asset bubbles and the phenomena they are trying to explain with their theoretical models. Recall that policymakers are motivated by historical episodes in which a surge in asset prices, often accompanied by growth in credit, leads to a subsequent collapse in asset prices that is associated with bad economic outcomes. But when economists model bubbles, they typically focus not on the possibility of collapse but on whether the asset is appropriately priced to begin with. As I discussed in the introduction, economists typically define a bubble as an asset whose price differs from the expected present discounted value of the dividends it generates. Of course, the two definitions are not unrelated; when an asset trades at a price above the present discounted value of the dividends it generates, it may very well be vulnerable to a fall in the price toward the present discounted value of dividends precisely because such a value is a natural candidate for the equilibrium price. Indeed, in some of the models I discuss next, such a scenario either can or must occur when there is a bubble. But a collapse in the price is not the defining feature of a bubble for most economists.

One of the insights from the theoretical work on bubbles as defined here is that there are several different situations in which the equilibrium price of an asset might deviate from the present discounted value of the asset's dividends. But what these cases have in common is that they all involve some type of friction in the underlying economy. Intuitively, agents purchase assets either to consume the dividends they generate or to sell them to others who will consume these dividends. It will, therefore, be hard to sustain a situation in which agents are willing to pay more for an asset than the dividends they or others can obtain from the asset without some frictions that can explain why they would do so. This theme is explicitly developed in

the work of Santos and Woodford (1997). They derive a set of fairly general conditions under which bubbles can be ruled out, and then show how frictions that lead to failures of these conditions allow bubbles to emerge.

Since the exact friction that allows bubbles to arise generally matters for how bubbles affect economic outcomes, I describe in this section five different types of frictions that economists have demonstrated can allow bubbles to arise, or, to be more precise, can allow assets to trade at a price that differs from the present discounted value of dividends that the asset generates.

Dynamic inefficiency

Models of bubbles due to dynamic inefficiency, beginning with the pioneering work of Samuelson (1958) and Diamond (1965), consider environments with successive cohorts of agents in growing economies where later cohorts are wealthier than the generations that preceded them, either because they have more productive technologies to work with or because they are larger and can produce more. A key feature of these economies is that there is some friction that impedes transfers between generations. In that case, each cohort is solely responsible for providing itself with consumption in old age, relying on storage or physical capital. But the fact that the economy keeps growing over time means that each cohort saving on its own is inefficient. All cohorts could be made better off if they agreed that younger cohorts would transfer some of the resources that they would have saved while young to their older and poorer peers, and in exchange they would receive transfers when they are older from future young cohorts who have even more resources to give them. These transfers could be achieved with a pay-as-you-go social security system in which taxes collected on young workers are used to pay benefits to older retirees. They could also be achieved with a program of government debt, in which the government makes payments to the old, financed by issuing new debt that it sells to the young. But in the absence of such government programs, these transfers could also be achieved by allowing people to trade an intrinsically worthless asset, one that offers no dividends. In particular, each cohort would be willing to pay a positive amount for such an asset when young if they expected that later cohorts would buy this asset for an even higher price, which the later cohorts could well afford given their larger wealth. The fact that agents would pay a positive amount for an asset that yields no dividends would make this asset a bubble. What sustains the bubble in this case is the fact that the economy keeps growing in a way that allows agents to transfer the wealth of richer cohorts to those who came earlier. When Samuelson (1958) first analyzed this environment, he interpreted the intrinsically worthless asset as money and used it to analyze why money circulates. Diamond (1965) interpreted the asset as perpetually rolled-over public debt. Tirole (1985) emphasized that this asset can be interpreted as a bubble. More recently, Galí (2014, 2017) used this framework to analyze the effects of monetary policy in a world with asset bubbles.

