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Information acquisition and market efficiency
NEW YORK STOCK EXCHANGE
LIVERMORE

- For a market to be efficient, traders need to hold information that can be incorporated into the price of the asset, but obtaining and processing such information will be costly.
- We will investigate what the existence of such costs implies for the efficiency of markets.

Noisy information

Noisy information

→ In order for prices to reflect information, such information must be available in the first place. We will look at the characteristics of information in this context.

- Of course, prices can only reflect information, if such information is available to investors; otherwise information that is not picked up cannot be included into the price as such incorporation of information can only happen through the actions of investors.
- Once the information is held by investors, it needs to be incorporated into the asset price, and this mechanism is what we will investigate to see how much of the information can be included.
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  - The information investors hold will usually not be absolutely perfect,
  - but it will be incomplete and might even include some errors. These imperfections are commonly called 'noise'; noise leads to a situation where despite having information on the value of the asset, the actual value might be different from the information obtained.

→ We can now determine how such noisy information affects the level of knowledge of investors.

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Knowledge with information

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→ We will see how access to information affects the uncertainty about the value of asset values.

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- Due to the imperfection of information, there will be a deviation of the true value from the information investors hold, which is the noise term.

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- The noise is neutral in that on average it is zero, thus there is no systematic bias in the information investors have.
- The noise has a variance and the larger the variance, the less precise the information is as the absolute noise term is, on average, increasing in the variance and hence the true value deviates more and more from the signal (information) investors have obtained.

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- Informed investors use their information (the signal) to obtain the expected value of the asset.
- This true value of the asset is uncertain due to the npise term and its variance.

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- Investors that do not have any information, cannot make any additional inferences about the value of the asset or the signal that informed investors have obtained. Therefore they will expect both, the signal and the value of the asset to be of some generic value.
- Uninformed investors know that the true value of the asset is a combination of the signal that informed investors obtain and the noise term. These two variances are additive if we assume that the noise term and the signal are independent of each other.

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- Information on the asset value consists of a signal
- $V = s$

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- The noise is unbiased
- $\mathsf{E}[\varepsilon] = 0$

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- The noise is unbiased and has a variance
- $\mathsf{E}[\varepsilon] = 0$, $\mathsf{Var}[\varepsilon] = \sigma_\varepsilon^2$
- Informed investors infer the asset value to be the signal

$\Rightarrow \mathsf{E}[V|s] = s$

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$\Rightarrow$ $\mathsf{E}[V|s] = s$, $\mathsf{Var}[V|s] = \sigma_\varepsilon^2$

- Uninformed investors only know the average asset value

- $\mathsf{E}[s] = \mathsf{E}[V] = V^*$

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$\Rightarrow$ $\mathsf{E}[V|s] = s$, $\mathsf{Var}[V|s] = \sigma_\varepsilon^2$

- Uninformed investors only know the average asset value and face larger uncertainty
- $\mathsf{E}[s] = \mathsf{E}[V] = V^*$, $\mathsf{Var}[V] = \sigma_V^2 = \sigma_s^2 + \sigma_\varepsilon^2$

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Demand by informed investors

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→ We will first determine the demand of informed investors.

- The profits for each unit of assets traded will be the difference between the value of the asset as assessed by the investor and the price the investor paid for it. To obtain the total profits, this will be multiplied by the total demand of the investor. We note that a negative demand can be interpreted as selling the asset, while a positive demand can be interpreted as buying the asset.
- The profits are not certain but due to the noise they are risky; we measure risk by the variance of the profits. Investors are assumed to be risk averse and the utility of such investors can be approximated by the expected value, less its variance, where we multiply by the degree of risk aversion.
- *Formula*
- The demand will be such that the expected utility if maximized and the first order condition os fulfilled.
- Solving the first order condition, we obtain the optimal demand as given in the *formula*.
- Inserting the optimal demand into the expected utility, we get the expected utility as given in the *formula*. We use that $\mathsf{E}[V|s] = s$.

→ We can now use the utility the informed investor obtains to determine if in an efficient market, he can trade profitably.

Demand by informed investors

- The profits an investor makes is the difference between the inferred value and price paid for each unit

- $U_I = (\mathsf{E}[V|s] - P)\, Q_I$

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$\Rightarrow Q_I = \frac{\mathsf{E}[V|s] - P}{z \mathsf{Var}[V|s]}$

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- The profits for each unit of assets traded will be the difference between the value of the asset as assessed by the investor and the price the investor paid for it. To obtain the total profits, this will be multiplied by the total demand of the investor. We note that a negative demand can be interpreted as selling the asset, while a positive demand can be interpreted as buying the asset.
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→ We can now use the utility the informed investor obtains to determine if in an efficient market, he can trade profitably.

