Stock Prices and the Stock Market

ECON 40364: Monetary Theory & Policy

Eric Sims

University of Notre Dame

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Readings

Mishkin Ch. 7

GLS Ch. 35

Stock Market

The stock market is the subject of major news coverage and is obviously of interest to monetary policymakers

Several different indexes – S&P 500, Dow Jones Industrial Average, NASDAQ, Russell 2000, Wilshire 5000

What is a stock?

How are stocks priced? How do returns on stocks compare to alternative investments?

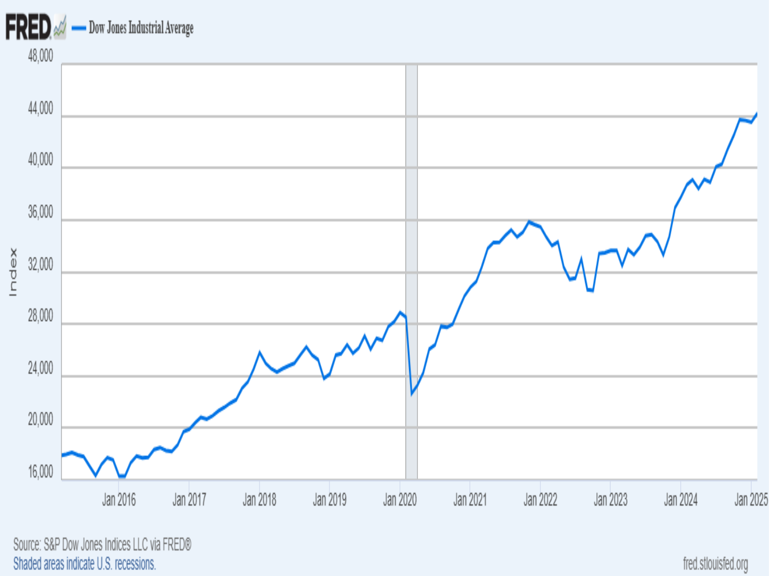
Are there "bubbles"?

Should monetary policymakers care?

S&P 500


FRED
S&P 500
7,000
6,000
5,000
4,000
3,000
2,000
1,000
Index
Jan 2016
Jan 2017
Jan 2018
Jan 2019
Jan 2020
Jan 2021
Jan 2022
Jan 2023
Jan 2024
Jan 2025
Source: S&P Dow Jones Indices LLC via FRED®
Shaded areas indicate U.S. recessions.
fred.stlouisfed.org

S&P 500



FRED
Dow Jones Industrial Average
48,000
44,000
40,000
36,000
32,000
28,000
24,000
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16,000
Index
Jan 2016
Jan 2017
Jan 2018
Jan 2019
Jan 2020
Jan 2021
Jan 2022
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Source: S&P Dow Jones Indices LLC via FRED®
Shaded areas indicate U.S. recessions.
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What is a Stock?

A stock, or sometimes an equity, is a share of ownership in a firm

A stockholder has an ownership share equal to his/her share of ownership in total stock outstanding

Gives owner voting rights

Stockholder is also a residual claimant on firm's assets (in event of bankruptcy/liquidation, debt claimants are "senior" to equity holders)

May get periodic dividend payments (distributed profits)

Can also earn money from capital gains (changes in price of shares)

How is a Stock Priced?

Just like for bonds, the price of a stock (or any asset) is equal to the present discounted value of cash flows

But stocks don't have maturity dates nor a meaningful face value (often "par" value is the original sale price, but doesn't entitle holder to anything in the future)

Cash flows from stock (dividends) are not pre-specified up front

Stock Pricing Continued

Let κ_e be the discount rate for equity (the e is for equity). Equivalently: the required return

Let D_{t+1} be the dividend payout in period $t+1$ and P_{t+1} the share price in $t+1$. Period t is the present and P_t is the price

Discount rate equates share price to present discounted value of cash flows:

$$P_t = \mathbb{E}\left[\frac{D_{t+1}}{1+\kappa_e} + \frac{P_{t+1}}{1+\kappa_e}\right]$$

The expectation operator reflects fact that future dividends and price are unknown

Price composed of two components – dividend, $\frac{D_{t+1}}{1+\kappa_e}$, and capital gain, $\frac{P_{t+1}}{1+\kappa_e}$

