



## Chapter 3

# Selling information

# Outline

- Problem and model assumptions
- Uninformed investment banks
- Informed investment banks
- Purchase of information
- Summary

- Investment banks are generally regarded as being informed. They can use the information themselves to generate profits, or they could sell the information to other market participants.
- This model investigates the incentives for investment banks to sell their information.
- A complication arises in that information cannot be verified prior to its purchase, hence an investment bank could sell information it does not hold.
- We will consider how purchasers of information will assess that an investment bank actually holds the information it sells.

- We will firstly look in more detail at the specific setting of the model and the assumptions that are required.
- Subsequently we will then look at the implications of uniformed investment banks selling information they do not hold.
- This will then be contrasted against those investment banks that are holding the information. At this point we will also derive conditions under which only investment banks holding the information will actually sell it.
- Of course, for a sale of information to occur, it must be purchased and we will look at conditions such that the information is valuable to a purchaser.

## ■ Problem and model assumptions

■ Uninformed investment banks

■ Informed investment banks

■ Purchase of information

■ Summary

- We will be looking at a situation where investment banks are seeking to sell information.
- We will see that a problem arises from the fact that information is not verifiable by purchasers.
- We will see how banks address this problem and what the implications are for the sale of information.

# Opportunity to sell information

# Opportunity to sell information

- Information is usually valuable and investment banks can make use of this information, one way of using information is to sell it.
- ▶ As already mentioned, it is common to assume in many situations that investment banks are better informed than their clients. They might be more informed about specific securities or the market in general.
- ▶ Investment bank can use their informational advantage to generate profits by conducting their own investments, for example purchasing or selling the securities on which they hold information.
- ▶ In addition, or instead, they could sell the information to clients. When selling information, they directly benefit from the revenue, increasing their profits.
- ▶ A problem is though that information cannot be verified at the time of purchase, nor retrospectively in many cases; investment banks might have an incentive to sell information they do not hold. Purchasers of the information would like to have an assurance that they information they are sold actually exists and we will look at developing a verification mechanism to this effect.
- The need to verify information actually exists will be at the heart of this model; the verification mechanism will restrict the ability to sell information, but it also ensures that the information has actual value to the purchaser.

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# Signals

- Investment banks will rely on information on the return or value of a security; such information is often referred to as a signal.
- ▶
  - Investment banks will obtain a signal that can be transformed into a return through the interpretation of the investment bank; this transformation is used as the signal in models.
  - Signals (information) will generally not be perfect, but have some degree of error. This is commonly modelled through an error term, which will capture all aspects that the signal does not include. The true return will then be given by the signal the investment bank receives, plus this error term.
- ▶ *Formula*
- ▶ If an investment bank has no information, it can not observe the signal and it would expect the signal they could obtain if they were informed to show the unconditional mean of the return. We also assume that the variance of the signal is known by all investment banks and their clients.
- ▶ We assume the error term to be unbiased such that the signal is, on average, correct. The variance of the error term is also known by all market participants.
- ▶ If we assume that the signal and error term are uncorrelated, the variance of the return can be given as the sum of variance of the signal and the error term. The resulting variance of the return is the risk that an uninformed investment bank faces.
- Uninformed investment banks will not be able to use signals, while informed investment banks will use the signal as information on their expected returns and it will also reduce the variance as they are only exposed to the variance of the error term, having obtained the signal.

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# Investments

- We can now look into the investments that investment banks are making and how the information they hold will affect their decisions. Of interest will be the total value of this investment after one time period.
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    - Investment banks will choose between government securities, investing the amount  $G$ , which yield the risk-free rate  $r$
    - and a risky asset, investing  $V$  and obtaining an uncertain return  $R$ . It is this risky asset that the investment bank obtains information about.
  - ▶ *Formula.* We can now use that the total investment  $W_0$  consists of the government bond  $G$  and risky asset  $V$ , hence  $W_0 = G + V$  and eliminate the government bonds from the equation.
  - ▶ Rather than looking at the value of the investment, we will consider the utility a bank obtains from their investment. This allows us to include the return of their investment, but also the risk. We assume that investment banks are risk-averse with risk aversion  $z$ . As the outcome of the investment is uncertain due to the risky asset, we use the expected utility investment banks obtain. The expected utility can be approximated as a the utility of the expected value less the variance, scaled by the risk aversion; the factor  $\frac{1}{2}$  emerges for mathematical reasons. It is common to omit the utility itself as it is monotonously increasing, it will not affect any optimisation outcome.
- We can now determine the optimal investment decisions of investment banks. We will see later, that we can use these investment decisions to distinguish banks with and without information. Therefore we will consider uninformed investment banks as well as informed investment banks.

