

HEC Paris — M1 — Spring 2022

Advanced Finance

[#2] Finance and Data (Part I: Financial Markets)

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Road map

Introduction

Adverse selection

Social value of trading

Glosten-Milgrom model

Social value of information

Private value of information

Information in financial markets



From Rothschild's carrier pigeons...



to...

Hedge funds rush to get to grips with retail message boards

Professional speculators start efforts to scrape data from Reddit to avoid assaults

1

DATA, EUROPE, REGULATION October 25, 2021 11:50 AM GMT

S&P Global and IHS Markit get green light from European Commission for \$44 billion megadeal

¹GameStop story: [blog post](#), [podcast](#)

Information in financial markets

- Information production chain

- ▶ Data collection & processing: financial market data, company data, internet data, etc.
- ▶ Data analysis: fundamental, statistical

- Main players

- ▶ Internal research by buy-side firms (hedge funds Renaissance, D.E. Shaw & Co, CPM, mutual funds BlackRock, Amundi, etc.)

and sell-side firms (investment banks JPMorgan Chase, Goldman Sachs, Morgan Stanley, BNP PARIBAS)

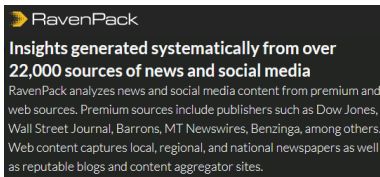
- ▶ Data providers Bloomberg, REUTERS, IHS Markit, REFINITIV, R

- ▶ Market intelligence fintechs

Market value of data providers

- Ongoing \$44 bn acquisition of IHS Markit (market and industry data) by S&P Global (market cap \$150 bn)
- Refinitiv (financial market data and infrastructure) acquired in 2019 for \$27 bn by London Stock Exchange Group (market cap \$45 bn)
- Compare with BNPP \$60 bn; HSBC \$100 bn; Goldman Sachs \$110 bn

Examples of market intelligence fintechs



SPACEKNOW

SpaceKnow has been using satellite data to understand the economy since our inception in 2014. With access to the world's most comprehensive collection of earth observation imagery, proprietary ML/AI algorithms, and a seasoned team of engineers and scientists, we provide traders, portfolio managers, corporate strategists, economists, and governments a unique view from above.

2

- 400+ providers of alternative data (alternativedata.org)
- \$1.7 bn invested in alternative data in 2020

²Katona, Painter, Patatoukas and Zeng, 2021, On the Capital Market Consequences of Alternative Data: Evidence from Outer Space [\[pdf\]](#)

This lecture

- **What is the value of information in financial markets?**

- ▶ For information holders (hedge funds, data providers)
- ▶ For society (individual investors, non-financial companies)

To answer this question, we first need to answer:

- **How is information used in financial markets?**

- ▶ How is information impounded into security prices?
- ▶ Who gains and who loses in this process?

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Theoretical framework

- Consider the market for a security (stock, bond, ETF, token, etc.)
- Investors assess the security's "fundamental value"

= PV of cash flow; or the price at some horizon [NB: Both are equivalent when markets are informationally efficient – see Problem 1 of Problem Set]

- \neq investors may have \neq estimates of the fundamental value

b/c they have \neq data, \neq data analysis capabilities, \neq expertise

- How is the price determined? \longrightarrow We need to understand:
 - a. How each investor behaves
 - b. How the aggregation of individual behaviors determines the market equilibrium

Individual behaviors

- Consider the set of investors in the market (mutual funds, hedge funds, individuals, etc.): $i = 1, \dots, N$
- Each investor i has her own estimate of the fundamental value: E_i
- Each investor i

buys shares if $E_i > P$

sells shares if $E_i < P$

does not trade if $E_i = P$

Case 1: Symmetric information Equilibrium

- (Mostly to warm up. Does not fit evidence in most cases.)
- Suppose all investors have the same estimate: $E_i = 30$ for all i

Q. What will the equilibrium price be equal to?

- *Definition:* The market is in **equilibrium** when supply and demand are equalized (a.k.a. market clearing).
- The equilibrium price is

Case 1: Symmetric information Equilibrium

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- Suppose all investors have the same estimate: $E_i = 30$ for all i

Q. What will the equilibrium price be equal to?

- *Definition:* The market is in **equilibrium** when supply and demand are equalized (a.k.a. market clearing).
- The equilibrium price is 30

Proof: By contradiction, if the price were $P < 30$, every investor buys, demand exceeds supply. Conversely, if $P > 30$, every investor sells, supply exceeds demand. Therefore, the equilibrium price can only be $P = 30$.