Returns and Price

The realized return on equity is defined as the cash flow divided by purchase price. This equals dividend plus capital gain (share price appreciation):

$$R_{t+1} = \frac{D_{t+1} + P_{t+1} - P_t}{P_t}$$

The expected return is:

$$R^e_{t+1} = \mathbb{E}\left[\frac{D_{t+1} + P_{t+1} - P_t}{P_t}\right] = \kappa_e$$

These will in general not be equal due to unexpected fluctuations in dividend payments and unexpected share price movements

You may demand compensation for this uncertainty, or risk, in the form of a higher expected return, κ_e

A Micro-Founded Asset Pricing Model

Suppose that an agent lives for two periods, t and $t+1$. Agent can save via one of two assets:

1. Risk-free discount bond, B_t. Purchase price of P_t^B in period t and which pays out 1 with certainty in $t+1$
2. Risky stock, S_t. Purchase price of P_t^S in period t, pays an unknown dividend per share, D_{t+1}, in period $t+1$. Price in period $t+1$ is 0 (since world ends after $t+1$)

Earns income, Y_t and Y_{t+1}. Period $t+1$ income is uncertain, period t income is known

$$C_t + P_t^S S_t + P_t^B B_t \leq Y_t$$

$$C_{t+1} \leq Y_{t+1} + B_t + D_{t+1} S_t$$

Preferences

Household wants to maximize expected lifetime utility:

$$U = u(C_t) + \beta \, \mathbb{E} \left[u(C_{t+1}) \right]$$

Future consumption is uncertain because future income and the dividend payout on the risky stock are uncertain

Optimality Conditions

Assuming constraints hold with equality, plugging in to lifetime utility to eliminate C_t and C_{t+1}, and taking derivatives with respect to B_t and S_t and setting equal to zero yields the following first order conditions:

$$P_t^B = \mathbb{E}\left(\frac{\beta u'(C_{t+1})}{u'(C_t)}\right)$$
$$P_t^S = \mathbb{E}\left(\frac{\beta u'(C_{t+1})}{u'(C_t)} D_{t+1}\right)$$

We call $\frac{\beta u'(C_{t+1})}{u'(C_t)}$ the stochastic discount factor

These FOC look similar – price (P_t^B or P_t^S) equals product of SDF and cash flow in period $t+1$ (1 or D_{t+1})

If There Were No Uncertainty over Stock Payout

The expected (gross) returns on each asset are just future cash flows divided by current price

Endowment economy structure: consumption equals endowment each period, assets in zero net supply (simplifying)

Since the future cash flow on the bond is known with certainty, its (gross) return is known:

$$R^e_{B,t+1} = \frac{1}{P^B_t} = \left[\mathbb{E}\left(\frac{\beta u'(Y_{t+1})}{u'(Y_t)}\right)\right]^{-1}$$

If D_{t+1} were known, then we could write:

$$R^e_{S,t+1} = \frac{D_{t+1}}{P^S_t} = \left[\mathbb{E}\left(\frac{\beta u'(Y_{t+1})}{u'(Y_t)}\right)\right]^{-1} = R^e_{B,t+1}$$

Numerical Example

Suppose that $Y_t = 1$, $\beta = 0.95$, and that the utility function is natural log

Allow for uncertainty over endowment, but not on payout from stock

Suppose that endowment can take on two values in $t + 1$ – Y^l_{t+1} or Y^h_{t+1}, where $Y^h_{t+1} \geq Y^l_{t+1}$. p is the probability of the low state, and $1 - p$ is the probability of the high state:

$$\mathbb{E}\left(\frac{\beta u'(Y_{t+1})}{u'(Y_t)}\right) = p \times \beta \frac{Y_t}{Y^l_{t+1}} + (1-p) \times \beta \frac{Y_t}{Y^h_{t+1}}$$

Suppose we have $p = 0.5$, $Y^l_{t+1} = 0.9$, and $Y^h_{t+1} = 1.1$. Then the expected value of the SDF is 0.9596, so this is the bond price, P^B_t