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■ Problem and model assumptions

■ Uninformed investment banks

■ Informed investment banks

■ Purchase of information

■ Summary

- We will first consider the investment decisions of uninformed investment banks, that is those investment banks that have not obtained a signal on the return of the risky asset.
- We will afterwards then look at informed investment banks and compare their investment decisions.
- As we consider investment banks that might sell information, we will have to take into account the impact such a sale has on their expected utility.

# Optimal investment without selling information

# Optimal investment without selling information

- We will seek to obtain the optimal investment of investment banks, but initially without them selling any information.
- ▶ Investment banks that are uninformed do not observe a signal and therefore their assessment of the return and risk of the risky asset will be based on public information.
  - ▶
    - This public information stipulates that the expected return of the risky asset is  $\mu$
    - and its variance is  $\sigma_R^2$ . The government bond is risk-free and we assume that the risk-free rate  $r$  is known and the variance of the government bond will be zero. We do not consider any interest rate risk in our assessment.
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    - We can now determine the expected value of the investment by taking expectations, using the formula on the previous slide ( $W_1 = (1 + r) W_0 + (R - r) V$ ).
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# Optimal investment without selling information

- ▶ If investment banks are uninformed, they observe **no signal**

# Optimal investment without selling information

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# Preventing uninformed selling of information

# Preventing uninformed selling of information

→ We now look at the case that investment banks sell information.

- ▶
  - As information is no physical good, an investment bank could claim that it holds the information it seeks to sell.
  - This claim does not have to be true as it is not verifiable whether they actually hold the information.
- ▶
  - Investment banks will charge a price  $P$  for providing this information. As investment banks charge a fixed price, there is no risk associated with selling information.
  - They can still make investments, so will obtain the utility from this.

▶ *Formula*

- ▶ They will still make investments, but these can change as there is additional revenue from selling information that needs to be taken into account.
  - ▶ At this point we do not seek to determine this optimal investment, but instead look at the condition such that the investment bank does not want to sell information. If their expected utility if selling information,  $\hat{U}_B$  is lower than if not selling information  $U_B^*$ , they will refrain from doing so. The utility if not selling information we have obtained on the previous slide.
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- Investors know that and investment banks charging a price higher than  $P^*$  has an incentive to sell information, even if they do not hold this information; this might dissuade them from purchasing information that is priced too highly. We will now analyse this incentive of an investment bank to sell information it does not own in more detail.

# Preventing uninformed selling of information

- ▶ Investment banks can **claim** they have received a signal

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# Preventing uninformed selling of information

- ▶ Investment banks can claim they have received a signal, **even if this is not true**

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# Preventing uninformed selling of information

- ▶ Investment banks can claim they have received a signal, even if this is not true
- ▶ Investment banks will charge a **price** for this information
- ▶  $\hat{U}_B =$   $+$   $P$

# Preventing uninformed selling of information

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# Preventing uninformed selling of information

- ▶ Investment banks can claim they have received a signal, even if this is not true
- ▶ Investment banks will charge a **price** for this information and obtain this revenue in addition to the **utility from investment**
- ▶  $\hat{U}_B = (1 + r) W_0 + (\mu - r) V + P - \frac{1}{2} z \sigma_R^2 V^2$

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- Investors know that and investment banks charging a price higher than  $P^*$  has an incentive to sell information, even if they do not hold this information; this might dissuade them from purchasing information that is priced too highly. We will now analyse this incentive of an investment bank to sell information it does not own in more detail.

# Preventing uninformed selling of information

- ▶ Investment banks can claim they have received a signal, even if this is not true
- ▶ Investment banks will charge a price for this information and obtain this revenue in addition to the utility from investment
- ▶  $\hat{U}_B = (1 + r) W_0 + (\mu - r) V + P - \frac{1}{2} z \sigma_R^2 V^2$
- ▶ Investment into **the risky asset** might change if selling information

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→ We now look at the case that investment banks sell information.

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  - As information is no physical good, an investment bank could claim that it holds the information it seeks to sell.
  - This claim does not have to be true as it is not verifiable whether they actually hold the information.
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  - Investment banks will charge a price  $P$  for providing this information. As investment banks charge a fixed price, there is no risk associated with selling information.
  - They can still make investments, so will obtain the utility from this.

