

Speculative Bubbles in Theory¹

We will begin this topic by developing a very simple model of asset pricing. We will then consider several different explanations for why asset prices may deviate dramatically from their fundamental values. This has been a challenging questions for macroeconomists. It is hard to write down a good model where asset prices rise to double their fundamental value before falling back down again. I personally think it is impossible to do so where agents are both fully informed and fully rational. The best explanations we have assume *bounded rationality* where agents form imperfect, but reasonable, expectations.

Denote the price of the asset as q_t . Although our focus is housing, this model is very general and can be used for many other assets as well. Assume that whoever owns the asset obtains a fundamental, denoted s_t in period t . For a stock, the fundamental is a dividend. For real estate, the fundamental may be a rent. Suppose that the owner of the asset holds the stock for one period and then sells it. Using basic supply and demand, the price of the asset must equal the fundamental plus the expected discounted value of the future sales price:

$$q_t = \frac{E_t[q_{t+1}]}{1 + i_t} + s_t \quad (1)$$

Looking at (1), the first term on the right hand side has a few features that merit discussion. First, because the owner does not know the future sales price with certainty, she must rely on her expectation. Hence the expectations operator, denoted $E_t[\cdot]$. This notation indicates the expectation, formed in period t of the asset price in period $t + 1$. Periods may be defined over years, quarters, months, days, etc. Second, because the owner of the asset does not receive the sales price for one period, the sales price must be discounted using $1 + i_t$, where i_t is the interest rate.

Now suppose that the owner of the asset is smart enough to understand that (1) explains how the market works. Furthermore, assume that she uses (1) to form her expectations. By intelligently using information about how the economy works, she is forming *rational expectations*. If (1) is true, then it must also be the case that:

$$q_{t+1} = \frac{E_{t+1}[q_{t+2}]}{1 + i_{t+1}} + s_{t+1} \quad (2)$$

¹These are undergraduate lecture notes. They do not represent academic work. Expect typos, sloppy formatting, and occasional (possibly stupefying) errors.

But because, in period t , she cannot know q_{t+1} or s_{t+1} , she must rely on an expectations instead of actual values. Thus instead of using (2), she must use:

$$E_t[q_{t+1}] = E_t \left[\frac{E_{t+1}[q_{t+2}]}{1 + i_{t+1}} + s_{t+1} \right] \quad (3)$$

Now insert (3) into (1):

$$q_t = \frac{E_t \left[\frac{E_{t+1}[q_{t+2}]}{1 + i_{t+1}} + s_{t+1} \right]}{1 + i_t} + s_t \quad (4)$$

The first term on the right hand side of (4) includes the owner's expectation in period t of her expectation in period $t + 1$. But if the owner is rational, then she should not expect to change her mind between periods t and $t + 1$. In other words, rational expectations are unbiased. This is known as the *law of iterated expectations*. Formally:

$$E_t[E_{t+1}[x_{t+2}]] = E_t[x_{t+2}] \quad (5)$$

Using the law of iterated expectations, we can rewrite (4) as:

$$q_t = E_t \left[\frac{q_{t+2}}{(1 + i_t)(1 + i_{t+1})} \right] + \frac{E_t[s_{t+1}]}{1 + i_t} + s_t \quad (6)$$

Note that we are assuming that i_t is known in period t . The expectation of a known variable is the variable's actual value. It is thus possible to pull i_t outside of expectations operator. The second term on the right hand side of (6) does this. The first term on the right hand side does not. It makes no difference. Equation (6) now represents the value of the asset to an owner who plans on selling it in two periods: they obtain value from the fundamental in periods t and $t + 1$, as well as the sale price in period $t + 2$.

The steps involved in going from (1) to (6) are known as iterating forward. Suppose that we do this again. Omitting the steps, we get:

$$q_t = s_t + \frac{E_t[s_{t+1}]}{1 + i_t} + E_t \left[\frac{s_{t+2}}{(1 + i_t)(1 + i_{t+1})} \right] + E_t \left[\frac{q_{t+3}}{(1 + i_t)(1 + i_{t+1})(1 + i_{t+2})} \right] \quad (7)$$

Equation (7) now represents the value of the asset to an owner who plans on selling it in three periods. The best part about iterating forward is that it is enthralling and never ceases being fun. So lets do it an infinite number of times:

$$q_t = s_t + \frac{E_t[s_{t+1}]}{1 + i_t} + E_t \left[\frac{s_{t+2}}{(1 + i_t)(1 + i_{t+1})} \right] +$$

$$E_t \left[\frac{s_{t+3}}{(1+i_t)(1+i_{t+1})(1+i_{t+2})} \right] + E_t \left[\frac{s_{t+4}}{(1+i_t)(1+i_{t+1})(1+i_{t+2})(1+i_{t+3})} \right] + \dots \quad (8)$$

Equation (8) is the asset's fundamental value. For a stock, the fundamental value is the expected discounted stream of dividends over the infinite horizon. For real estate, replace dividends with rents. Because there is no future price in (8), there is no speculative motive.

