



Information acquisition and market efficiency

Noisy information

Noisy information

- ▶ In order for prices to reflect available information, investors need to **obtain** such information

Noisy information

- ▶ In order for prices to reflect available information, investors need to obtain such information
- ▶ This information needs then to be included into the **asset price**

Noisy information

- ▶ In order for prices to reflect available information, investors need to obtain such information
- ▶ This information needs then to be included into the asset price
- ▶ Information is generally not perfect, but will be subject to **errors**

Noisy information

- ▶ In order for prices to reflect available information, investors need to obtain such information
- ▶ This information needs then to be included into the asset price
- ▶ Information is generally not perfect, but will be subject to errors, called **noise**

Noisy information

- ▶ In order for prices to reflect available information, investors need to obtain such information
- ▶ This information needs then to be included into the asset price
- ▶ Information is generally not perfect, but will be subject to errors, called noise

Knowledge with information

Knowledge with information

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

Knowledge with information

- ▶ Information on the **asset value** consists of a **signal**, which is subject to **noise**
- ▶ $V = s + \varepsilon$

Knowledge with information

- ▶ Information on the asset value consists of a signal, which is subject to noise
- ▶ $V = s + \varepsilon$
- ▶ The noise is **unbiased**
- ▶ $E[\varepsilon] = 0$

Knowledge with information

- ▶ Information on the asset value consists of a signal, which is subject to noise
- ▶ $V = s + \varepsilon$
- ▶ The noise is unbiased and has a **variance**
- ▶ $E[\varepsilon] = 0$, **$\text{Var}[\varepsilon] = \sigma_\varepsilon^2$**

Knowledge with information

- ▶ Information on the asset value consists of a signal, which is subject to noise
- ▶ $V = s + \varepsilon$
- ▶ The noise is unbiased and has a variance
- ▶ $E[\varepsilon] = 0$, $\text{Var}[\varepsilon] = \sigma_\varepsilon^2$
- ▶ Informed investors infer the **asset value to be the signal**

$$\Rightarrow E[V|s] = s$$

Knowledge with information

- ▶ Information on the asset value consists of a signal, which is subject to noise
 - ▶ $V = s + \varepsilon$
 - ▶ The noise is unbiased and has a variance
 - ▶ $E[\varepsilon] = 0$, $\text{Var}[\varepsilon] = \sigma_\varepsilon^2$
 - ▶ Informed investors infer the asset value to be the signal, but this has some **uncertainty** due to the noise
- ⇒ $E[V|s] = s$, $\text{Var}[V|s] = \sigma_\varepsilon^2$

Knowledge with information

- ▶ Information on the asset value consists of a signal, which is subject to noise
- ▶ $V = s + \varepsilon$
- ▶ The noise is unbiased and has a variance
- ▶ $E[\varepsilon] = 0, \text{Var}[\varepsilon] = \sigma_\varepsilon^2$
- ▶ Informed investors infer the asset value to be the signal, but this has some uncertainty due to the noise
- ⇒ $E[V|s] = s, \text{Var}[V|s] = \sigma_\varepsilon^2$
- ▶ Uninformed investors only know the **average asset value**

- ▶ $E[s] = E[V] = V^*$

Knowledge with information

- ▶ Information on the asset value consists of a signal, which is subject to noise
 - ▶ $V = s + \varepsilon$
 - ▶ The noise is unbiased and has a variance
 - ▶ $E[\varepsilon] = 0, \text{Var}[\varepsilon] = \sigma_\varepsilon^2$
 - ▶ Informed investors infer the asset value to be the signal, but this has some uncertainty due to the noise
- ⇒ $E[V|s] = s, \text{Var}[V|s] = \sigma_\varepsilon^2$
- ▶ Uninformed investors only know the average asset value and face **larger uncertainty**
 - ▶ $E[s] = E[V] = V^*, \text{Var}[V] = \sigma_V^2 = \sigma_s^2 + \sigma_\varepsilon^2$

Knowledge with information

- ▶ Information on the asset value consists of a signal, which is subject to noise
- ▶ $V = s + \varepsilon$
- ▶ The noise is unbiased and has a variance
- ▶ $E[\varepsilon] = 0, \text{Var}[\varepsilon] = \sigma_\varepsilon^2$
- ▶ Informed investors infer the asset value to be the signal, but this has some uncertainty due to the noise
- ⇒ $E[V|s] = s, \text{Var}[V|s] = \sigma_\varepsilon^2$
- ▶ Uninformed investors only know the average asset value and face larger uncertainty
- ▶ $E[s] = E[V] = V^*, \text{Var}[V] = \sigma_V^2 = \sigma_s^2 + \sigma_\varepsilon^2$