Borrowing constraints

Models of bubbles due to borrowing constraints consider environments with binding constraints on agents who could create social surplus if only they were able to borrow additional resources. For example, a household whose income fluctuates seasonally might want to borrow when its income is low and pay back when its income is high in order to smooth its consumption. Such a household would stand to gain by borrowing from lenders that would be willing to give up some of their resources for an appropriate return in the future. But if lenders cannot trust that borrowers will repay them in full, households will be unable to borrow enough to smooth their consumption. As another example, poor but productive entrepreneurs who can earn a higher return on their investment than wealthy agents can earn on their own stand to gain by borrowing from the wealthy. But frictions that make the wealthy worried about how much they will be repaid might restrict the amount entrepreneurs can borrow. In these cases, the desire for agents to obtain resources may allow an intrinsically worthless asset that yields no dividends to trade at a positive price. This is because agents

who anticipate needing funds in the future might buy such an asset beforehand, intending to sell it later when they have a greater need for resources. Others, who anticipate future funding needs, would buy these assets. Alternatively, agents might borrow against these assets and sell them later, when they no longer need the resources. Thus, an intrinsically worthless asset can substitute for credit by allowing agents to shift resources over time without explicitly borrowing. Early work in this vein focused on borrowing by households with volatile income flows. Examples include Bewley (1980), Kocherlakota (1992), and Santos and Woodford (1997). More recent work has focused on borrowing by entrepreneurs. Examples include Kocherlakota (2009), Farhi and Tirole (2012), Martin and Ventura (2012, 2016), Rocheteau and Wright (2013), Hirano and Yanagawa (2017), and Miao and Wang (forthcoming).[8]

Information frictions

Models of bubbles due to information frictions consider environments in which agents who trade assets have private information. Suppose there are some states of the world in which agents can benefit from trading assets. For example, the agents that own assets may need immediate liquidity in certain states of the world and prefer cash to assets in those cases, while others with less-pressing liquidity needs would be willing to part with their cash for assets that offer a sufficiently high rate of return. At the same time, suppose the agents who own assets have private information about whether their dividends are positive or zero. In this setting, agents contemplating buying the asset do not know whether those selling the asset know that the asset will pay positive dividends but have an immediate need of liquidity or whether sellers do not need liquidity and are only willing to sell the asset at a positive price because they know it is intrinsically worthless. As is well known, an intrinsically worthless asset could in this case trade at a positive price, given that buyers are unsure about its dividend. But not all agents know the asset is overvalued, so it is not obvious that this should be viewed as a bubble. However, given some additional assumptions, one can construct a more elaborate setup in which all agents in the economy know the asset is intrinsically worthless and yet it can still trade at a positive price. This will occur when agents are unsure if other agents know the asset is intrinsically worthless. In that case, there can be a state of the world in which all agents know the asset will pay no dividends and yet are still willing to buy the asset in the hope of selling it later at an even higher price to agents who are still uncertain about dividends. Examples of these types of models include Allen, Morris, and Postlewaite (1993), Conlon (2004), and Doblas-Madrid (2012). Such models are sometimes known as "greater-fool" theories of bubbles, since agents are willing to buy assets they know are overpriced in the hope of passing them on to someone who is less informed about the asset than they are. See Barlevy (2015) for a survey.

Agency problems

Models of bubbles due to agency problems consider environments in which people buy assets with funds they secure from others rather than with their own funds. In that sense, those who buy the assets are effectively serving as agents on behalf of those who provide the funding. Suppose wealthy households can earn relatively low returns on their own and would rather lend to others with limited resources who can earn a higher return on those funds. For example, lenders might extend credit to productive entrepreneurs with inadequate resources. Or they might extend credit to households that want to make a large purchase, such as a home, but lack the immediate resources to pay for their purchase. If wealthy lenders cannot easily monitor what borrowers do with their funds, they may attract additional borrowers whose purpose is not to use the funds for productive activities but to gamble on activities that will yield a high return only with some probability. If debt contracts feature limited liability, gambling in this way can be profitable: Borrowers can retain any profits if the asset they buy yields a high payoff but default and shift any losses to their lenders if it yields a low payoff. Although lenders would like to avoid such borrowers, they may not be able to distinguish those who gamble on risky assets from good borrowers. For example, it may be hard for a lender to distinguish

those who buy a home they intend to stay in for a long time but can't fully afford from speculators who buy a home intending to sell it if house prices rise and default if house prices fall. Likewise, investors in mortgage securities may be unable to tell how risky the underlying mortgages are. The reason these models can allow for asset bubbles is that the agents who borrow to buy risky assets would be willing to buy an asset even if its price exceeded the expected return on the asset because they only care about the most favorable realizations of dividends. Examples of these types of models include Allen and Gorton (1993), Allen and Gale (2000), and Barlevy (2014).