Case 1: Symmetric information

Public news and trading

- Suppose good news arrives
 - E.g., better-than-expected quarterly earnings
 - All investors update their estimate to $E_i = 32$
 - Price goes to 32

Q. How much trading takes place to move the price to 32?

Case 1: Symmetric information

Public news and trading

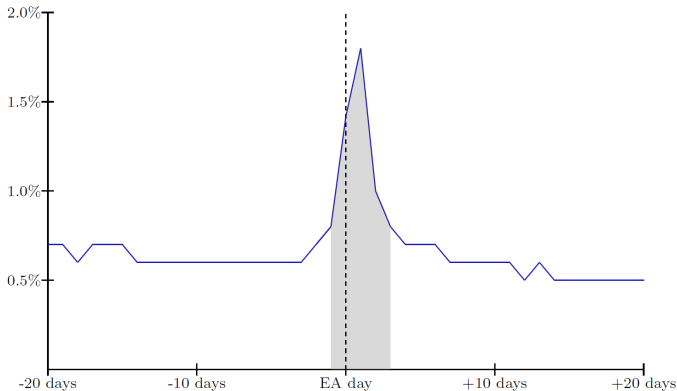
- Suppose good news arrives
 - E.g., better-than-expected quarterly earnings
 - All investors update their estimate to $E_i = 32$
 - Price goes to 32

Q. How much trading takes place to move the price to 32?

- None!
 - No one wants to sell at 30 (nor at any price < 32)
 - The price impounds new info without any trading happening
 - This is counterfactual (next slide)

Public news and trading: Evidence

- Trading volume increases after Earnings Announcements³



Trading volume is computed as the percentage of shares that are turned over on each day, from 20 days preceding the announcement to 20 days after the announcement.

³Fedyk, 2018, News-Driven Trading: Who Reads the News and When? [\[pdf\]](#)

Case 1: Symmetric information

Summary

- The symmetric information case is not satisfactory
 - A priori implausible
 - Predicts no trading, which is inconsistent with empirical evidence

Case 2: Asymmetric information

- Different investors have different estimates because some investors are better informed than others
- To illustrate, consider $N = 2$ investors
 - ▶ Investor 1 has better information, more expertise, more resources (e.g., a hedge fund)
 - ▶ Investor 2 has less information (e.g., an individual)

Case 2: Asymmetric information

- Initially, both investors have the same information and estimate the asset value at 30
- Then, one of three events can happen, with equal probabilities
 - ▶ Investor 1 receives **positive** information; her best estimate moves to **32**. Investor 2 receives no information; his best estimate remains 30.
 - ▶ Investor 1 receives **negative** information; her best estimate moves to **28**. Investor 2 receives no information; his best estimate remains 30.
 - ▶ Both investors receive **no** information; their best estimate remains 30.

Q. What is the equilibrium of the market?

Case 2: Asymmetric information Equilibrium

- No trading takes place (if investor 2 is rational)
- Why?
 - ▶ Investor 1 would only buy when the price is too low and sell when the price is too high \Rightarrow Investor 2 should never trade against investor 1
 - ▶ “I refuse to join any club that would have me as a member”
(Groucho Marx)
- \Rightarrow **Adverse selection** (a Nobel winning idea)



George A. Akerlof (2001)

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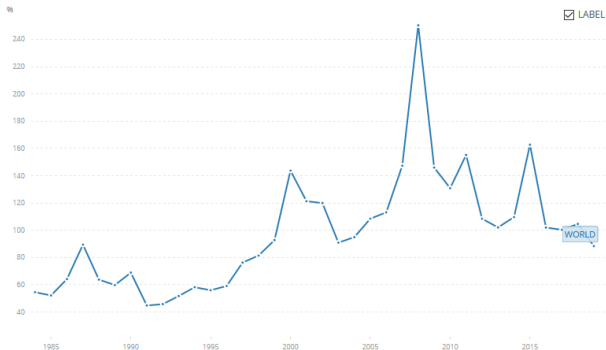
Private value of information

Two questions

1. Why is there so much trading in financial markets?
2. What is the social value of trading?

Why so much trading?

