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Rational bubbles
NEW YORK STOCK EXCHANGE
LIVERMORE

- Asset prices deviate often substantially from their fundamental value for prolonged times. This is often referred to as 'bubble'.
- While such bubbles persist for a long time, it can happen that the asset price adjusts suddenly, leading to a crash of the asset price.
- We will look at why bubbles may emerge and why they might crash.

Existence of bubbles

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→ We have strong empirical evidence that the prices of assets and its fundamental value deviate substantially from each other for longer periods of time.

- We often observe that stock prices in particular deviate a lot from the fundamental value.
- Such deviations which are persisting for a long period of time are called a 'bubble'.

- We observe that stock prices are above the fundamental value, thus stocks are overvalued.
- It is very rarely the case that stocks are undervalued for a long period of time, the price is below the fundamental value. These assertions hold for stocks where there is no information that is not available to traders, or which is barely known. We here assume that most, if not all, traders agree on the fundamental value and the price is nevertheless different.

- Such observations are not limited to stock markets. We also find them in property, residential houses as well as commercial property, such as office spaces or property in industrial estates.
- We also often find that one currency is significantly overvalued or undervalued; this would be an example of an asset with a bubble being undervalued.
- Commodities can also show significant and prolonged overvaluations.
- This is particularly observed in precious metals, such as gold, sometimes also in silver. It might also occur in rare earth metals (like Lithium) or other metals such as cobalt, mainly arising from potential demand in computer chips.

→ We will seek to explain the existence of such bubbles and show that their existence is rational.

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- Stock prices are exceeding their fundamental value substantially

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- Similar observations are also made in real estate

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- Similar observations are also made in real estate, exchange rates

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→ We now discuss conditions under which investing into stocks having a bubble can be rational.

- Investing into a stock which is known to be in a bubble, that is its price is above the fundamental value, can be rational if the expected return on this stock is identical to other investments (adjusting for risks). In that case, even if a stock (or another asset) is overvalued, would it be rational to invest into this stock.
- The idea is that even though the stock is bought at a price exceeding the fundamental value, it would be rational to do so if the investor expects the stock price to increase even further. In that case he would be able to sell the stock at a higher price and the fundamental value becomes irrelevant.
- However, the bubble might burst and the stock price return to the fundamental value of the asset. In that case the investor would face a significant loss. The possibility of such a loss needs to be considered when assessing the returns of the investment.
- If the expected return of investing into a stock during its bubble is the same as that of the same stock not in a bubble, the investment would be rational. We choose the same stock here such that we do not need to adjust for different risks.

→ Formally, the risks of a stock in a bubble and a stock not ina bubble are not the same, the possibility of the bubble bursting will increase risks. We neglect this aspect here, but note that for risk averse investors, this would reduce the utility of investing into a stock during a bubble; however, we could easily comensate the investor for this additional risk by a slightly higher return on the stock in a bubble without changing arguments.

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Bubble specification

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→ We can now develop a simple model of a bubble that meets all these requirements.

- We divide the price of a stock up into two components; the first components is the fundamental value of the stock.
  - The second component would be any deviation from this fundamental value, which we call a 'bubble'.
- *Formula*
- The fundamental value increases by its expected return, which could be determined from the CAPM, for example.
- We assume that if a bubble burts, the price changes instantly to be the fundamental value, this implies that the bubble becomes zero. We assume that the bubble bursts with some probability $1 - \pi$.
  - Alternatively, the bubble will continue to exist and grow at a some rate R.
- *Formula*
- After the afore mentioned, the expected return of the stock in a bubble has to be equal to the expected return of a stock without the bubble. The expected return of the stock ina bubble is given by the case where the bubble persists (when the bubble bursts the bubble becomes zero) and this needs to generate the same return μ as the fundamental value of the stock (the stock without the bubble).
- *Formula*
- [$\Rightarrow$] This easily solves for the required return of the bubble, as long as it persists.

→ We can now analyse the implications of our findings.

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- The stock price consists of the fundamental value
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- The fundamental value increases with its expected return: $P_{t+1}^* = (1 + \mu)\, P_t^*$
- A bubble may burst and the price reverts to its fundamental value
- $B_{t+1} = \begin{cases} 0 & \text{with probability} \quad 1 - \pi \end{cases}$

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- The fundamental value increases with its expected return: $P_{t+1}^* = (1+\mu)\, P_t^*$
- A bubble may burst and the price reverts to its fundamental value, or the bubble continues to exist
- $B_{t+1} = \begin{cases} (1+R)\, B_t & \text{with probability} \quad \pi \\ 0 & \text{with probability} \quad 1-\pi \end{cases}$

Bubble specification

→ We can now develop a simple model of a bubble that meets all these requirements.

- We divide the price of a stock up into two components; the first components is the fundamental value of the stock.
  - The second component would be any deviation from this fundamental value, which we call a 'bubble'.
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- The fundamental value increases by its expected return, which could be determined from the CAPM, for example.
- We assume that if a bubble burts, the price changes instantly to be the fundamental value, this implies that the bubble becomes zero. We assume that the bubble bursts with some probability $1 - \pi$.
  - Alternatively, the bubble will continue to exist and grow at a some rate R.
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- After the afore mentioned, the expected return of the stock in a bubble has to be equal to the expected return of a stock without the bubble. The expected return of the stock ina bubble is given by the case where the bubble persists (when the bubble bursts the bubble becomes zero) and this needs to generate the same return μ as the fundamental value of the stock (the stock without the bubble).
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Increasing deviations of stock price and fundamental value

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→ We can now see that over time stock price increase faster than the fundamental value, at least until the bubble bursts.