Misguided beliefs

Models of bubbles due to misguided beliefs consider environments in which agents are willing to buy assets at a price exceeding the present discounted value of dividends either because they don't think the assets they buy are overvalued or because they think there are other agents they could sell to who don't know the asset is overvalued. Although these models typically involve a variety of features, such as agents who hold different beliefs from one another, the reason they give rise to bubbles is that the presence of traders with incorrect beliefs leads agents to pay more for the asset than its fundamental value. Examples of these types of models include Scheinkman and Xiong (2003) and Hong, Scheinkman, and Xiong (2006, 2008). These models fall under the category of behavioral finance, a field that explores the implications of cognitive biases and failures on the part of traders in asset markets.

Although all of these frictions give rise to the same phenomenon, in which an asset can trade at a price that exceeds the present discounted value of the dividends it generates, the models vary in terms of their implications. This will become more apparent when I relate these models to some of the policy questions I discussed earlier. One thing worth noting now is that in the simplest versions of the models that feature dynamic inefficiency or borrowing constraints, the presence of a bubble serves to mitigate the distortions that arise because of the very friction responsible for the bubbles arising in the first place. The same is not true in models where bubbles arise because of information frictions, agency problems, or misguided beliefs. Not surprisingly, this distinction will have important implications for welfare and policy in the face of a bubble.

Theoretical insights on intervening versus waiting

Now that I have described some of the different types of models that can give rise to bubbles, I turn to the question of what these models have to say about the policy questions we began with. Recall that one of the long-standing debates in policy circles is whether central banks should intervene if they observe evidence of a potential bubble or wait to see if asset prices fall and only then act. How do the various models of bubbles I have described inform this question?

As I already noted, in models of bubbles that rely on dynamic inefficiency or borrowing constraints, or at least in their simplest formulations, the bubble alleviates the friction that allows the bubble to arise in the first place. This implies that there is no cost of allowing the bubble to grow that trades off against the benefits from waiting to act against the bubble. The right thing to do in the simplest version of these models is to let the bubble persist. In models of dynamic inefficiency, a growing bubble achieves the intergenerational transfer that is needed to make all agents better off, since each cohort gives resources to their older peers when they buy intrinsically worthless assets from them and then receives resources from their younger peers when they sell the assets they bought. In models with binding borrowing constraints, a bubble likewise facilitates the transfer of resources to those agents who would be able to use them to create social surplus. There is no reason in these models for policymakers to intervene against a bubble while it persists. Of course, since bubbles serve a useful purpose, the bursting of a bubble is harmful, and there may be scope for intervention at that point. But there is no reason to try to rein in the bubble early. On the contrary, policymakers should, if anything, act to preserve the bubbles that emerge if at all possible.

Once we move to more elaborate models of bubbles that are based on dynamic inefficiency or borrowing constraints, there may be a cost to waiting to act against a bubble, especially if the bubble can burst stochastically. One nice illustration of this is the paper by Biswas, Hanson, and Phan (2018). They consider a model in which bubbles arise because of borrowing constraints. Thus, a bubble can help reallocate resources to the most-productive entrepreneurs and increase overall productivity. But Biswas, Hanson, and Phan also assume that wages are downwardly rigid. During the bubble phase, the improvement in productivity will lead to higher wages for workers. Once the bubble bursts and resources cannot flow to the most-productive entrepreneurs, the downward rigidity will mean that wages are too high relative to productivity. This will dampen hiring and produce a recession. Such a model can thus explain why the collapse of a bubble is associated with a recession. It also suggests that a larger bubble earlier on will lead to a more severe contraction if and when the bubble bursts. In this case, policymakers do face a trade-off: Letting a bubble continue improves productivity and resource allocation while the bubble is growing, but letting the bubble grow will exacerbate the harm caused to the economy if and when the bubble does finally collapse.