- Stock market turnover (% per year) = value of shares traded divided by market capitalization (source: [World Bank](#))



≈ 100% annual turnover

Why so much trading?

- High trading volume can not be explained by conceptual framework in previous slides, neither with symmetric nor asymmetric information

Q. What is missing that could explain trading?

Why so much trading?

1. Less-than-rational traders with behavioral biases

- Overconfidence, cognitive dissonance, self-attribution bias, limited attention, etc. (see lecture 1 with Daniel)
 - Explains high trading volume in general
 - Explains surge in trading around news events (more room for mistakes)
- NB: Being non-rational \neq Having no information
 - One may have no info and correctly account for not having info (e.g., investor 2 in previous example)
 - One may have info but fail to use it properly

Why so much trading?

2. Liquidity traders who trade for non-informational reasons

- For liquidity reasons

ex: receive a bonus and invest it \Rightarrow buy stocks

ex: need cash to buy an apartment \Rightarrow sell stocks

- For risk rebalancing

ex: take a job in the finance industry \Rightarrow sell stocks of financial companies and buy stocks of tech companies to diversify

ex: standard investment advice is to reduce share of stocks in portfolio as one ages \Rightarrow sell stocks and buy bonds over time⁴

- These trading motives can only explain a small share of trading

- ▶ Cannot explain why investors buy and sell at daily frequencies
- ▶ Cannot explain why trading surges around news events

⁴This advice is debatable: blog post [Should you buy stocks when young or old?](#)

Does trading create social value?

- Trading between rational investors and less-than-rational investors



- ▶ The former benefits at the expense of the latter
- ▶ Zero sum gam \Rightarrow No social value

Does trading create social value?

- Trading between strategic traders and liquidity traders
 - Valuable for both: strategic traders earn profits; liquidity traders satisfy a trading need
- ⇒ Positive social value (not a zero sum game)

Trading in financial markets — Summary

- Asymmetric information alone does not generate trading
- Overconfidence/limited rationality generates trading but this trading does not create social value (at least not directly but it may create social value through information creation – see later)
- Liquidity needs generate trading and this trading creates social value

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Glosten-Milgrom model⁵

- A model that
 - encompasses different trader types and trading motives
 - determines transaction costs
 - determines how private information gets impounded into prices
 - determines the private value of information

⁵Glosten and Milgrom, 1985, Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously informed traders, *Journal of Financial Economics*. Modern presentation in Foucault, Roell and Pagano, *Market Liquidity: Theory, Evidence and Policy*, chapter 3

Organization of trading

- Securities can trade in organized exchanges with a limit order book (Euronext, NYSE, CME, etc.)
 - ▶ Two types of trading orders:
 - limit order: an offer to buy (or sell) at a given price
 - market order: buy (or sell) against a limit order in the book
 - ▶ Market makers (hedge funds, investment banks) are specialized in posting limit orders
- Other securities trade in over-the-counter (OTC) markets
 - ▶ Investors trade with dealers (Goldman Sachs, JP Morgan, BNP Paribas, etc.), who play the role of market makers

Glosten-Milgrom model

- Initially, everyone agrees that the fundamental value is 30
- A market maker posts limit orders
 - to buy at price 29.5 (the “bid” price)
 - to sell at price 30.5 (the “ask” price)
- nb: the “bid-ask spread” = $30.5 - 29.5 = 1$ creates a transaction costs for investors: it represents the cost of a round-trip trade (buy then sell)
- Two types of investors who may trade using market orders
 - “Informed trader”: rational and informed
 - “Noise trader”: irrational trader or liquidity trader, i.e., uninformed
- One of four events happens, with equal probabilities
 - Informed trader finds out the fundamental value is 32
 - Informed trader finds out the fundamental value is 28
 - Noise trader buys
 - Noise trader sells
- Trading is anonymous: market maker doesn't know if orders come from informed trader or noise trader

