



Hedging and market crashes

- Stock market crashes are often seen as the result of overvalued stocks correcting their prices and aligning again with their fundamental value.
- However, the reason for such a sudden change in the stock price is not easily identified.
- We will here discuss a model based on the demand for stocks that includes hedging by uninformed investors.

# Demand for assets by informed and uninformed investors

- ▶ Informed investors will demand more stocks the lower the price is
- ▶ If the stock price is high, uninformed investors may want to hedge their exposure
- ▶ Uninformed investors would like to participate in any future gains of the asset, but limit losses
- ▶ Uninformed investors would buy put options as a hedge
- ▶ Such hedges might be entered into at similar times by uninformed investors, which may result in similar strike prices being chosen

# Demand for assets by informed and uninformed investors

- In general we have informed and uninformed investors acting in the market and we will suggest ways how their behaviour might differ.
- ▶ Informed investors will have signals about the value of the stock, and we assume these signals to differ. The higher the price, the fewer informed investors will have a signal that suggests an even higher fundamental value. Thus the demand for stocks will decrease the higher the price is.
- ▶ If the stock price is particularly high, uninformed investors, who maximize their utility and are thus not noise traders, will see substantial risks in that the value of the stock is below this price. To avoid large losses, they might want to hedge their risks from a falling stock price.
- ▶
  - However, this hedging is ideally such that they can still make gains if the stock price increases further,
  - but they want to avoid or at least limit the losses they could make if the stock price declines.
- ▶ Such a hedge can be made using options; specifically, they would buy a put option, giving them the right to sell the stocks at an agreed price. Thus the investor is guaranteed this price, but as the option does not need to be exercised, will still participate in gains if the stock price is higher.
- ▶
  - It could be that due to media coverage about high valuations in the stock market, or the reaching of landmark prices/index values, for example 100, 5000, 10000, uninformed investor decide to enter such hedges at roughly the same time.
  - Most will choose a strike price for the option which is around the current stock price, thus they will all hold put options with very similar strike prices.
- We can now determine the impact such behaviour by uninformed investors has on stock prices.

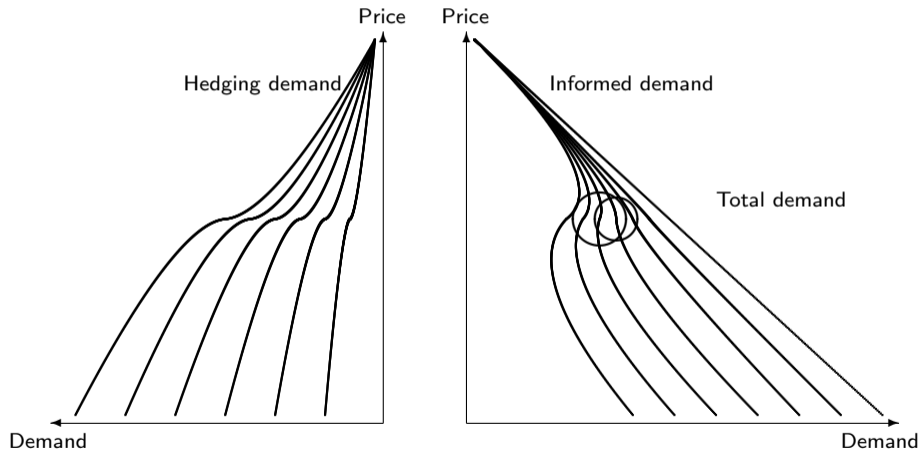
## Demand for assets from hedging

- ▶ The seller of the put option may want to hedge their own exposure to the asset market
- ▶ They can do so through  $\Delta$ -hedging
- ▶ They would short-sell  $\Delta_P = N(d_1) - 1$  assets for each put option sold
- ▶ This creates a negative demand, driven by the  $\Delta_P$  of the put option
- ▶ The higher the demand for put options, the more short-selling occurs
- ▶ The amount of short-selling will depend non-linearly on the current price of the asset

# Demand for assets from hedging

- We firstly establish implications of hedging on the demand for stocks.
- ▶ With informed investors buying put options, the seller of such options, often banks, hedge funds, pension funds, or insurance companies, may want to hedge the exposure the selling of the put option has caused them.
- ▶ The way of achieving this is by replicating the option in line with the option pricing formula. This is commonly known as  $\Delta$ -hedging.
- ▶ The strategy would mean to engage in a short position of the underlying asset, the stock. From the Black-Scholes option pricing formula, we know that this  $\Delta$  is given as in the *formula*.
- ▶ This expression is negative and will hence create a negative demand for shares and how big this demand is can be obtained from  $\Delta_P$ .
- ▶ The more put options are bought by informed investors, the more hedging demand exists, thus the more short selling can be observed.
- ▶ The nature of  $\Delta_P$  is such that the demand will depend on the price of the underlying stock, but it will do so on a nonlinear way.
- We will now look at how these short positions affect the total demand for the stock.