At first glance, this setup would seem to be directly relevant to the question of whether policymakers should intervene immediately or wait and let the bubble collapse on its own. It suggests some relevant factors that policymakers should look at to gauge the merits of early intervention, including the probability of the bubble collapsing, the extent of wage rigidity, and the degree to which wages grow while the bubble is growing. However, I would venture to guess that many policymakers would balk at consulting this model, just as they have mostly ignored earlier models of bubbles based on dynamic inefficiency and borrowing constraints. This is because the first-best outcome in all of these models is to foster a bubble and allow it to last indefinitely. Yet the reason policymakers refer to the rapid increase in asset prices they face as a "bubble" is precisely because they worry that the run-up in asset prices is unsustainable. If policymakers looking at previous episodes of asset price booms are worried that an asset price collapse is inevitable, they may well be skeptical that models in which nothing inherently prevents a bubble from sustaining itself forever are the relevant framework for analyzing their policy options in such situations.

Turning to models of bubbles based on private information, agency problems, and misguided beliefs, the bubbles that can arise in these settings could, in principle, give rise to a cost of allowing the bubble to grow that must be balanced against the benefits of waiting to intervene, since bubbles in these models do not serve a useful social purpose. Moreover, in some of these models, bubbles cannot persist indefinitely and must eventually collapse. However, existing work based on these models has yet to yield sharp insights on the question of whether it is better to move against a bubble or wait until asset prices fall. The reason these models have not had much impact on policy, then, is not because of doubts as to whether they capture the situations policymakers believe they face when they talk about bubbles, but because they have yet to offer useful answers to the questions policymakers are interested in.

In the case of models of bubbles based on private information or misguided beliefs, welfare analysis turns out to be tricky, since it raises questions about which information set or which beliefs should be used to evaluate welfare and determine optimal policy. This is a practical issue for policymakers, who are often uncomfortable with intervening on the grounds that their information is superior to that of market participants. For models of bubbles that are based on agency problems, welfare analysis is less complicated. Allen, Barlevy, and Gale (2018) have recently shown that even though an intervention that raises rates can exacerbate some of the problems that dampening bubbles is meant to fix, in the spirit of Svensson (2014, 2017), an intervention by a central bank to raise rates can in certain cases make society better off. For example, they show that raising rates can improve welfare when default is sufficiently costly, since dampening the price of the bubble asset will reduce the cost to society if and when the bubble bursts. Even when the costs of default are low, they show that a threat to raise rates in the future if and when the bubble persists can improve welfare because it mitigates the distortions due to the bubble while it is present. While this analysis suggests

a benefit to acting against a bubble, it does not really compare the merits of intervening immediately and waiting to intervene after the fact. For example, the way they model the aftermath of a collapse in asset prices does not admit a corrective role for monetary policy that can substitute for moving to stem a bubble earlier.

How can we bridge the gap between policy and theory?

Although policymakers have not relied on existing models so far to guide them on whether to move quickly in the face of a potential bubble or wait to see what happens to asset prices, can economists build on and further develop the theoretical models to provide such guidance in the future? I would argue there are at least three scenarios in which the models of bubbles I have described can contribute to the policy debate going forward.

The first would be that economists succeed in convincing policymakers that models based on dynamic inefficiency of borrowing constraints are relevant and useful for the situations policymakers are reacting to, and that while policymakers should be concerned about the collapse of bubbles and how to respond if that happens, there is no reason that they should not try and sustain bubbles indefinitely. While this view runs counter to the way most policymakers think about bubbles, it is a perfectly coherent and internally consistent view. Models of bubbles based on dynamic inefficiency and borrowing constraints offer a formal demonstration of why it is possible for assets to trade indefinitely at a price above their fundamental value. In both types of models, the high price at which the asset trades essentially reflects the value of the transaction services the asset offers rather than a reason for concern.

During the panel session in which I first presented the comments that I developed into this article, my co-panelist, Jaume Ventura from CREI, argued that one of the reasons bubbles are such interesting phenomena is that they offer the exciting prospect of creating value out of thin air, and the reason we should study them is to understand how we can harness such possibilities. My response to him at the time was that the other reason bubbles are interesting, and the primary reason policymakers worry about them, is the alarming prospect that their value will vanish into thin air. Although Ventura's framing is instructive, I suspect that it will be difficult to convince policymakers to accept models in which bubbles can and should be sustained indefinitely, at least as these models are currently set up. First, in these models bubbles arise not because the price of the asset is too high but because the fundamental value of the asset as conventionally defined is too low and does not account for the services the asset provides in allowing agents to transfer resources intertemporally. Second, in these models bubbles can, in principle, be sustained indefinitely, even if these models can also exhibit stochastic equilibria in which asset prices can collapse. Without prominent historical examples of rapid surges in asset prices that did not end in collapse to counter the many examples that did end in collapse, policymakers facing asset price booms that have seemingly always ended badly in the past are likely to remain skeptical about the relevance of models in which bubbles can and should be allowed to last forever.