Suppose $D_{t+1} = 1.1$ with certainty. Then the price of the stock is 1.0556

Price and Yields

The yield on the riskless bond is:

$$1 + i_B = \frac{1}{P_t^B} = 1.0421$$

The required/expected return on the stock is then:

$$1 + \kappa_e = \frac{D_{t+1}}{P_t^S} = 1.0421$$

If there is no uncertainty over asset payouts, you use the same discount rate to price different assets:

$$\frac{1}{1.0421} = 0.9596 = P_t^B$$
$$\frac{1.1}{1.0421} = 1.0556 = P_t^S$$

Now Enter Uncertainty over Future Dividend

Now suppose that the future dividend takes on two values, D_{t+1}^{l} and D_{t+1}^{h}, where $D_{t+1}^{h} > D_{t+1}^{l}$. Suppose that these different values materialize in the same high/low state for the endowment with the same probabilities (p and $1-p$)

Suppose that $D_{t+1}^{l} = 1$ and $D_{t+1}^{h} = 1.2$. With $p = 0.5$ we have $\mathbb{E}[D_{t+1}] = 1.1$, just like before

We get a stock price of $P_t^s = 1.0460$, which is less than the case where there was no uncertainty. Expected/required return on the stock is:

$$1 + \kappa_e = \frac{E[D_{t+1}]}{P_t^s} = \frac{1.1}{1.0460} = 1.0516$$

This is higher than the yield on the bond

Equity Risk Premium

Define the equity risk premium as the difference between the discounts rates on equity and the riskless bond:

$$\psi = \kappa_e - i_B$$

In our numerical example, this works out to be 0.0096

As when thinking about the risk and term structures of interest rates, it is <u>covariance</u> of stock payouts with marginal utility that drives an equity premium, not variance per se

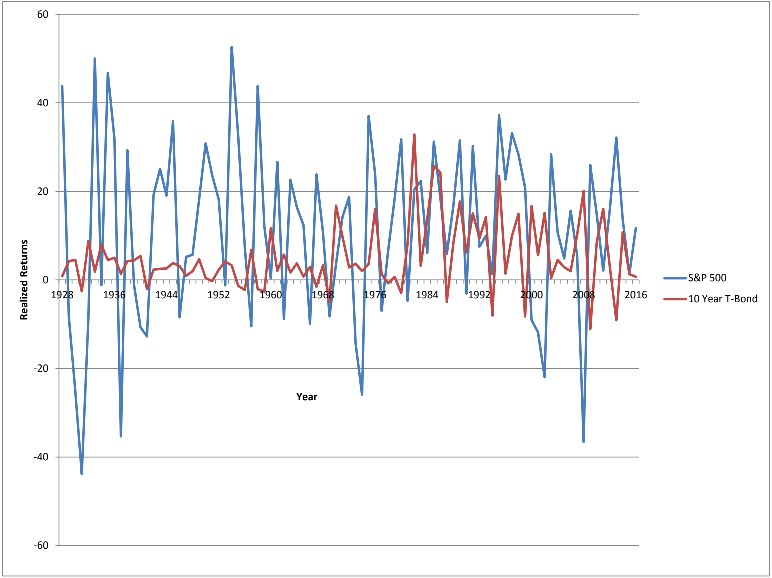
Equity Premium

Simple theory would suggest that stocks offer high expected returns if cash flows co-vary negatively with the stochastic discount factor

For stocks, stands to reason that we should observe a negative covariance, and hence positive equity premium, in the data. Why?

- In periods of recession, we are likely to observe both low endowment and low stock returns (dividends in the two period example)
- Vice-versa for expansion
- With log utility, SDF in two period endowment example is $\beta \frac{Y_t}{Y_{t+1}}$. When Y_{t+1} is low (recession), SDF is high and dividend rate, D_{t+1} is likely to be low
- You most like assets which give high returns when output is low, not high. Hence demand a premium to hold such assets (stocks)

Realized Returns on S&P 500 and 10-Yr Treasury Bond



Asset Pricing for Dummies

1. All assets are substitutable ways to transfer resources intertemporally, but have different risk characteristics

2. There is a risk-free yield/rate that is an equilibrium construct that depends on demand and supply forces (i.e., short-term gov. debt)

3. Longer-term government debt is priced off of short-term debt (term premium)

4. Privately-issued debt is priced off of government debt of comparable maturity (risk premium)

5. Stocks are priced off of longer maturity private debt (equity premium)

6. These premia depend on <u>covariances</u> with SDF

Equity Premium Puzzle

In the data, the historical average (real) return on equity is something like 7 percent per year

But the average real return on bonds is something like 1 percent: avg. equity premium $\approx$ 6 percent