# Increasing hedging demand



# Increasing hedging demand

- Let us consider what happens if we increase the demand for hedging.
  - ▶ We look at the relationship between the stock price and the demand.
  - ▶ The demand by informed investors we argues was having a negative slope as indicated here.
  - ▶ We now introduce the hedging demand. This demand was negative.
  - ▶ If the amount of put options bought by uninformed investors is low, the hedging demand will be low.
  - ▶ We take this hedging demand off the demand by informed investors as we interpret the demand as the overall net demand.
  - ▶ We can now increase the number of put options bought, increasing the hedging demand. Note that the hedging demand is non-linear.
  - ▶ This will reduce the total demand further and we see that the total demand also becomes non-linear.
  - ▶ We increase the number of options bought even further.
  - ▶ This reduces the bet demand even more.
  - ▶ However, now we see in the circle that the slope of the total demand become very high at one point. We will now sow what happens if we increase the number of bought options further.
  - ▶ We increase the hedging demand again.
  - ▶ Now the total demand become highly non-linear.
  - ▶ In the circle area, the demand curve becomes backwards sloping. Thus the demand curve is not always having a negative slope, there is a small area where the slope is positive; a higher price increases demand for the stock.
  - ▶ We can now increase the demand further.
  - ▶ We see that the backward sloping part becomes more pronounced and covers a larger area.
  - ▶ A final increase in hedging demand.
  - ▶ This gives us a clearly non-monotonous demand function.
- We therefore see that if hedging demand is sufficiently large, that is there are enough uninformed investors seeking to hedge their positions, the demand for the stock becomes non-monotonous.



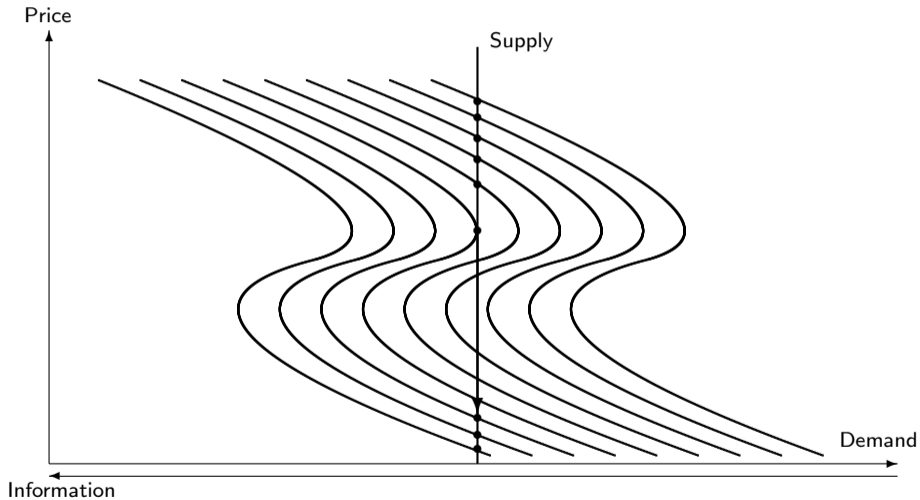
# Backward-sloping demand curve

- ▶ The non-linear amount of short-selling can lead to a backward sloping demand curve
- ▶ This occurs if the hedging demand by uninformed investors is sufficiently large
- ▶ A backward-sloping demand curve has implications for the equilibrium prices

# Backward-sloping demand curve

- We have thus established that with sufficient hedging demand, the demand curve for a stock becomes back-ward sloping, that is has an area with a positive slope.
- ▶ The reason for this backward-sloping demand curve is that the short-selling of the stock due to hedging is non-linear and it will in general have a (positive) slope that is larger than the (negative) slope of the demand by uninformed investors in some area, giving rise to this feature. This backward sloping part is usually near the strike price of the options.
- ▶ For this to occur, we need that many uninformed investors hedge their positions, thus it is not something that happens in all cases.
- ▶ Having such a demand curve has significant impact on the equilibrium prices that emerge.
- We will now assess the implications of such a demand curve for equilibrium prices.