Demand by informed investors

Demand by informed investors

- ▶ The profits an investor makes is the difference between the **inferred value** and **price** paid for **each unit**
- ▶ $U_I = (\mathbf{E}[V|s] - P) Q_I$

Demand by informed investors

- ▶ The profits an investor makes is the difference between the **inferred value** and **price** paid for **each unit**
- ▶ **Risk averse** investors dislike the **risks** arising from these profits, measured by its variance
- ▶ $U_I = (\mathbf{E}[V|s] - P) Q_I - \frac{1}{2} z Q_I^2 \text{Var}[V - P|s]$

Demand by informed investors

- ▶ The profits an investor makes is the difference between the inferred value and price paid for each unit
- ▶ Risk averse investors dislike the risks arising from these profits, measured by its variance
- ▶ $U_I = (E[V|s] - P) Q_I - \frac{1}{2} z Q_I^2 \text{Var}[V - P|s]$
- ▶ The optimal investment is then given if $\frac{\partial U_I}{\partial Q_I} = 0$

Demand by informed investors

- ▶ The profits an investor makes is the difference between the inferred value and price paid for each unit
- ▶ Risk averse investors dislike the risks arising from these profits, measured by its variance
- ▶ $U_I = (\mathbf{E}[V|s] - P) Q_I - \frac{1}{2} z Q_I^2 \text{Var}[V - P|s]$
- ▶ The optimal investment is then given if $\frac{\partial U_I}{\partial Q_I} = 0$

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

Demand by informed investors

- ▶ The profits an investor makes is the difference between the inferred value and price paid for each unit
- ▶ Risk averse investors dislike the risks arising from these profits, measured by its variance
- ▶ $U_I = (\mathbf{E}[V|s] - P) Q_I - \frac{1}{2} z Q_I^2 \text{Var}[V - P|s]$
- ▶ The optimal investment is then given if $\frac{\partial U_I}{\partial Q_I} = 0$

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

$$\Rightarrow U_I = \frac{(s - P)^2}{2z\sigma_\epsilon^2}$$

Demand by informed investors

- ▶ The profits an investor makes is the difference between the inferred value and price paid for each unit
- ▶ Risk averse investors dislike the risks arising from these profits, measured by its variance
- ▶ $U_I = (\mathbf{E}[V|s] - P) Q_I - \frac{1}{2} z Q_I^2 \text{Var}[V - P|s]$
- ▶ The optimal investment is then given if $\frac{\partial U_I}{\partial Q_I} = 0$

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

$$\Rightarrow U_I = \frac{(s - P)^2}{2z\sigma_\varepsilon^2}$$

Acquiring information in an efficient market

Acquiring information in an efficient market

▶ Acquiring information is costly

$$\text{▶ } U_I = \frac{(s-P)^2}{2z\sigma_\varepsilon^2} - C$$

Acquiring information in an efficient market

- ▶ Acquiring information is **costly** and the decision to acquire information is made **before receiving it**
- ▶ $E[U_I] = E\left[\frac{(s-P)^2}{2z\sigma_\varepsilon^2}\right] - C$

Acquiring information in an efficient market

- ▶ Acquiring information is **costly** and the decision to acquire information is made **before receiving it**
- ▶ Information will only be acquired if this is **profitable**
- ▶ $E[U_I] = E\left[\frac{(s-P)^2}{2z\sigma_\varepsilon^2}\right] - C \geq 0$

Acquiring information in an efficient market

- ▶ Acquiring information is costly and the decision to acquire information is made before receiving it
- ▶ Information will only be acquired if this is profitable
- ▶ $E[U_I] = E\left[\frac{(s-P)^2}{2z\sigma_\varepsilon^2}\right] - C \geq 0$
- ▶ If prices are **efficient** and reflect all available information, we have $P = s$