It is very difficult to generate a premium this high with "standard" preferences

- In fact, in a more sophisticated model with standard (i.e., log) preferences, people like Mehra and Prescott (1985) find an equity premium of about one percent
- Just like we did in the simple numerical example above
- Puzzle: to justify 6 percent, needs **enormous** amount of risk aversion (i.e., "curvature" in utility function)
- This is needed to get stochastic discount factor to move around a bunch (i.e., to make the negative covariance term **big**)

Moving Beyond Two Periods

We started with the pricing equation. Then "solve forward"

$$P_t = \mathbb{E}\left[\frac{D_{t+1}}{1+\kappa_e} + \frac{P_{t+1}}{1+\kappa_e}\right]$$

$$P_t = \mathbb{E}\left[\frac{D_{t+1}}{1+\kappa_e} + \frac{1}{1+\kappa_e}\left(\frac{D_{t+2}}{1+\kappa_e} + \frac{P_{t+2}}{1+\kappa_e}\right)\right]$$

Keep going. Since stock never matures (unlike a bond):

$$P_t = \mathbb{E}\left[\sum_{j=1}^{\infty}\frac{D_{t+j}}{(1+\kappa_e)^j}\right] + \mathbb{E}\left[\lim_{T\to\infty}\frac{P_{t+T}}{(1+\kappa_e)^T}\right]$$

No bubble condition: last term drops out (PDV of price in infinite future is zero), so stock price is just PDV of future dividends

Gordon Growth Model

Impose the no bubble condition. Assume that dividends grow at a constant rate across time, $D_{t+1} = (1+g)D_t$ and so on for any two adjacent periods. Hence, no uncertainty over future dividends

After some math, you get the following condition:

$$P_t = \frac{(1+g)D_t}{\kappa_e - g}$$

This is essentially a price-earnings ratio, if you take D_t to be earnings The PE ratio will be higher the:

1. Lower is κ_e (i.e. the less risky the stock is)
2. The higher is g (the more dividends are expected to grow)

Monetary Policy and the Stock Market

Gordon growth model provides a simple and intuitive way to understand how monetary policy might affect the stock market

Expansionary monetary shock (lowering short-term interest rates):

- Likely lowers κ^e because of lower short-term bond rates (which influence longer term bond rates, off of which stocks are "priced")
- Likely temporarily raises g because an expanding economy is good for dividends
- Both ought to raise stock prices

At onset of COVID-19, stock prices plummeted, but have since recovered

Rational Expectations and Efficient Markets

Rational expectations: agents form optimal, model-consistent expectations using all available information

Intuition: if you make choices optimally, and choices depend on expectations, it makes sense to use all available information to form expectations optimally

Does not mean that your forecasts are always right, it means your forecasts are right on average and forecast errors are unpredictable

Formally, for a random variable X_{t+1}, we have:

$$\mathbb{E}(X_{t+1}) = X_{t+1} + \varepsilon_{t+1}$$

ε_{t+1} is a forecast error and is (i) zero on average and (ii) unpredictable

Efficient Markets

Suppose that the expected return consistent with the SDF on an asset is R_t^*. This could differ across assets due to risk, liquidity, etc. R_t^* is the required return on the asset

Suppose that $R_t^e > R_t^*$ for this asset. What should a smart investor do? Buy more of that asset until $R_t^e = R_t^*$. Doing so will drive the price of that asset, P_t, up, and hence the return down

Vice-versa if $R_t^e < R_t^*$

Smart investors ought to eliminate arbitrage opportunities Price of asset should be set such that $R_t^e = R_t^*$

Implication: there is no such thing as an under- or over-valued stock according to efficient markets!

Random Walk Hypothesis

An implication of efficient markets is something known as the random walk hypothesis

Basic idea: changes in stock prices ought to be unpredictable

Suppose a stock pays no dividend, so the price satisfies:

$$P_t = \mathbb{E}\left[\frac{P_{t+1}}{1+\kappa_e}\right]$$

This implies that, approximately:

$$\mathbb{E}\left[\frac{P_{t+1}-P_t}{P_t}\right] = \kappa_e$$

The stock ought to be priced where the expected growth rate of price (more generally, return if stock pays dividend) equals the required return

Bubbles

Recall from earlier that successively substituting in gave us the expression for a stock price:

$$P_t = \mathbb{E}\left[\sum_{j=1}^{\infty} \frac{D_{t+j}}{(1+\kappa_e)^j}\right] + \mathbb{E}\left[\lim_{T\to\infty} \frac{P_{t+T}}{(1+\kappa_e)^T}\right]$$