# Decreasing informed demand



# Decreasing informed demand

- We will look at a scenario where the demand by informed traders reduces. such a reduction in demand might be the result of negative information being received. The consequence is that the demand curve of informed investors will move to the left.
- ▶ We will consider again the stock price as a function of the demand.
- ▶ We assume that the supply of shares is fixed; this would be the number of outstanding shares.
- ▶ We now have a situation in which the demand curve is backward-sloping, thus there is a large demand for hedging.
- ▶ The equilibrium is where demand and supply are equal, as indicated in the blue point.
- ▶ We now reduce the demand of the informed investors and this shifts the demand curve to the left.
- ▶ Again the equilibrium is where demand and supply equal; the price will shift marginally in reaction to the reduced demand by informed traders.
- ▶ Reducing the demand by informed investors further does lead to a further shift of the total demand.
- ▶ As a consequence, the price reduce again marginally. Thus far we had a small reduction of the demand resulted in a small reduction in the equilibrium price.
- ▶ If we now reduce the demand further, we see that due to the back-ward sloping nature of the demand curve, there are three possible equilibria. For reasons we discuss later, we will ignore these for now.
- ▶ It is therefore that the price again reduces marginally.
- ▶ Now, if the demand reduces even further, we may reach the point where the demand just about meets the supply.
- ▶ The price is still changing slowly.
- ▶ We now reduce the demand even further and we see that we return to the situation where there is only a single equilibrium.
- ▶ The new equilibrium price would be substantially below the previous price, even though the change in demand was low. We this have a small change in demand causing a large change in price.
- ▶ Reducing the demand further
- ▶ will again result in a small change of the price.
- ▶ We have reduced the demand in each step above by the same amount and we can now look at the prices that have emerged as a result.
- ▶ Most importantly, we see that the stock price at one point jumps downwards, which is akin to a market crash. This market crash was the result of a small reduction in demand, thus a small reduction in the fundamental value of the stock.
- ▶ This sudden change occurred where the backward sloping demand curve caused the upper equilibrium to cease, leaving only a jump to the lower equilibrium.
- ▶ We can now identify the lower demand which we had with less and less favourable information.
- We have thus created a market crash; there was a small change in the information, the fundamental value, but this caused a large drop in the price.

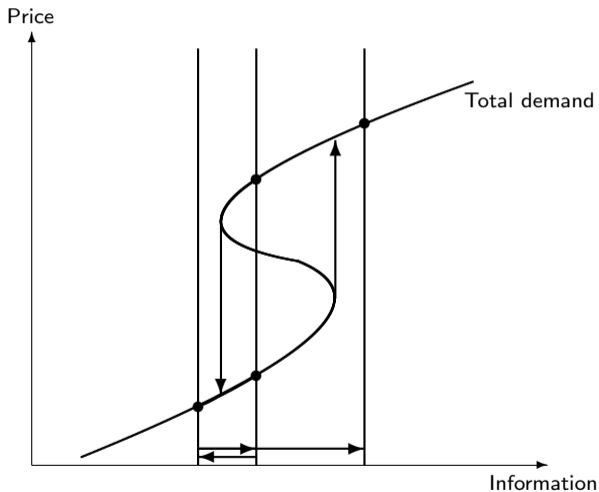
# Market crashes can occur

- ▶ If the total demand of informed investors is reducing, sudden large price drops can occur
  - ▶ Such price drops are not the result of significant changes in demand, a small change in demand can lead to a large price change
  - ▶ As demand increases with information becoming more positive, we can identify the level of demand with information
- ⇒ A small change in information can cause a market crash

# Market crashes can occur

- We have thus seen that sudden large price reductions without much new information becoming available are possible; such large price reductions are referred to as a 'crash'.
- ▶ A small reduction in the demand by informed investors, for example due to slightly negative information, can give rise to a large change in the stock price. This change in the stock price is compatible with the information received, the information suggests a much smaller reduction in the stock price.
- ▶
  - The price drop (crash) is not the result of a sudden change of demand or information.
  - A small change might be sufficient to have this effect. This is due to the hedging demand and the resulting backwards-sloping demand curve.
- ▶ There is a strong relationship between demand and information, more positive information results in higher demand by informed investors. Thus we can use these two expressions synonymously.
- ▶ [⇒] We have therefore shown that a small change in information can cause a crash.
- We can now investigate this phenomenon a little bit further.