▶ *Formula*

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# Selling news for long positions ( $V > 0$ )

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- Let us now consider the case of the investment bank having a short position in the risky asset. The main considerations of the investment bank are the same, as well as the threshold price at which they sell information they do not have.
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    - If we again determine the risk aversion at which the threshold price  $P^*$  is smallest, we have to change the sign when taking the square root from the expression for the squared risk aversion,  $z^2 = \frac{(\mu-r)^2}{\sigma_R^4 V^2}$
    - Inserting this risk aversion into the price threshold gives us a positive value due to the value of the investment into the risk asset,  $V$ , being negative. It is thus that the minimum price must be positive if investment banks hold short positions in the risky asset.
    - The investment bank would only want to sell information if the price is sufficiently high.
  - ▶ Of course, banks will always charge the maximum possible price, neglecting any constraints coming from the demand for information. The price demanded by informed investment banks would seek to ensure that uninformed investment banks have no incentive to sell information and hence would choose a price marginally below the threshold for uninformed investment banks.
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    - We can now insert the maximum price  $P^*$  into the expected utility of uninformed investment banks.
    - As the threshold price depends on the investment into the risky asset,  $V$ , we can now determine the optimal investment by maximizing the expected utility.
  - ▶ Solving the first order condition, we get the optimal investment, which will be negative as required.
  - ▶ We can now insert this optimal investment into the risky asset,  $V^*$ , back into the threshold price  $P^*$  and obtain the price that can be charged for information without inducing uninformed investment banks to sell information they do not have.
- If investment banks have a short position in the risky asset, a sufficiently low price for information will prevent them from selling information they do not own.

# Selling news for short positions ( $V < 0$ )

► If  $V < 0$ , then  $z = -\frac{\mu-r}{\sigma_R^2}V$

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# Selling news for short positions ( $V < 0$ )

► If  $V < 0$ , then  $z = -\frac{\mu-r}{\sigma_R^2} V$  and  $P^* = -2(\mu-r)V > 0$

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- If investment banks have a short position in the risky asset, a sufficiently low price for information will prevent them from selling information they do not own.

## Selling news for short positions ( $V < 0$ )

- If  $V < 0$ , then  $z = -\frac{\mu-r}{\sigma_R^2 V}$  and  $P^* = -2(\mu - r)V > 0$  and the investment bank would want to **sell** the information **if the price is high enough**

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- We can now summarize our results so far on the sale of information by uninformed investment banks.
- ▶ We have seen that if uninformed investment banks hold long positions in the risky asset they seek to sell information about, they will do so at any price. Hence in such a situation, no information should be sold, it could come from uninformed investment banks that do not hold any information. For a potential buyer, there is no value in this information, although he might be unaware of this.
- ▶ In contrast, if uninformed investment banks hold short positions in the risky asset they seek to sell information about, they would only sell information if the price is sufficiently high. Thus, if information is sold at a price below the threshold, the information must come from an informed investment bank. Selling information above the price threshold does not allow a buyer to know whether the information they purchase is held by the investment bank or not.
- We have thus seen that uninformed investment banks have an incentive to sell information, if holding short positions in the risky asset only if the price they can obtain is sufficiently high. Thus to ensure that information is actually held, it needs to be sold at a sufficiently low price. We will now explore whether informed investment bank, those actually holding the information, have an incentive to sell their information at all.

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■ Problem and model assumptions

■ Uninformed investment banks

■ **Informed investment banks**

■ Purchase of information

■ Summary

- We have looked at the incentives for uninformed investment banks to sell information they do not own and found that if investment banks hold long position in the risky asset, they will always seek to sell information.
- If they hold short positions, they will only sell information if the price is sufficiently high.
- We will now see whether investment banks are willing to sell information at a sufficiently low price such that uninformed investment banks do not sell information.

# Optimal investment without selling information

# Optimal investment without selling information

- We first look at the utility of an investment bank not selling any information but instead using their information to make better investments than uninformed investment banks
- ▶ Informed investment banks observe the signal  $s$ , which is their information about the return of the risky asset.
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  - Using this information, the expected return of the risky asset will be given by the signal, given that the error term was assumed to have a mean of zero.
  - The variance of the return will be the residual variance arising from the fact that information is not perfect and can have errors.
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  - We can use these expected returns and variances now to determine the expected value of the investment
  - as well as its risk.
- ▶ The utility function of informed investment banks is identical to that of uninformed investment banks, the only difference are only whether they have information or not. We can therefore insert the expected investment value and its variance into the expected utility, which we then maximize over the optimal investment into the risky asset. From this we need to solve the first order condition.
- ▶ The first order condition can be solved for the optimal investment into the risky asset. It will depend on the signal received as well as the variance of the error term, that is the remaining uncertainty after receiving the signal. This uncertainty will be smaller than for uninformed investment banks, implying a larger investment due to the lower risk. However, the signal will also affect the amount invested.
- ▶ Using the optimal amount to invest into the risky asset, we can then obtain the expected utility of the informed investment bank.
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# Optimal investment without selling information