Define the bubble term as the last part:

$$B_t = \mathbb{E}\left[\lim_{T\to\infty} \frac{P_{t+T}}{(1+\kappa_e)^T}\right]$$

Define the fundamental price, P_t^F, as the PDV of dividends:

$$P_t^F = \mathbb{E}\left[\sum_{j=1}^{\infty} \frac{D_{t+j}}{(1+\kappa_e)^j}\right]$$

Bubbles Continued

Actual price is sum of fundamental price and bubble:

$$P_t = P_t^F + B_t$$

Earlier, e.g., Gordon Growth Model, we imposed a no-bubble condition, $B_t = 0$

Can we do that?

For a finitely-lived asset (e.g., bond), **yes**

For infinitely-lived asset (e.g., stock), **not necessarily**

Bubbles Continued

Recall that we can write:

$$P_t = \mathbb{E}\left[\frac{D_{t+1} + P_{t+1}}{1 + \kappa_e}\right]$$

Using facts that $P_t = P_t^F + B_t$, as well as fact that $P_t^F = \mathbb{E}\left[\frac{D_{t+1}+P_{t+1}^F}{1+\kappa_e}\right]$, we can conclude:

$$\mathbb{E}\left[B_{t+1}\right] = (1 + \kappa_e)B_t$$

If bubble exists ($B_t \neq 0$), then it must be expected to grow at the discount rate for equity

Intuition: you would "overpay" for an asset (pay more than fundamental value) if and only if you think you can sell it to someone else in the future who will overpay by more

Bubbles Bursting

Note that, if one exists, a bubble must grow in expectation, but this doesn't mean that the bubble will in actuality last forever

Suppose that $B_t = 1$ and $\kappa_e = 0.05$

Suppose that the bubble "bursts" with probability p (meaning $B_{t+1} = 0$) and continues with probability $1 - p$

We can solve for what the realized value of B_{t+1} must be in the event it does not burst by noting:

$$\mathbb{E}(B_{t+1}) = p \times 0 + (1 - p) \times B_{t+1} = (1 + \kappa_e) B_t$$

So, if $p = 0.2$ for example:

$$B_{t+1} = \frac{(1 + \kappa_e) B_t}{1 - p} = \frac{1.05}{0.8} = 1.3125$$

Simulating Bubbles

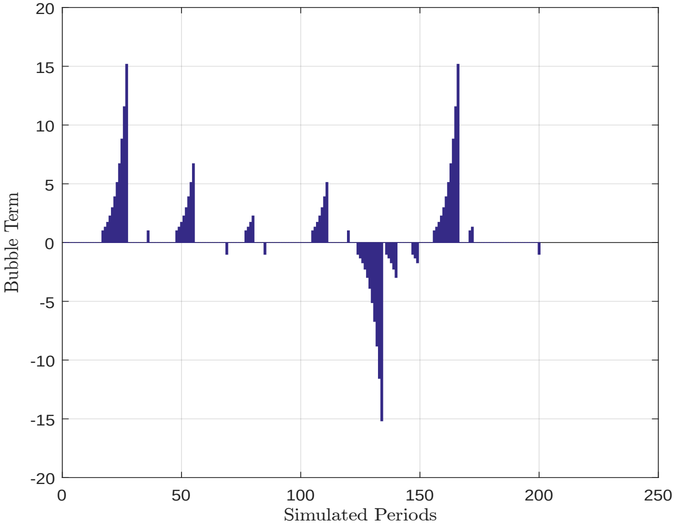
Suppose I have a bubble process

If $B_t = 0$, there is a p probability of entering a positive bubble ($B_{t+1} = 1$), and a q probability of entering a negative bubble ($B_{t+1} = -1$). Hence a $1 - p - q$ probability you stay out of a bubble

If you're in a bubble, $B_t \neq 0$, in expectation the bubble must grow at $(1 + \kappa_e)$, but you exit the bubble (go back to 0) with probability r

Assume $\kappa_e = 0.05$, $p = q = 0.05$, and $r = 0.2$

Simulating Bubbles



Bubbles Continued

Recall that the bubble term is:

$$B_t = \mathbb{E}\left[\lim_{T\to\infty} \frac{P_{t+T}}{(1+\kappa_e)^T}\right]$$