# Small changes can have a large impact



# Small changes can have a large impact

- We will now look again at the critical point where a small change in information can cause a large change in the price and investigate some of its properties.
  - ▶ Rather looking at the demand, we now look at information, which we found to be equivalent.
  - ▶ We here have the total demand in the case that hedging demand is substantial. Note that the demand function is mirrored to account for us using information rather than demand; we here show the possible market clearing points; that is the points at which demand and supply are equal.
  - ▶ We currently have information as indicated here, which gives rise to the equilibrium price as indicated by the red point.
  - ▶ Let us now assume that information deteriorates, that is we obtain some negative information.
  - ▶ This leads to a new price which is substantially below the original price
  - ▶ As the information changed slightly, we had a market crash.
  - ▶ Now suppose the information improves again and positive information brings us back to the original level of information.
  - ▶ In this case, the price increases only marginally;
  - ▶ it does not return to its previous level as it moves up the equilibrium path.
  - ▶ Only once we have a much larger improvement in the information, can we return to the high prices we previously saw.
  - ▶ We then find the only equilibrium we have is the high price.
  - ▶ This increase in equilibrium prices would necessitate a price jump; this is essentially an 'inverse market crash'.
- We will below rule out that such a scenario of an inverse market crash can be observed in real markets.



# Reversing information

- ▶ Reversing the information that lead to a market crash does not lead the price to revert to their old level
- ▶ Prices have reached a new lower equilibrium and small improvements in information will only lead to a small increase in prices
- ▶ For prices to revert to their previous level, significantly improved information needs to be emerging

# Reversing information

- We will now summarize the result on what might happen if we see a change in information, which is subsequently reversed.
- ▶ We have seen that reversing a change in information does not lead to a reversal of a market crash, the price will remain low, even if the information is reversed after a crash.
  - ▶
    - It is that prices have reached another equilibrium, which is lower than the original equilibrium.
    - Small changes to this equilibrium will lead to small changes in the price and not a reversal to the old equilibrium.
  - ▶ Information needs to improve significantly to return to its previous level and then the price would be slightly higher than before, but on much better information.
- Thus a small change in information can have a substantial impact on prices, leading to a market crash, and a reversal of this change would only have a small impact, not reversing the crash that has been observed.

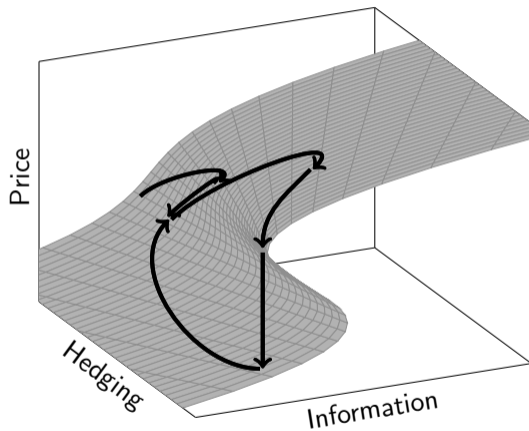
# Absence of sudden market jumps

- ▶ If positive news are received, the demand of informed investors increases, prices increase
- ▶ Uninformed investors may be concerned about losses if prices are high due to a bubble and commence hedging
- ▶ The higher the price goes, the more hedging is conducted
- ▶ If bad information arrives, the demand by informed investors reduces, which may cause a market crash
- ▶ After a crash, hedging will reduce as uninformed investors are not concerned about further losses

# Absence of sudden market jumps

- We will now seek to address the fact that 'inverse market crashes', that is sudden jumps in prices, are not observed in markets.
- ▶
  - Let us assume that we have positive news about a stock, resulting in a higher demand by informed investors.
  - This higher demand of informed investors will increase prices.
- ▶ Uninformed investors observe the higher price and they might worry about stocks being overvalued as they do not hold the information; they might be thinking that a bubble has emerged. To limit their risk, some will start to hedge their positions by buying put options, instigating hedging demand.
- ▶ If the information improves further, and hence the price increases further, more and more uninformed investors become concerned about making losses; therefore more and more uninformed investors will hedge their positions, increasing hedging demand. If the hedging demand is high enough, the demand curve becomes backwards-sloping.
- ▶
  - Now assume that negative information arrives, reducing the demand by informed investors.
  - With the above said, this might cause a market crash.
- ▶ Once the stock price has reduced, options are exercised and the hedging demand vanishes; furthermore, uninformed traders are no longer concerned about the high price as the price is now lower. Therefore no new hedging demand builds up once the existing options are expiring.
- We can now assess this process graphically and based on this reasoning conjecture that jumps in stock prices are very unlikely to occur.