Acquiring information in an efficient market

- ▶ Acquiring information is costly and the decision to acquire information is made before receiving it
 - ▶ Information will only be acquired if this is profitable
 - ▶ $E[U_I] = E\left[\frac{(s-P)^2}{2z\sigma_\varepsilon^2}\right] - C \geq 0$
 - ▶ If prices are efficient and reflect all available information, we have $P = s$
- $\Rightarrow E[U_I] = -C < 0$

Acquiring information in an efficient market

- ▶ Acquiring information is costly and the decision to acquire information is made before receiving it
- ▶ Information will only be acquired if this is profitable
- ▶ $E[U_I] = E\left[\frac{(s-P)^2}{2z\sigma_\varepsilon^2}\right] - C \geq 0$
- ▶ If prices are efficient and reflect all available information, we have $P = s$
- ⇒ $E[U_I] = -C < 0$
- ⇒ Information acquisition is **not profitable** if markets are efficient

Acquiring information in an efficient market

- ▶ Acquiring information is costly and the decision to acquire information is made before receiving it
- ▶ Information will only be acquired if this is profitable
- ▶ $E[U_I] = E\left[\frac{(s-P)^2}{2z\sigma_\varepsilon^2}\right] - C \geq 0$
- ▶ If prices are efficient and reflect all available information, we have $P = s$
- ⇒ $E[U_I] = -C < 0$
- ⇒ Information acquisition is not profitable if markets are efficient

Demand by uninformed investors

Demand by uninformed investors

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

- ▶ $U_U = (E[V] - P) Q_U$

Demand by uninformed investors

- ▶ The profits an investor makes is the difference between the **inferred value** and **price** paid for **each unit**
- ▶ **Risk averse** investors dislike the **risks** arising from these profits, measured by its variance
- ▶ $U_U = (\mathbf{E}[V] - P) Q_U - \frac{1}{2} z Q_U^2 \text{Var}[V - P]$

Demand by uninformed investors

- ▶ The profits an investor makes is the difference between the inferred value and price paid for each unit
- ▶ Risk averse investors dislike the risks arising from these profits, measured by its variance
- ▶ $U_U = (E[V] - P) Q_U - \frac{1}{2} z Q_U^2 \text{Var}[V - P]$
- ▶ The optimal investment is then given if $\frac{\partial U_U}{\partial Q_U} = 0$

Demand by uninformed investors

- ▶ The profits an investor makes is the difference between the inferred value and price paid for each unit
- ▶ Risk averse investors dislike the risks arising from these profits, measured by its variance
- ▶ $U_U = (E[V] - P) Q_U - \frac{1}{2} z Q_U^2 \text{Var}[V - P]$
- ▶ The optimal investment is then given if $\frac{\partial U_U}{\partial Q_U} = 0$

$$\Rightarrow Q_U = \frac{E[V] - P}{z \text{Var}[V]}$$

Demand by uninformed investors

- ▶ The profits an investor makes is the difference between the inferred value and price paid for each unit
- ▶ Risk averse investors dislike the risks arising from these profits, measured by its variance
- ▶ $U_U = (E[V] - P) Q_U - \frac{1}{2} z Q_U^2 \text{Var}[V - P]$
- ▶ The optimal investment is then given if $\frac{\partial U_U}{\partial Q_U} = 0$

$$\Rightarrow Q_U = \frac{E[V] - P}{z \text{Var}[V]}$$

$$\Rightarrow U_U = \frac{(V^* - P)^2}{2z\sigma_V^2}$$

Demand by uninformed investors

- ▶ The profits an investor makes is the difference between the inferred value and price paid for each unit
- ▶ Risk averse investors dislike the risks arising from these profits, measured by its variance
- ▶ $U_U = (E[V] - P) Q_U - \frac{1}{2} z Q_U^2 \text{Var}[V - P]$
- ▶ The optimal investment is then given if $\frac{\partial U_U}{\partial Q_U} = 0$

$$\Rightarrow Q_U = \frac{E[V] - P}{z \text{Var}[V]}$$

$$\Rightarrow U_U = \frac{(V^* - P)^2}{2z\sigma_V^2}$$

Becoming informed

► We have $E[(s - P)^2] = (V^* - P)^2 + \sigma_s^2$

Becoming informed

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

Becoming informed

- ▶ We have $E[(s - P)^2] = (V^* - P)^2 + \sigma_s^2$
 - ▶ It is more profitable becoming informed if $E[U_I] \geq U_U$
- $\Rightarrow C \leq \frac{(V^* - P)^2 \sigma_S^2}{2z\sigma_\varepsilon^2 \sigma_V^2}$