If the asset in question has a finite "life span" (e.g. a bond with a known maturity), there cannot be bubbles

Why? The value of the asset at maturity is zero, so $P_{t+T} = 0$ at maturity, and therefore $B_t = 0$

We should not observe bubbles for assets with known maturities (e.g. bonds, cars), but may see them in assets without maturities (e.g. stocks, land/housing)

Bubbles in the Press

Economists have a precise definition of a bubble – deviation of price from fundamental value, where fundamental value is PDV of cash flows

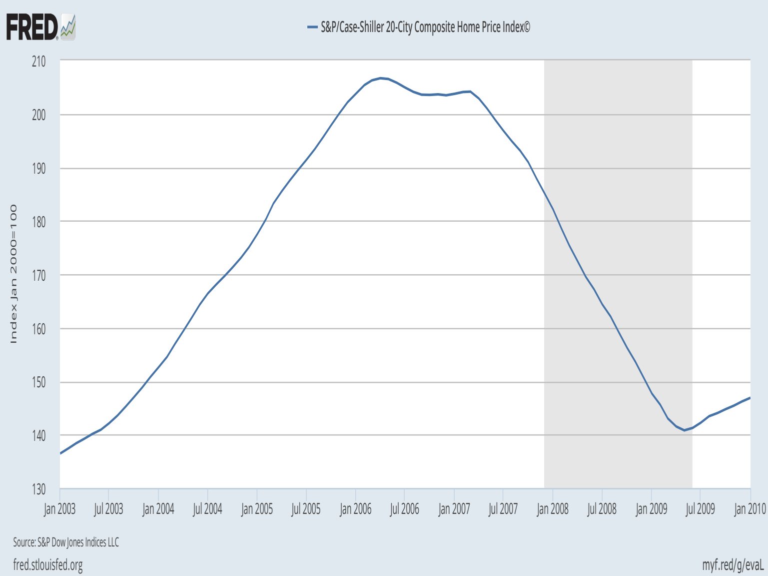
In the press and in the media, a “bubble” is more loosely defined as a situation in which an asset (e.g. stocks, housing) experiences very rapid price growth, followed by a subsequent decline (i.e. a bursting of the bubble)

Real-life examples:

1. Tech boom and bust of late 1990s
2. Housing boom and bust of mid-2000s

Tech Boom and Bust

Housing Boom and Bust



Were These Episodes Actual Bubbles?

Very hard to say, especially in "real time," but even after the fact

Evidence of prices rising and then subsequently falling is <u>not</u> necessarily evidence of a bubble that subsequently burst

People could have expected dividends (rents, in the case of housing) to grow in future, and this didn't materialize

Alternatively, people could have had temporarily low discount rates that subsequently increased

Analysis on Simulated Data

I created a computer program to simulate stock price. Constant required return, $\kappa^e = 0.07$

I assume dividends are given by $D_{t+1} = (1 + g_t)D_t$, where g_t is the growth rate, which follows a stochastic process:

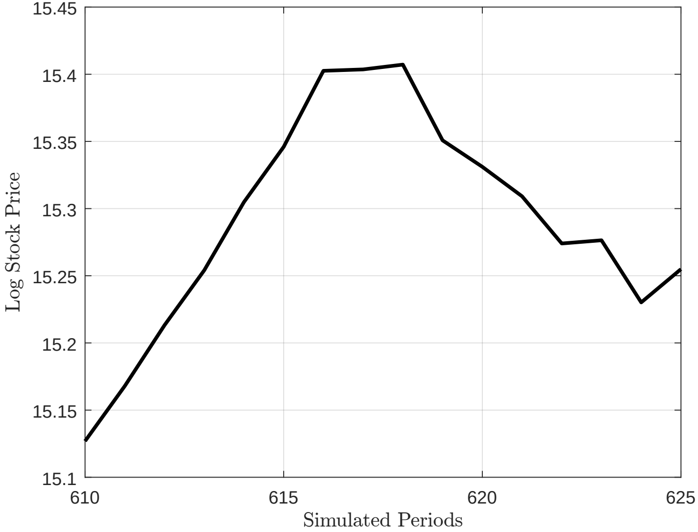
$$g_t = (1 - \rho)g^* + \rho g_{t-1} + \varepsilon_t$$

g^* is the average growth rate, $0 < \rho < 1$ is a measure of persistence, and ε_t is an iid shock drawn from a normal distribution with standard deviation s_g