A second scenario in which theoretical models of bubbles could ultimately be adopted by policymakers is if economists build on the models that policymakers currently dismiss to make these models seem more relevant and applicable to the scenarios policymakers face. One example of this is the Biswas, Hanson, and Phan (2018) paper I discussed earlier, which introduces rigid wages into a model of bubbles driven by binding borrowing constraints. This modification allows for the possibility that letting a bubble grow can both serve a useful role and magnify the distortions that arise when the bubble bursts. Even if the first-best policy in this model is to sustain the bubble indefinitely, which as I noted earlier is likely to limit its appeal to policymakers, there are other features one could introduce into these models that imply it would not be optimal to sustain a bubble indefinitely.

As an illustration of this, consider the Grossman and Yanagawa (1993) model. Their model builds on the Diamond (1965) one in which bubbles arise because of dynamic inefficiency. A necessary condition for a bubble to arise in this model is that, in the absence of a bubble, the economy grows in the long run at least as fast as the long-run return on capital. This is because agents would only agree to buy the bubble if it offered them the same return as any alternative investments they could make, which in their model includes buying physical capital. Since the return to an intrinsically worthless asset is only due to its price appreciation, the price of the intrinsically worthless asset must grow at least as fast as the return on capital. But for agents to be able to keep buying the asset, the resources they can use to buy the asset must grow in pace with the asset's price.

In Diamond's setup, an economy that grows faster than the interest rate is associated with excessive capital accumulation, since agents could consume more if in each period the young would give some of their resources to the old instead of using these resources to add to the capital stock. Since a bubble asset replicates such transfers, it makes agents better off. But Grossman and Yanagawa consider an economy with capital externalities. In particular, in their model an agent who accumulates capital will help make other agents more productive, in line with the Romer (1986) interpretation of capital as including knowledge of production techniques that can be useful beyond directly to those who acquire it. Because of this spillover, there will generally be too little capital accumulation in their economy. Agents who accumulate capital do not take into account that they are helping make others more productive. To put it another way, the social return to capital is higher than the private return to capital. As long as the social return to capital exceeds the growth rate, society would be better off directing resources to be used to add to the capital stock than to pay for the consumption of the current old. But the condition for the bubble to exist is that the economy grows at least as fast as the private return to capital. Introducing externalities can thus turn a bubble that would otherwise be useful into a social liability. Grossman and Yanagawa (1993) show that the bubble makes all generations except the initial old worse off.[9] Since the bubble now represents a social liability, there may be a basis for intervening to deflate the bubble immediately rather than waiting for it to collapse on its own. Depending on the strength of capital externalities, the policy that makes agents better off can be either to squash the bubble immediately or to attempt to sustain it indefinitely.

A third scenario in which theoretical models of bubbles could end up contributing to the policy debate is if further work on models of bubbles that are based on imperfect information, agency problems, and misguided beliefs yields insights that directly relate to the questions policymakers are interested in. Since these models of bubbles do not inherently imply that bubbles can and should survive indefinitely, they are less likely to be dismissed by policymakers as irrelevant. The reason these models have had little impact on the policy debate so far is that they are not nearly as developed as models of bubbles based on dynamic inefficiency and borrowing constraints and have yet to provide clear answers to the questions that policymakers grapple with.

To be clear, the above scenarios should not be understood as mutually exclusive or competing paths for future research. Among the features that one could introduce into models of bubbles based on dynamic inefficiency or binding borrowing constraints are private information, agency problems, and misguided beliefs. Likewise, one could introduce dynamic inefficiency or binding borrowing constraints into models of bubbles based on private information, agency problems, and misguided beliefs. The different models of bubbles should not be viewed as rival explanations for the same phenomena, but as different starting points, each of which on its own allows for the possibility of a bubble. One can build on any of these starting points in various ways to understand the phenomena that policymakers confront.