- ▶ If investment banks are informed, they observe their signal
- ▶ Then  $E[R] = s$  and  $Var[R] = \sigma_\epsilon^2$
- ▶ This gives  $E[W_1|s] = (1+r)W_0 + (s-r)V$  and  $Var[W_1|s] = \sigma_\epsilon^2 V^2$

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# Selling information

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- ▶ When selling information at a price, this will increase the profits of the investment bank as they obtain additional revenue but by assumption have no additional costs.
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# Selling information

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# Reasons for only selling negative information

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- We have seen that only negative information can be sold if we want to prevent uninformed investment banks to sell information they do not hold.
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    - Positive information makes a long position of the risky asset optimal for informed investment banks; uninformed investment banks would always prefer a long position as we had assumed that  $\mu > r$ .
    - Hence with positive information, both types of investment banks, informed and uninformed, would hold similar positions and the buyer of information will not be able to ascertain who he is buying the information from and therefore whether he purchases information that actually exists.
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    - With negative information, informed investment banks take a short position, but uninformed investment banks do not hold this information and will therefore still invest into a long position. We assume here that uninformed investment banks cannot purchase information from informed investment banks and then sell the information on.
    - As the investment banks now take different positions, potential buyers of the information can distinguish them. A short position means that the investment bank is informed, while a long position could be either an uninformed investment bank or, if information is positive, either an informed or uninformed investment bank.
  - ▶ Uninformed investment banks in principle could copy informed investment banks and thereby appear to be informed. This is however not optimal as the adjustment of the investment is too large to make it profitable, given that the price they can obtain for the information is low. It was set this low in order to prevent uninformed investment banks from making such adjustments to their investments.
  - ▶ Looking at the investments of investment banks, buyers of information can distinguish between informed and uninformed investment banks. This, however, only works if the information is negative. For positive information, the costs of adjustment for uninformed investment banks are small and the types of banks cannot be distinguished.
- We use the investment decisions in the risky asset as an indicator for the presence of information and buyers of information can easily distinguish investment banks, but only for negative information. The sale of positive information is not possible in this model.

## Reasons for only selling negative information

- ▶ **Positive information** makes a **long position** optimal for informed and uninformed banks

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## Reasons for only selling negative information

- ▶ Positive information makes a **long position** optimal for informed and uninformed banks, this means they **cannot be distinguished** well

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■ Problem and model assumptions

■ Uninformed investment banks

■ Informed investment banks

■ Purchase of information

■ Summary

- We have thus far been concerned with the sale of information and how purchasers can ensure they obtain this information from an informed investment bank.
- We will now look at the decision to purchase information.

# Investor decisions

- Investors are purchasing information with the aim of making investment decisions. We will thus have to assess the benefits of purchasing information by comparing investment decisions with and without acquiring information.
- ▶ The considerations for investments into the risky asset are identical for investment banks and other investors. Then investors not purchasing the information are similar to uninformed banks not selling information.
- ▶ An investor not purchasing information will make the same decisions as an uninformed bank as they have the same information, hence their expected utilities will be identical.
- ▶ Investors purchasing the information from an informed investment bank will have the same information as the informed investment bank itself and therefore they are very similar.
  - Investors purchasing the information will therefore make the same decisions as an informed investment bank and obtain the same utility.
  - However, their utility will be reduced by the price they pay for the information
- ▶ Investment banks sell information typically not to a single investor only, but to many investors. The price we established as the threshold for preventing uninformed investment banks selling information was representing the revenue from all information sales. If we assume that information is sold to multiple investors, each pays its fraction of the total revenue the investment bank obtains.
- With investors being identical to investment banks, with the only difference being the purchase of information, we can now evaluate under which conditions investors will purchase information.