- We see that the return of the bubble term for as long as it persists is higher than the return of the fundamental value. This implies that the bubble term grows faster than the fundamental value.
- This higher return is the compensation for the large negative return in the case that the bubble bursts. Thus a higher return if the bubble persists offsets a negative return if the bubble bursts.
- [⇒] With the bubble term becoming ever bigger, the stock price becomes more and more detached from the fundamental value.
- We also see that bubbles that are more likely to burst (π) have a higher growth rate. This higher growth rate compensates for the higher risk of the bubble bursting. It is thus that the more unstable a bubble is, the faster it grows.
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Starting of a bubble

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→ The first point to consider is how a bubble can start. From our model it is apparent that if $B_0 = 0$, no bubble will emerge.

- A bubble cannot emerge endogenously from the simple model we have established here.
- We need to introduce an initial bubble term exogenously.

- If information on the fundamental value is not perfect, the signals traders receive might give rise to misvaluations, which could then form part of the initial bubble.
- Noise traders with their random demand can also create a bubble term purely by chance, which then can persists in the manner described here.

→ While the start of a bubble can have many reasons, we predominantly see positive bubble terms in stock markets. We will now explore the reason for this observation.

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Impossibility of negative bubbles in stock markets

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→ We will now show that in many markets, negative bubbles cannot emerge.

- Stocks have limited liability, that is shareholders have no obligations to cover any shortfall to creditors if the company fails. It is therefore that the value of the stock can never become negative.
- - We had established that for as long as bubbles do not burst, they are increasing. Suppose now we have a negative bubble. As the stock price can never become negative, there is a limit to the size of the bubble.
  - The largest possible bubble is when the bubble has reached the fundamental value of the stock as then the stock price is zero.
- - Any investor who buys the stock at the price zero, can be sure that it will not be reducing any further.
  - However, if the bubble bursts, it will increase and the investor makes a large profit.
- [⇒] The stock price has to increase as such a stock would be very attractive to investors and there would be a large demand. This demand will increase the stock price, thus reduce the bubble, which in our model implies that the bubble bursts.
- - A time period earlier, investors will anticipate that the bubble will burst in the next time period for sure and hence the profits will be large.
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- We can take this logic back to the initial time period and we can never have a negative bubble to commence.
- Commodities also have a lower price limit (which might be slightly negative due to storage costs) and real estate.

→ We have thus seen that in many markets negative bubbles cannot emerge as prices have a lower limit.

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- Commodities also have a lower price limit (which might be slightly negative due to storage costs) and real estate.

→ We have thus seen that in many markets negative bubbles cannot emerge as prices have a lower limit.

Impossibility of negative bubbles in stock markets

- Stocks have limited liability and a stock price below zero is not possible
- As the bubbles has to increase as long as it persists, investors know when it will stop to grow, at $B_t = -P_t$
- Investors would invest at this moment as the stock price cannot reduce, but only increase if the bubble bursts

$\Rightarrow$ Stock price increases and the bubble bursts

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  - We had established that for as long as bubbles do not burst, they are increasing. Suppose now we have a negative bubble. As the stock price can never become negative, there is a limit to the size of the bubble.
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Impossibility bubbles in fixed income securities

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- Fixed income securities (bonds) are repaid at a specific date and the amount that is repaid is fixed as well (usually the face value of the bond).
- As this payment is known and neglecting the possibility of default, there cannot be a bubble at the maturity of the bond. Even if the issuer can default on the bond, the size of the bubble will be strictly limited as the most that will be repaid is the agreed amount and the least repaid is zero, giving maximum sizes for the size of the bubble.

- Investors know that the bubble will burst at maturity
- and hence they would sell the bond in the time period before to avoid the certain loss.

- [⇒] As investors sell the bond, the bubble will burst a time period prior to maturity.
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- [⇒] The same logic now applies and the bubble will burst two time periods prior to maturity
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- [⇒] Hence we cannot have a bubble, positive or negative, in fixed income markets.

→ The fixed repayment amount and maturity date are certainties and this does not allow the emergence of any bubble, positive or negative.

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- Fixed income securities are repaid at a fixed price and fixed date, at this point the bubble must burst
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- Fixed income securities are repaid at a fixed price and fixed date, at this point the bubble must burst
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Positive and negative bubbles in exchange rates

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→ However, we will now argue that negative bubbles can exist, at least in currencies.

- Foreign exchange markets are different in that no lower or upper limitation of the price applies, even though exchange rates cannot be negative.
- A bubble in a currency can be a positive bubble for one investor (overvaluation of their currency), but for an investor in the other currency it would be a negative bubble (undervaluation of the other currency). The exchange rates are e and $\frac{1}{e}$, respectively, thus they van never reach zero. Thus a positive bubble is always also a negative bubble and vice versa.
- In derivatives markets, negative values are possible (futures/forwards and swaps) and hence we have no lower limit and negative bubble should also be possible.
- However, derivatives are different in that their value is tied to the value of the underlying asset and arbitrage between the derivative and the underlying asset should make any bubbles impossible.

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- In derivatives markets, negative values are possible (futures/forwards and swaps) and hence we have no lower limit and negative bubble should also be possible.
- However, derivatives are different in that their value is tied to the value of the underlying asset and arbitrage between the derivative and the underlying asset should make any bubbles impossible.

→ It is thus only foreign exchange markets that can have negative bubbles, otherwise only positive bubbles can be observed.

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  - Most commonly bubbles are discussed in the stock market,
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→ As assets with bubbles give the same return as the fundamental value, it is rational to invest into such assets, even if the investor knows that there is a bubble. He hopes to be able to sell the asset later, before the bubble bursts ('ride the wave').

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