Becoming informed

- ▶ We have $E[(s - P)^2] = (V^* - P)^2 + \sigma_s^2$
- ▶ It is more profitable becoming informed if $E[U_I] \geq U_U$
- ⇒ $C \leq \frac{(V^* - P)^2 \sigma_S^2}{2z\sigma_\varepsilon^2 \sigma_V^2}$
- ▶ If information costs are **sufficiently low**, then investors prefer becoming informed

Becoming informed

- ▶ We have $E[(s - P)^2] = (V^* - P)^2 + \sigma_s^2$
- ▶ It is more profitable becoming informed if $E[U_I] \geq U_U$
- ⇒ $C \leq \frac{(V^* - P)^2 \sigma_S^2}{2z\sigma_\varepsilon^2 \sigma_V^2}$
- ▶ If information costs are sufficiently low, then investors prefer becoming informed

Equilibrium information acquisition

Equilibrium information acquisition

- ▶ If information costs are low, it is **profitable to become informed**

Equilibrium information acquisition

- ▶ If information costs are low, it is profitable to become informed
- ▶ If markets are efficient, informed investors **cannot recover their information costs**

Equilibrium information acquisition

- ▶ If information costs are low, it is profitable to become informed
 - ▶ If markets are efficient, informed investors cannot recover their information costs
- ⇒ Becoming informed is **not profitable**

Equilibrium information acquisition

- ▶ If information costs are low, it is profitable to become informed
- ▶ If markets are efficient, informed investors cannot recover their information costs
- ⇒ Becoming informed is not profitable
- ▶ Without informed investors, markets **cannot reveal information**

Equilibrium information acquisition

- ▶ If information costs are low, it is profitable to become informed
- ▶ If markets are efficient, informed investors cannot recover their information costs
- ⇒ Becoming informed is not profitable
- ▶ Without informed investors, markets cannot reveal information
- ⇒ If information is costly, markets **cannot be fully efficient**

Equilibrium information acquisition

- ▶ If information costs are low, it is profitable to become informed
- ▶ If markets are efficient, informed investors cannot recover their information costs
- ⇒ Becoming informed is not profitable
- ▶ Without informed investors, markets cannot reveal information
- ⇒ If information is costly, markets cannot be fully efficient

Summary

Summary

- ▶ If markets are efficient, informed investors **cannot** make any trading profits

Summary

- ▶ If markets are efficient, informed investors cannot make any trading profits
- ▶ This **prevents** investors from recovering any information costs

Summary

- ▶ If markets are efficient, informed investors cannot make any trading profits
- ▶ This prevents investors from recovering any information costs, and they will **not acquire any information**

Summary

- ▶ If markets are efficient, informed investors cannot make any trading profits
- ▶ This prevents investors from recovering any information costs, and they will not acquire any information
- ▶ In the absence of information, markets **cannot be efficient**

Summary

- ▶ If markets are efficient, informed investors cannot make any trading profits
 - ▶ This prevents investors from recovering any information costs, and they will not acquire any information
 - ▶ In the absence of information, markets cannot be efficient
- ⇒ Fully efficient markets **cannot exist**

Summary

- ▶ If markets are efficient, informed investors cannot make any trading profits
 - ▶ This prevents investors from recovering any information costs, and they will not acquire any information
 - ▶ In the absence of information, markets cannot be efficient
- ⇒ Fully efficient markets cannot exist



Copyright © by Andreas Krause

Picture credits:

Cover: Tobias Deml, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons, https://upload.wikimedia.org/wikipedia/commons/2/26/Gaming-Wall-Street_BTS_Prodigium-266.jpg

Back: Michael Vadon, CC BY 2.0 <https://creativecommons.org/licenses/by/2.0/>, via Wikimedia Commons, [https://upload.wikimedia.org/wikipedia/commons/9/97/Manhattan\(NYC-New-York-City\)Skyline\(31769153946\).jpg](https://upload.wikimedia.org/wikipedia/commons/9/97/Manhattan(NYC-New-York-City)Skyline(31769153946).jpg)

Andreas Krause
Department of Economics
University of Bath
Claverton Down
Bath BA2 7AY
United Kingdom

E-mail: mnsak@bath.ac.uk