# Dynamics leading to a crash



# Dynamics leading to a crash

- We will now look at the dynamic evolution of our parameters will then give rise to a crash.
- ▶ We will look at the impact information and the amount of hedging by uninformed investors have on the price of stocks.
- ▶ We here have a three-dimensional representation of the equilibria. For small hedging demand, the demand will be monotonously decreasing in price and the equilibrium price will be steadily be increasing in the information. As the hedging demand increases, the demand slowly becomes backwards-sloping, giving rise to the backward-sloping relationship between information and equilibrium prices.
- ▶ We now start in a situation where the information is not particularly high, but then informed traders obtain information, which increases the stock price, but will also increase hedging demand. If the information was sufficiently good to increase the price far enough, then hedging demand is substantial and we are in the area of backwards-sloping demand curves.
- ▶ Let us now assume that informed investors obtain some negative information, reducing their demand for the stock. This will reduce the stock price slightly, but as the price remains high, the hedging demand will either continue to rise or remains stable.
- ▶ Once we reached the edge of the backward-sloping demand curve, we will observe a market crash.
- ▶ After the market crash, the hedging demand will reduce as explained above. We are then back to a situation in which hedging demand is low and the price/information is also relatively low.
- ▶ If the information obtained by informed investors is not very large or uninformed investors are not concerned much about hedging, we never enter the area in which the demand curve becomes backwards-sloping and we observe no market crash.
- With these dynamics of information and hedging demand, a market jump cannot occur as this would require a high hedging demand while prices are low, effectively a reversal of the dynamics discussed here. It is therefore very unlikely that a price jump occurs.

# Hedging demand driving market crashes

- ▶ The behaviour of uninformed investors hedging their exposure can lead to market crashes
- ▶ If hedging demand is sufficiently high, market crashes can occur without significant information being received
- ▶ The run-up the a market crash sees some negative information emerging, but not significant enough to justify a market crash
- ▶ The market moves from a high equilibrium to a low equilibrium once the information is sufficiently negative
- ▶ Market jumps are unlikely to occur due to the hedging demand being low if the low equilibrium is reached

# Hedging demand driving market crashes

- We can now summarize some of the finding from this model.
- ▶ We have seen that it is the hedging demand by uninformed investors that ultimately causes market crashes. It is there demand which makes the overall demand for the stock non-monotonous and leads to a stock market crash.
- ▶ If hedging demand is sufficiently high, then this will lead to such a non-monotonicity and crashes can occur; these crashes may occur on informed investors receiving negative information, even if the information was not significant.
- ▶
  - We usually see a some accumulation of negative information leading to a small reduction in the stock price,
  - this information, even if accumulated, does not justify the size of the price movement we observe in a crash.
- ▶ What we observe is that the stock price moves from a high equilibrium to a second, lower equilibrium as the higher equilibrium ceases to exist once information reaches a certain threshold.
- ▶ We do not observe price jumps (inverse market crashes) as with low prices the hedging demand by uninformed investors will be low and hence no price jump will occur as the total demand remains monotonous.
- It is not the 'erratic' behaviour of informed investors or speculators that cause market crashes, but it is the hedging of uninformed investors seeking to protect their view on overvalued stocks.



# Market crashes and market jumps

- ▶ If the low equilibrium is reached, hedging demand in some markets may still be high
- ▶ In the foreign exchange market, investors in one country may see their currency as having low value
- ▶ Investors in the other country will then see it as having high value
- ⇒ Who hedges might change, but high hedging demand may persist
- ▶ A market crash from the perspective of one country is a market jump from the perspective the other country
- ▶ The same applies in commodity markets with producers and users of the commodity

- We now argue that in some instances market jumps might nevertheless occur.
- ▶ We have argued above that price jumps should not occur, as at low prices, hedging demand will be low.
- ▶ In some markets, even after a crash, the hedging demand might remain high. In foreign exchange markets, for example, a crash might have reduced the value of one currency such that those concerned about it being overvalued are no longer hedging.
- ▶ But now some investors might feel that the currency is undervalued (or the other currency overvalued) and seek to hedge against adverse movements of the exchange rate.
- ▶ [⇒] • Those hedging against the currency being overvalued will cease to hedge their positions,
  - but instead those concerned about the currency being undervalued might commence with hedging and hedging demand might remain high.
- ▶ We also need to remember that a crash in one currency, is a price jump in the other currency.
- ▶ • A similar logic might also apply in commodity markets.
  - Here a high price would be hedged by producers of the commodity, but not the purchaser, while for low prices, the purchaser would want to hedge while producers are not hedging.
- It is therefore that in some markets price jumps can occur, such as foreign exchange and commodity markets, but in stock markets this is unlikely to seen.



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