Credit-driven bubbles and macroprudential policy

Given the evolution of views about bubbles after the global financial crisis, another question that models of bubbles can potentially help answer is what is the best way to intervene against a bubble if this is what policymakers are inclined to do. As I discussed earlier, the policy debate in the shadow of the financial crisis has largely focused on two interventions, raising interest rates and tightening macroprudential regulation. This suggests it would be useful to have a framework for comparing these two policies. But existing theory has yet to offer much perspective on the relative merits of these two approaches.

For the macroprudential approach to be a useful tool for dampening bubbles, it must be the case that credit plays an important role in propagating bubbles. Among the various models of bubbles described above, not all imply that credit plays an essential role in allowing for bubbles. Models of bubbles that are based on dynamic inefficiency, private information, and misguided beliefs can all generate bubbles in the absence of any credit. In their most basic formulation, in which there is no borrowing and lending, there would no role for greater oversight and regulation of financial intermediation to affect asset prices. That said, there has been some work incorporating credit into these models, which has found that credit can amplify a bubble that would have arisen even in the absence of credit markets. For example, Doblas-Madrid and Lansing (2016) have introduced credit into a model of bubbles based on private information; they find that the growth rate of credit governs the rate at which the price of the bubble grows over time. Similarly, Hong and Sraer (2013) and Simsek (2013) have introduced credit into models in which agents have heterogeneous beliefs, meaning that at least some of those who trade assets hold misguided beliefs. They too find that allowing for credit can contribute to higher asset prices by increasing the demand of those with the most positive outlook on assets. These modifications suggest there may be a role for restrictions on credit to dampen bubbles even if they don't completely eliminate bubbles.

By contrast, in models of bubbles based on borrowing constraints or agency problems, credit can be an essential feature that allows for bubbles to arise. Among the models of bubbles that feature binding borrowing constraints, in some the bubble emerges because agents can use such assets as collateral for borrowing. Restrictions on credit would then directly affect demand for assets and thus their prices. In models of agency problems, credit also plays an essential role in allowing a bubble to emerge: The reason agents are willing to pay more for an asset than its fundamental value is that they can shift their losses to their creditors if their asset purchase turns out to be unprofitable. That said, even in these types of models, bubbles could occur in the absence of credit, and so strict macroprudential regulation need not necessarily eliminate bubbles. For example, Martin and Ventura (2012) generate a bubble in a model with borrowing constraints, in which entrepreneurs are unable to borrow at all. In that model, bubbles do not emerge because agents can borrow against the assets they own. Rather, bubbles arise because agents who anticipate needing credit in the future invest in assets that they expect to sell later at a higher price to reduce their need for borrowing. Since there is no credit in that model, there is no scope for macroprudential regulation in that particular setting. Similarly, models where bubbles arise because of agency problems do not all involve debt. For example, Allen and Gorton (1993) develop a model in which agents enter into limited liability equity sharing contracts. The agents who purchase assets receive a share of the profits they earn if profits are positive but do not share in the losses if their purchase is unprofitable. In both of these cases, restrictions that only affect debt arrangements would have no implications for bubbles.

Even if credit does not always play an essential role in allowing for bubbles, existing models of bubbles should, in principle, allow us to explore the effects of credit restrictions on bubbles. However, so far there has been little work on whether restricting credit is an appropriate policy response to a potential bubble, and if so what type of regulations would be most effective if a policymaker wanted to act against a bubble. For example, should policy seek merely to dampen bubbles or to eliminate them altogether? The

answer to this question would likely vary across models, especially since in some models it is clearly not optimal to eliminate bubbles altogether given they serve a useful purpose, although it may still be desirable to regulate their size. Researchers working with these models have started to ask these questions, although analysis along these lines remains in its infancy.

But even if we make progress on the question of how macroprudential policies work in environments where bubbles arise, what policymakers seek is a resolution to the lean versus screen debate: Should policymakers intent on reining in bubbles rely on tighter macroprudential regulation, higher interest rates, or a combination of both? Are these policies substitutes, complements, or neither? Existing research has little to say about this. Economists have only recently started to examine the effects of monetary policy in environments with bubbles, although the literature is growing. Some of the papers that study monetary policy and bubbles include Galí (2014, 2017), Ikeda (2017), Asriyan et al. (2016), Dong, Miao, and Wang (2018), and Allen, Barlevy, and Gale (2018). These papers differ in some of their conclusions, in part because they analyze models with different types of frictions and in part because some of these models feature multiple equilibria and different papers focus on different equilibria within the set of all possible equilibria. But even if we reach consensus on the effects of monetary policy, we need to compare macroprudential regulations and monetary policy and how they interact. It should be possible to use existing models to do this.