I set $\rho = 0.8$, $g^* = 0.02$, and $s_g = 0.01$

I simulate a process for dividends, then at each date, given current dividends and the known process for the growth rate, I forecast future dividends and discount those to compute the price at each date, assuming no bubble

Looks Like a Bubble, But Not



Detecting Bubbles in the Data

Robert Shiller (Nobel Prize Winner) is an advocate of the existence of bubbles

One empirical test he proposes is to look at correlation between P/E ratios and subsequent realized returns

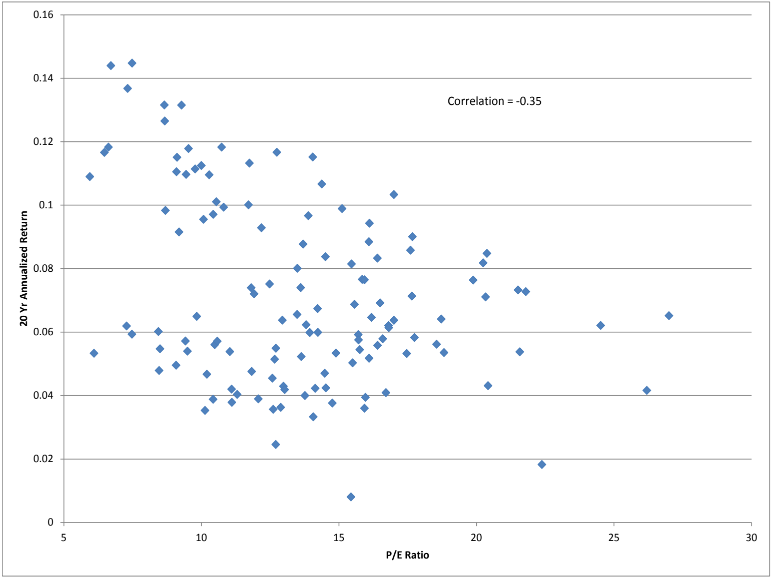
Basic idea: if there is a bubble, P/E ratio will be high (or low) but the bubble will eventually burst, so realized returns will be low (or high)

In other words, bubbles would manifest as negative correlations between P/E ratios and subsequent realized returns

Other ways to try to do this (such as try to calculate fundamental price and compare deviation from observed prices)

Look at S&P 500 stock market, evidence roughly consistent with this

P/E Ratios and Subsequent 20 Year Annualized Returns: Data



Is This a Good Test?

To see whether this test makes sense, I return to the model simulation

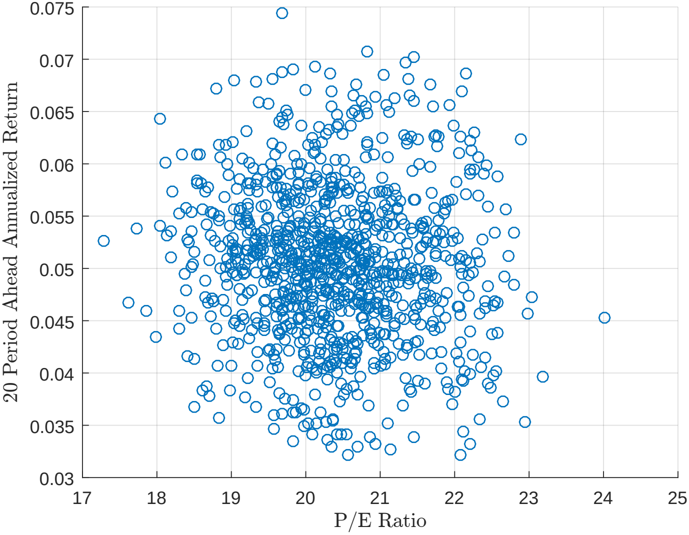
I use the same parameter values, and assume no bubbles

I calculate P/E ratios and subsequent 20-period returns and produce a scatter plot

It's really a "blob" – no obvious correlation between PE ratios and subsequent returns