Most economists believe that asset prices equal their fundamental values in the long run. But a speculative bubble occurs when (8) does not hold. In hindsight, it is clear that there was a housing bubble before 2007. We now consider 4 explanations for the increase in housing prices in the context of our simple asset pricing model.

#1: People are Dumb

This is the simplest and least interesting explanation. It is possible that the public is not capable of correctly pricing real estate, or that their expectations are irrational.² While some households are certainly stupid, we usually don't think that large markets are collectively stupid. The goal of economics is to explain events like the housing bubble under the assumption that households are rational utility maximizers with decent, but possibly incomplete, information.

Note that assuming that agents are rational utility maximizers is not the same as assuming that they are extraordinarily smart. Many of the most promising explanations for bubbles assume that agents are boundedly rational. Here, agents attempt to maximize their utility, but do so in the presence of an informational constraint. Explanations #3 and #4 are examples of bounded rationality.

#2: Fundamentals Changed

A doubling of housing prices is not necessarily the result of a bubble. It is possible that the expected discounted stream of fundamentals changed. In fact, this did clearly happen. Long term interest rates are often thought of as a collection of current and expected future short term interest rates. Therefore a crude way to quantify the role of interest rates in (8) is to

²Here, by irrational, I mean that they not only fail to make the best use of the available information, but that they fail to even make a reasonable effort. Expecting an 8% increase in housing, no matter what the data suggest, would be an example.

examine a long term interest rate. The following graph shows the interest rate associated with 10 year Treasury Bonds:³



Recall that the Fed lowered short term rates after the 2001 recession and kept these rates low through 2006. This had the effect of driving longer term rates down as well (though note that they are much lower now). Lower interest rates increase the present expected value of future rents. It is direct from (8) that they increase home prices. It is fairly straightforward to quantify this effect.

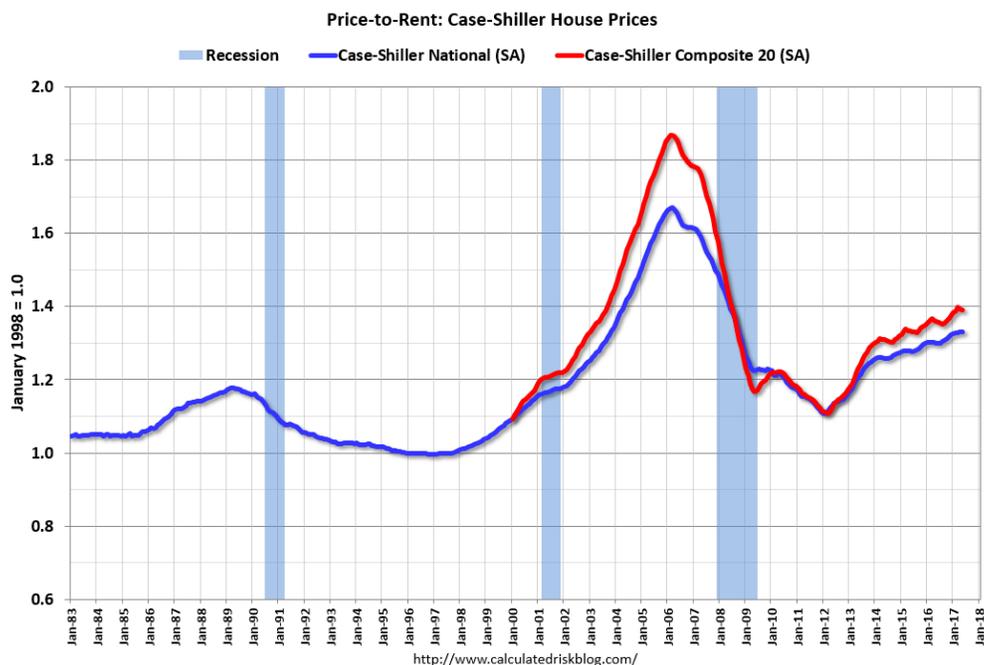
Macroeconomists have tested for whether low mortgage rates were a major cause of the housing bubble. This usually consists of setting up a model, fitting it to the data, and then comparing simulations with low vs. normal mortgage rates. In my opinion, the best evidence suggests that low mortgage rates were only a minor factor in causing the housing bubble.⁴ Some prominent economists, however, disagree and have argued that the Federal Reserve by keeping interest rates “too low for too long” caused low mortgage rates which were a major factor in causing the housing bubble.⁵

It is also possible that the stream of rents increased. This is a second potential avenue for fundamentals to explain the increase in housing prices. Recall the following chart:

³I had planned on displaying the longest Treasury Bond, the 30 year, in this graph. During the 1990s, however, these were temporarily discontinued due to the unusually small national debt.