Policy evaluation

Finally, recall that a key question for policymakers intent on fighting bubbles is what real-time measures they can use to evaluate whether their interventions are useful and effective. The fact that the fundamental value of assets is unobservable means policymakers must rely on other data instead. As I noted earlier, Svensson (2014, 2017) argues that increasing the interest rate likely raises the ratio of household debt to income, even if it reduces the growth rate of household debt, and that this would increase the odds of a crisis. However, the macroeconomic model he uses to determine what the ratio of household debt to income would have been if the Riksbank had not increased the interest rate features neither a bubble nor an explicitly modeled financial crisis. In the end, Svensson's arguments rely on either economic intuition regarding what might precipitate a crisis or reduced-form empirical work that looks at how different economic variables are correlated with the frequency of financial crises.

One of the advantages of theoretical models of bubbles is that they can help to identify which variables are relevant for assessing both the probability of a crisis and its severity. For example, although Svensson reasonably argues that a higher ratio of household debt to income means more-distressed households, to the extent that a higher rate dampens a bubble, that could in principle lower the odds and severity of a financial crisis. Intuitively, lenders may not suffer as much if households are forced to default when the assets households borrowed against were less overvalued to begin with. While current work on bubbles has yet to offer a satisfactory connection with financial crises, recall that some of the models of bubbles I described earlier feature credit, either as an essential feature that allows a bubble to emerge or as a feature that amplifies bubbles. This suggests an avenue for future work. Models of bubbles based on agency problems seem particularly well suited to this task, given they feature the prospect of agents borrowing against bubble assets and then defaulting.

To explore fully how both bubbles and interventions against them are likely to unfold, we need a general equilibrium model that can speak to these issues. For example, one of the arguments in the original lean versus clean debate was that central bankers should focus on macroeconomic variables, such as inflation and output, or also respond to asset prices. However, little work using existing models of bubbles has explored whether the two are related. Does the emergence of a bubble contribute to higher inflation and overheating? Does the presence of a bubble interact with monetary policy and affect how inflation and

output respond to a raise in interest rates? These questions have yet to be answered. Moreover, while some of the current models of bubbles, most notably those that feature dynamic inefficiency and borrowing constraints, use a general equilibrium setup that is conducive to macroeconomic analysis, some of the other models of bubbles are more stylized. The focus in these papers is typically to show that a particular friction will allow a bubble to occur. So one way in which economists could make models of bubbles more relevant for policymakers would be to incorporate the various frictions that we now know can allow for bubbles into a general equilibrium framework.

Conclusion

In this article, I have focused on two key themes. The first is that there is a list of questions that policymakers are grappling with as they attempt to formulate an appropriate response to the prospect of asset bubbles that existing models of bubbles have yet to address adequately. This list includes questions such as when is it better to act against bubbles and when is it better to wait to intervene (the lean versus clean debate); when is it better to use interest rate policy and when is it better to rely on macroprudential policy (the lean versus screen debate); and what economic variables might policymakers be able to use to evaluate whether their interventions are working as intended. The second theme is that even if existing models have not addressed these issues effectively up to now, it should be possible to extend them so that they can address these questions in the future. In particular, models have already started to incorporate both credit and certain types of policy interventions that can begin to shed some light on these questions. As we continue to make progress on this front, the increasing policy relevance of these models should become apparent.