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- The profits an investor makes is the difference between the inferred value and price paid for each unit
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- $U_I = (\mathsf{E}[V|s] - P) Q_I - \frac{1}{2} z Q_I^2 \mathsf{Var}[V - P|s]$
- The optimal investment is then given if $\frac{\partial U_I}{\partial Q_I} = 0$

$\Rightarrow Q_I = \frac{\mathsf{E}[V|s] - P}{z \mathsf{Var}[V|s]}$

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Acquiring information in an efficient market

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→ We now look again at the expected utility of the informed investor and will take into account the costs of information.

- It is generally costly to acquire information and to process this information. Such costs may include access to databases, but also the time spent on searching for and accessing information, as well as using the information to determine the value of the asset.
- Information cannot be assessed before it is obtained, hence the investor 'buys a pig in a poke'. thus he will have to form expectations about the value the acquisition of information generates.

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- Hence, if the market is efficient, then acquiring information is not profitable

→ We have thus seen that if markets are efficient, informed traders make a loss, but then there would be no informed traders and no information could be included into the price as none has been obtained. Thus with costly information, a fully efficient market is not possible.

Acquiring information in an efficient market

- Acquiring information is costly
- $U_I = \frac{(s-P)^2}{2z\sigma_\varepsilon^2} - C$

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Becoming informed

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→ We now determine the conditions under which an investor would become informed.

- We can first rewrite the squared differences between the signal and the price as the squared difference of the difference in the value to uninformed investor assigns the asset and the price, plus the variance of the signal. We obtain this by using that $s = V - \varepsilon$.
- An investor will become informed if his expected utility is higher than when remaining uninformed.
- [⇒] This condition can be solved for the *formula*.
- We see that investors become informed if the information costs are not too high. Of course, while investors might want to become informed, not all investors will be able to actually become informed; this is because they might not be able to access information in the first place or they do not have the necessary skills to process and analyse the information they have obtained.

→ We can now derive some overall implications of our results so far.

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- We have $\mathrm{E}\left[(s-P)^2\right] = (V^*-P)^2 + \sigma_s^2$
- It is more profitable becoming informed if $\mathrm{E}\left[U_I\right] \geq U_U$

$\Rightarrow C \leq \frac{(V^*-P)^2 \sigma_S^2}{2z\sigma_\varepsilon^2 \sigma_V^2}$

- If information costs are sufficiently low, then investors prefer becoming informed

Becoming informed

→ We now determine the conditions under which an investor would become informed.

- We can first rewrite the squared differences between the signal and the price as the squared difference of the difference in the value to uninformed investor assigns the asset and the price, plus the variance of the signal. We obtain this by using that $s = V - \varepsilon$.
- An investor will become informed if his expected utility is higher than when remaining uninformed.
- [⇒] This condition can be solved for the *formula*.
- We see that investors become informed if the information costs are not too high. Of course, while investors might want to become informed, not all investors will be able to actually become informed; this is because they might not be able to access information in the first place or they do not have the necessary skills to process and analyse the information they have obtained.

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Equilibrium information acquisition

Equilibrium information acquisition

→ These findings have implications for the efficiency of markets in equilibrium.

- We have seen that if information costs are sufficiently low, investor want to become informed. The gain in utility for informed investors is not from the higher trading profits as the information is not known in advance, but from the reduced uncertainty the informed investor faces ($\sigma_V^2 = \sigma_S^2 + \sigma_\varepsilon^2$ and hence $\sigma_s^2 < \sigma_V^2$ and $\sigma_\varepsilon^2 < \sigma_V^2$).
- However, the profitability of being informed will also depend on the efficiency of the market. If the price adjusts too much to the information informed investors hold, the signal, their expected profits are too low to recover the costs of becoming informed.
- [⇒] If markets are too efficient, becoming informed is not profitable.
- However, if there are no informed investors, prices cannot reflect information as no investor acquires them, thus markets cannot be efficient.
- [⇒] We can therefore conclude that if information is costly, markets cannot be perfectly efficient. We need a certain degree of inefficiency to allow informed investors to generate profits that at least recover their costs.

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→ We can now summarize our main results on the ability of market to efficient.

- We have seen that is markets were fully efficient, informed traders would not be able to make any profits
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  - Without making profits, informed traders would not recover any costs associated with obtaining and processing any information.
  - 4¿Which will result in them not obtaining this information in the first instance.
- As then there is no information in the market, the prices cannot be efficient as no information can be included.
- [⇒] We have therefore concluded that fully efficient markets cannot exist in real markets.

→ The idea of markets being efficient is theoretically impossible, unless we assume that information is free. A certain degree of market inefficiency is required to ensure informed traders are rewarded for obtaining information in the first place.

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