Also, not an enormous amount of variation in P/E ratios

P/E Ratios and Subsequent 20-Year Annualized Returns: Model



Now Add in Bubbles

Similar setup as above, but slightly different parameters

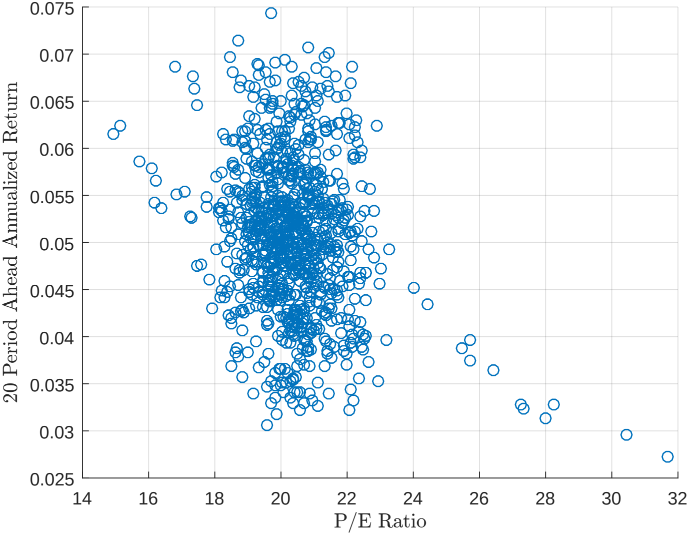
Probability of entering a positive or negative bubble is $p = q = 0.005$, so bubbles are pretty rare

Conditional on being in a bubble, stay in the bubble with probability $1 - r = 0.90$ (10 percent chance of exit)

If you enter a bubble, its size is proportional to current level of dividends (this ensures bubble term isn't irrelevant later in the sample since dividends and hence price are growing)

You generate a downward-sloping scatter plot, just as in data

P/E Ratios and Subsequent 20-Year Annualized Returns: Model with Bubble



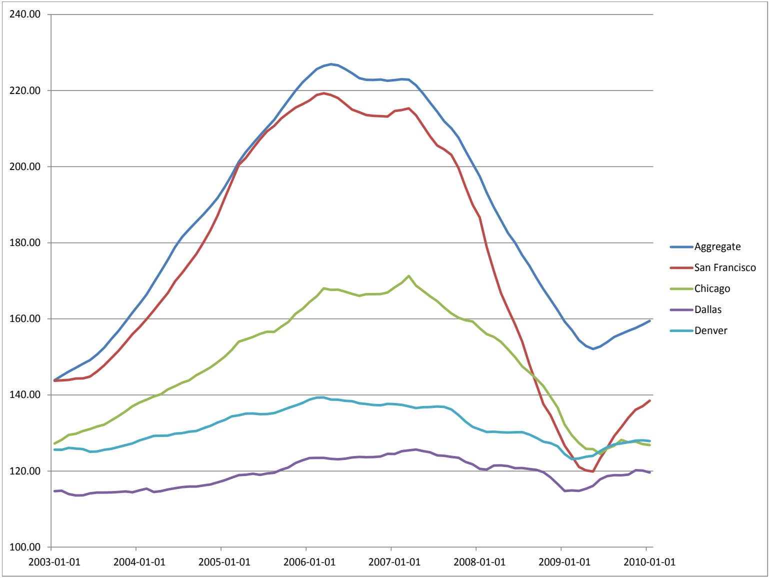
Should Monetary Policy Try to Prevent Bubbles?

Some argue that (i) the Fed helped fuel the housing bubble by keeping interest rates too low for too long after early 2000s recession and (ii) the Fed should seek to identify bubbles and use monetary policy to burst them before they get too big and before their bursting becomes as painful

Empirical evidence on (i) is not great – see Dokko et al (2007, "Monetary Policy and the Global Housing Bubble," *Economic Policy*

What about (ii)? Interest rate is a rather crude tool – it applies to all markets equally, and bubble may not be same in all markets (see next slide)

Comparing the Housing "Bubble" In Different Markets



Macroprudential Regulation

If "bubble" not the same in all markets (it wasn't), interest rate is a pretty blunt tool

Macroprudential regulation: macro (as opposed to micro) financial market rules and regulations which try to prevent the kind of financial market upheaval recently witnessed

1. Loan-to-value ratios
2. Lending standards
3. Capital requirements

In a nutshell, trying to make it difficult to get debt-fueled asset price increases in the first place (through lending standards and loan to value ratios), and trying to make consequences of prices falling less disastrous for other markets (capital requirements) if prices do decline