In my own work on bubbles, I have focused primarily on models of bubbles based on agency problems. This is in part because these models seem to capture key elements of the episodes that policymakers typically worry about. For example, credit plays an essential role in these models, in line with the view that the most alarming bubbles are those that are accompanied with a boom in credit. The collapse of a bubble in these models triggers a wave of defaults, which can lead to financial crisis or recession as is often true in the data. Finally, since bubbles seem to be associated with new technologies that are hard to understand or assets, such as housing, that are hard to value because individuals can value housing services differently, asymmetric information seems to be an important feature of these episodes. However, as I have tried to make clear in my discussion, other models can speak to these episodes as well, so the types of models I have analyzed in my own work are far from the only way to explore these issues. Moreover, the different frictions that can give rise to bubbles do not contradict one another. For example, in models of agency problems, information frictions make it difficult for lenders to distinguish between agents who borrow to gamble on risky assets and agents who borrow to create surplus and whom lenders would like to finance. The fact that some agents are able to pass off as worthy borrowers does not mean that the borrowers who can create surplus are able to secure all of the credit they need. In an economy where some agents borrow too much relative to what lenders want while others are borrowing constrained, bubbles may introduce some distortions while alleviating others. Even if policymakers are skeptical about models of bubbles based on one particular friction, this does not mean they should ignore the lessons from these models given that the same friction can appear in the models with other features that allow for bubbles.

Since it is essentially impossible to measure the fundamental value of an asset and determine whether an asset is a bubble in practice, questions about how to deal with asset bubbles ultimately require a theoretical framework to address. A good analogy is the notion of the natural rate of output in macroeconomic models that central banks use to guide them in carrying out monetary policy. The natural rate of output is an empirically elusive concept that is as hard to measure as the fundamental value of an asset. And because the natural rate of output is not observable, it is a controversial notion that not all economists accept, just as not all economists agree that bubbles occur in practice. Yet policymakers have found theoretical models

that explain why the economy can deviate from the natural rate to be instructive. In principle, models of bubbles should be able to contribute to policy debates in the same way. With existing models already containing some of the key features needed to provide these answers, and with capable researchers working on these questions, it shouldn't be too long before policymakers start to view theoretical models as a natural resource for aiding their policy discussions.

NOTES

[1]This article is adapted from my presentation as part of a panel on the state of the academic literature on bubbles at the Workshop on Bubbles in Macroeconomics: Recent Developments, organized by CREI (Centre de Recerca en Economia Internacional), in Barcelona, Spain, on October 26–27, 2017.

[2]For a summary of how the models that central banks use to analyze monetary policy and to forecast how macroeconomic outcomes have evolved over time, see Pescatori and Zaman (2011).

[3]For a discussion of some of the different models the CBO uses to forecast the effects of fiscal policy on the economy, see Congressional Budget Office (2014).

[4]A bubble can, therefore, include the case in which an asset trades at a price that is too low. I focus on bubbles in which asset prices exceed fundamental values.

[5]Notwithstanding its apparent success during the dot-com bubble, there were some who questioned the wisdom of the wait-and-see approach even back then. One concern was that lowering rates after a fall in asset prices would tend to lift asset prices in addition to stimulating output. This may well encourage agents to speculate during the boom, knowing intervention would keep asset prices from falling too much. Indeed, traders had begun to talk about a "Greenspan put" on asset prices in the wake of this episode.

[6]For a more detailed discussion of macroprudential regulation, see Hanson, Kashyap, and Stein (2011).

[7]The case for macroprudential regulation does not hinge solely on bubbles. A separate literature has argued that macroprudential regulation can address the problem of agents taking on too much debt because they fail to internalize the consequences of what would happen if they were forced to delever later. Examples of such arguments include Lorenzoni (2008), Korinek and Simsek (2016), Farhi and Werning (2016), and Caballero and Simsek (2018). In this article, however, I only consider macroprudential policy as it relates to asset bubbles.

[8]Models of bubbles due to binding borrowing constraints bear some similarity to models of bubbles due to dynamic inefficiency. Conceptually, in both cases the bubble asset is money-like, in that it allows individuals to exchange goods when they don't really need them for an asset that they can then trade for goods when they do need them. Woodford (1990) shows how the two settings can even yield identical equilibrium conditions, although he also emphasizes the ways in which these two environments differ.

[9]In particular, they argue that the only way to reap the benefits of greater capital accumulation in their model is to take some of the resources paid to the old for their asset and use these resources to create capital. This means there is no way to compensate the old for dampening the bubble, since they won't be around to benefit once the new capital is created. Allen, Barlevy, and Gale (2018) argue that this result hinges on the initial old being endowed with bubble assets rather than expending resources to create them. If the old produced the assets they sell, an intervention to dampen the bubble might make all agents weakly better off, including the initial old.

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