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# Becoming informed

→ Investors need to decide whether to purchase information and thus become informed

- ▶ Investors will purchase information if the utility of doing so is higher.
  - ▶ Inserting for all expressions, we can easily solve this condition for the signal to be sufficiently different from the risk-free rate.
  - ▶ Only if the signal is sufficiently low, information sufficiently negative, can information be sold. This will exclude the possible high values for the signal
  - ▶ *Formula*
  - ▶ Information needs to be sufficiently negative to be of value to the buyer. This constraint is more strict than the constraint on the investment bank to be identified as being informed,  $s < r$ . Investors will only buy information if its contents are sufficiently different from their current level of information,  $\mu$ . Smaller deviations from their current information do not increase the utility of investors sufficiently to compensate them for the costs.
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- ▶  $s \leq r - \frac{\sigma_\varepsilon}{\sigma_R} \sqrt{(\mu - r)^2 + \frac{2z\sigma_R^2 P^*}{N}} < r$

- Investors need to decide whether to purchase information and thus become informed
  - ▶ Investors will purchase information if the utility of doing so is higher.
  - ▶ Inserting for all expressions, we can easily solve this condition for the signal to be sufficiently different from the risk-free rate.
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  - ▶ *Formula*
  - ▶ Information needs to be sufficiently negative to be of value to the buyer. This constraint is more strict than the constraint on the investment bank to be identified as being informed,  $s < r$ . Investors will only buy information if its contents are sufficiently different from their current level of information,  $\mu$ . Smaller deviations from their current information do not increase the utility of investors sufficiently to compensate them for the costs.
- Investors only buy information if it is sufficiently negative. As they cannot know the contents of the information prior to purchasing it, and the price is independent of the signal itself, investors have to rely on investment banks selling them only information that is valuable to them. Investment banks might do that in order to retain investors as clients by ensuring they are only offered information that is valuable to them.

# Becoming informed

- ▶ Investors become informed if  $\hat{U}_D^* \geq U_D^*$
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■ Problem and model assumptions

■ Uninformed investment banks

■ Informed investment banks

■ Purchase of information

■ Summary

- We can now summarize the key model results and look at some implications this model has.

# Only negative information is sold

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  - Negative information can be sold as the investments into risky assets by the investment bank can be used to verify that they hold this information. They short position suggests that they have obtained negative information and as they put their own money on this information, information is seen as existing.
  - In contrast, positive information, or not sufficiently negative information, could be sold by uninformed investment banks. They can adjust their investments into the risky asset accordingly and still make a profit from selling this non-existent information.
- ▶ It is central that investors purchasing information can verify the existence of information by observing the investment banks' own investments. This investment will be based on the information, if any, of the investment bank and can therefore be seen as a proxy variable for the existence of the information itself.
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- ▶ Of course for information to be valuable to investors it needs to provide benefits that exceed the costs of obtaining this information. This is only achieved if the information is sufficiently different from the current information investors have; the information must be sufficiently negative.
- We should observe that mainly negative information is sold in the market as it can be verified more easily when purchasing that the information is genuine. The sale of positive information is more difficult to achieve and would have to rely on a different mechanism to verify its existence.

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# Market implications

- These result have some implications for the type of information that is available in the market and also how the market reacts to such information.
- ▶ We have seen that negative information can be verified by the investment bank's action, it is therefore valuable to investors as they know they will obtain true information.
- ▶ Positive information could be sold by informed or uninformed investment banks, thus there is some degree of uncertainty whether the information is true or not. This makes the information much less valuable, and investors would be willing to pay less for it, but it will also increase the uncertainty about the expected returns. This increased risk will make investors more cautious about using the information and they will invest less into the risky asset compared to an equivalent negative information.
- ▶ An implication of this result is that investors should react stronger to negative information than positive information, given that negative information is more reliable. If they react more strongly in terms of their investment decisions, they will affect market price more for negative than positive information. Consequently, security prices should react more strongly to negative than to positive information.
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- ▶ Investors should react stronger to negative information than positive information

- These results have some implications for the type of information that is available in the market and also how the market reacts to such information.
- ▶ We have seen that negative information can be verified by the investment bank's action, it is therefore valuable to investors as they know they will obtain true information.
- ▶ Positive information could be sold by informed or uninformed investment banks, thus there is some degree of uncertainty whether the information is true or not. This makes the information much less valuable, and investors would be willing to pay less for it, but it will also increase the uncertainty about the expected returns. This increased risk will make investors more cautious about using the information and they will invest less into the risky asset compared to an equivalent negative information.
- ▶ An implication of this result is that investors should react stronger to negative information than positive information, given that negative information is more reliable. If they react more strongly in terms of their investment decisions, they will affect market price more for negative than positive information. Consequently, security prices should react more strongly to negative than to positive information.
- Investment banks are willing to sell information and investors are willing to purchase such negative information. However, the need to verify that an investment bank holds the information itself, makes the sale of negative information much more common and reliable; this will have an impact on securities markets. It is therefore that investment banks have an impact on market prices through their sale of information and this impact is biased towards price reductions due to negative news being more dominant and more reliable.



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Andreas Krause: Theoretical Foundations of Investment Banking, Springer Verlag 2024  
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