⁴See, for example, Gelain, P. Lansing, K. and G. Natvik. 2015. “Explaining the Boom-Bust Cycle in the U.S. Housing Market: A Reverse Engineering Approach.” *Working Paper*.

⁵See, for example, Taylor. J. 2007. “Housing and Monetary Policy.” Paper presented in Jackson Hole, Wy, 9/1/07



This chart shows that rents were increasing at only a modest rate. While it is possible that expected future rents were increasing more dramatically, there seems little reason to believe that such an effect was significant.

Prior to the bursting of the bubble, some economists were aware of the price to rent ratio and still argued that housing appreciation was entirely due to fundamentals. They discounted the price to rent ratio in several notable ways. First, they noted the lower mortgage rates. Second, they argued that standard indices of housing prices failed to reflect improvements in the quality of housing.⁶ My problem with the second argument is that if housing quality were increasing dramatically, this should have affected both owner occupied housing and rental housing so that the price to rent ratio is largely unaffected.

Finally, another argument that fundamentals were driving housing prices came from Alan Greenspan in 2005, then the Chairman of the Federal Reserve.⁷

Where once more-marginal applicants would simply have been denied credit, lenders are now able to quite efficiently judge the risk posed by individual applicants and to price that risk appropriately.

⁶If you are interested in more details on this argument see the following paper from 2004: McCarthy, J. and R. Peach. 2004. "Are Home Prices the Next Bubble." *Federal Reserve Bank of New York Economic Policy Review*, 10(3): 1-17.

⁷Greenspan, A. 2005. Consumer Finance, Remarks at the Federal Reserve System's Fourth Annual Community Affairs Research Conference, Washington, D.C., (April 8).

Although it is harder to map this into our model, Greenspan’s argument is that housing prices were rising because better screening technology allowed new buyers into the market. Time has shown this, and the other fundamentals based arguments, to be unlikely at best. The new buyers coming into the market were generally high risk and many would end up in default on their mortgages,

This type of argument is an example of “This Time is Different,” a pattern that people have noticed about speculative bubbles.⁸ Although the data (*e.g.* the price to rent ratio) might suggest a bubble, there are usually people there to explain why these data are no longer good predictors of a bubble (*e.g.* better technology). This optimism is necessary to keep prices high and sustain the bubble. If everyone comes to believe that we are in a bubble, they will seek to sell their assets, and the bubble will then burst.

#3 Learning and Misspecification

One of the main concepts that separates economics, and especially macroeconomics, from the natural sciences is the role of expectations. Suppose that a person in the economy is trying to decide how much to pay for real estate using (1). It is not obvious how they should go about forming expectations. In my opinion, the most plausible approach for explaining bubbles is to assume that they use *adaptive learning* to form expectations. Adaptive learning assumes that agents (the people in the model) are neither too stupid nor too smart. When faced with having to make a forecast, they thus turn to econometrics.

The problem is that all econometric models are misspecified.⁹ Suppose that the owner of an asset is trying to forecast q_{t+1} . A misspecified, but reasonable, econometric model might be:

$$q_t = a + bs_{t-1} + cv_{t-1} + \mu_t \tag{9}$$

The fundamental (s_t) should appear in the estimation because it also appears in (1). Define v_t as something extraneous that should not appear in the model. That is, if properly specified, $c \rightarrow 0$ as $T \rightarrow \infty$. To make the math a little easier, we assume that agents must rely on the lagged values of these variables. There are a couple of reasons why $c \neq 0$ in the above regression.

⁸This is the ironic title of a 2009 book by Ken Rogoff and Carmen Reinhart which makes this exact point

⁹I don’t mean this as a swipe at my more empirical colleagues. All theory models are misspecified too. Except for mine of course.

i. The model may be misspecified. Perhaps another fundamental variable is being omitted. If so, omitted variable bias may cause $c \neq 0$, even for large sample sizes. Or the relationship between Q and b may not be perfectly linear. Or there could be an unresolved econometric problem such as non-stationarity, omitted variable bias, etc.

ii. If the sample size is small, then $c \neq 0$.

It is thus possible that $c > 0$ and $v_t > 0$, or $c < 0$ and $v_t < 0$. In both cases, their misspecification allows for an extraneous increase in home prices.

Suppose that agents use (9) to form their expectations. They can do this by re-dating (9) so that:

$$E_t[q_{t+1}] = a + bs_t + cv_t \tag{10}$$

The error term does not appear because its one period ahead expectation is zero. Recall from your econometrics class that this is a property of OLS and other common estimators. So if $cv_t > 0$, then this has the effect of causing agents to expect higher housing prices in the next period. When this term increases, it follows from (1) that current home prices increase as well. This provides a mechanism where changes to v_t can extraneously affect housing prices.

A great paper would rigorously identify a variable like v_t , formalize this story, and use it to help explain the housing bubble. I am unaware of such a paper, however. But there is anecdotal evidence that suggests a story in the spirit of this one may help explain the bubble. Consider the following article from 2005 that asked several economists whether or not a bubble existed:

“Housing Bubble or Bunk?” *Business Week*, 6/22/05

Frank Nothaft, the Chief Economist at Freddie Mac makes the following argument:

I don't foresee any national decline in home price values. Freddie Mac's analysis of single-family houses over the last half century hasn't shown a single year when the national average housing price has gone down. The last consistent drop was during the Great Depression, when the unemployment rate got up to 25%, or five times the level we're at now.

Nothaft's opinion is not absurd, it is based on data. But it is misspecified because it looks at other factors instead of or in addition to fundamentals. In this case the extraneous variable is the last 50 years of data on housing appreciation. While related to fundamentals, it is not

a fundamental itself. What the analysis misses is the fact that while home prices had never declined in fifty years, there had also never been such a steep increase in real estate prices over the same time period.

Another example is James F. Smith, chief economist at the Society of Industrial & Office Realtors:

There are several reasons why a national housing bubble is relatively silly. According to census data, current home-ownership rates are at 69.3% of all households, a record. If you look at home ownership by age group, the highest rate – above 83% – are among owners aged 70 to 74. Only marginally below that is owners aged 65 to 69.

Baker's argument is also not absurd. He is arguing that increased demand is causing a sustainable increase in housing prices. Here, home ownership rates represent v_t . But like Nothaft's argument, it isn't focused on fundamentals. And with hindsight, such a increase in the price to rent ratio was simply not sustainable.

The appeal of using adaptive learning in this context is that it is backwards looking. Suppose that you were attempting to forecast future housing price appreciation at the peak of the bubble. Looking back at years of strong appreciation, it is easy to imagine that a flawed, but not stupid, forecaster could use this to guess that appreciation would remain strong in the future as well.

#4: Information Cascades

Informational cascades are another example of bounded rationality. In this case, agents have only a *noisy signal* of the true state of the world. For example, suppose that the fundamentals suggest that housing prices are too high. It is possible that agents will be able to know this with some probability but that there is a chance they will have erroneous information that yields an incorrect conclusion.

Read the following op/ed from Robert Shiller, a prominent economist, and co-winner of the 2013 Nobel Prize in Economics. who studies housing. It represents his argument for how the bubble occurred:

Shiller, Robert. 3/2/08. "How a Bubble Stayed Under the Radar," *New York Times*

Suppose that the fundamentals suggest that real real estate is a bad investment, but that there is a 60% chance that any individual person's information leads them to a correct conclusion.

There is a 40% probability that the first person to form expectations will have bad information. If this occurs then they will expect home prices to increase and they will pay more for their house.

Now consider the next person to form expectations. He knows that in addition to his own information, the first person had unique information. Because the first person was optimistic, the second person infers that the first person's information was positive.

With probability 40% the second person also has erroneous, favorable information and will also be optimistic. In this case, everyone that follows will infer that the first 2 people had positive information, and will therefore also be optimistic. Even if their personal information is negative, it is outweighed by the positive information of the first two people. This is an informational cascade and causes a large mass of people to form bad expectations, even though they are behaving intelligently. Another name for this is *herd behavior*.

With probability 60%, however, the second person will have negative information. His negative information cancels out the first person's positive information so that he is truly unsure. If we assume that the second agent flips a coin, this is a second possibility for informational cascades.

Three economists, Sushil Bikchandani, David Hirshleifer, and Ivo Welch, developed this concept and showed that if the probability of having bad information is 40%, then there is a 37% chance that the public will collectively act on this bad information.¹⁰ [Note: This results are dependent on the specific type of expectations formation presented in this example.]

While these explanations shed light on why housing prices rose so dramatically, they do not provide a fully satisfying answer. Bubbles remain a challenging topic and the subject of much ongoing research.

¹⁰Bikhchandani, Sushil, Hirshleifer, David, and Welch, Ivo, 1992. "A Theory of Fads, Fashion, Custom, and Cultural Change in Informational Cascades," *Journal of Political Economy*, vol. 100(5), p. 992-1026.