Q. Suppose a trader buys. What is the expected profit for the market maker?

Glosten-Milgrom model

- Market maker's profit when a trader buys = ask price minus fundamental value
 - Market order to buy may come from
 - ▶ Informed trader
 - Probability informed trader is buying conditional on someone is buying = $\frac{P[informed\ buy]}{P[informed\ buy] + P[noise\ buy]} = \frac{0.25}{0.25 + 0.25} = 0.5$
 - Profit = $30.5 - 32 = -1.5$
 - ▶ Noise trader
 - Probability = $\frac{P[noise]}{P[informed\ buy] + P[noise\ buy]} = 0.5$
 - Profit = $30.5 - 30 = +0.5$
- ⇒ Expected profit = $0.5 \times (-1.5) + 0.5 \times (+0.5) = -0.5$

Q. At what ask price does the market maker break even?

Glosten-Milgrom model

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- Market order to buy may come from
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$$\Rightarrow \text{Expected profit} = 0.5 \times (-1.5) + 0.5 \times (+0.5) = -0.5$$

Q. At what ask price does the market maker break even?

- $0.5 \times (\text{ask price} - 32) + 0.5 \times (\text{ask price} - 30) \geq 0$
the market maker breaks even if ask price ≥ 31

Glosten-Milgrom model

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- $0.5 \times (\text{ask price} - 32) + 0.5 \times (\text{ask price} - 30) \geq 0$
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Q. Can the market maker quote an ask price at 31.5 and earn an expected profit of $0.5 \times (31.5 - 32) + 0.5 \times (31.5 - 30) = 0.5$?

Glosten-Milgrom model

- Market maker's profit when a trader buys = ask price minus fundamental value
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- it depends on the intensity of competition between market makers

Competition between market makers

- When competition between market makers is intense
 - ▶ If a market maker quotes an ask price at 31.5, another market maker will undercut at 31.4, then another will undercut at 31.3, etc., until the ask price is very close to 31 and market maker's profits are close to zero
- When competition between market makers is limited
 - ▶ Market makers are able to sustain an ask price significantly above 31 and earn significant profits
- In practice, competition between market makers is fairly intense in organized markets, sometimes less so in OTC markets

Competition between market makers

- The same process takes place on the bid side
 - $\text{Bid} = 29$ if competition between market makers is intense
 - $\text{Bid} < 29$ if competition between market makers is limited

Transactions costs

- Adverse selection generates a bid-ask spread
 - The bid-ask spread compensates market makers for the trading losses they incur when trading against informed investors
- The bid-ask spread creates a transaction cost
 - For noise traders (this explains why amateur traders lose money on average)
 - For informed traders (it reduces their trading profit)

Transactions costs

- The bid-ask spread is an inverse measure of liquidity
 - Liquidity: cheapness of trading large quantities of shares
 - Low bid-ask spread \Leftrightarrow liquid market
 - High bid-ask spread \Leftrightarrow illiquid market
- The bid-ask spread is (twice) the cost of trading one share
- The cost of trading larger quantities grows more than proportionally with the number of shares traded
 - Because the bid-ask drifts against the trader (see Problem 4 in problem set)

How the price incorporates private information

- After a market buy order, market makers update their estimate of the fundamental value
 - Because they know the order was informed with some probability

⇒ The price increases

- Both the bid and the ask
- The “mid-price” (= mid-point of bid and ask) increases

⇒ The price incorporates private information through trading

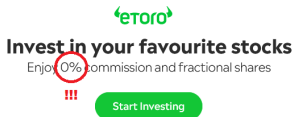
Zero-commission trading apps

- It would be valuable for a market maker to know whether an order comes from an informed trader or a noise trader
- Market makers pay retail brokerage firms to execute the trades of retail investors (“payment for order flow”)

Citadel Is Paying for Order Flow from Nine OnLine Brokerage Firms – Not Just Robinhood

By Pam Martens and Russ Martens: February 4, 2021 ~

⇒ Business model of zero-commission trading apps



“If you don’t pay, you are the product”

Problem 3 of Problem Set

Road map

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Social value vs. private value of information





- What is the value of information about a company?
- Private value: profit for the informed investor
- Social value: value created for all (not just the informed investor)
- Main source of social value: informative securities prices = useful signals for capital budgeting decisions
 - Investors trade on info \Rightarrow Information gets incorporated into prices
 \Rightarrow Prices become informative about economic fundamentals \Rightarrow
Useful signals for companies to make real investment decisions





Information and capital allocation

- Consider a company that considers a new project
- PV of assets in place: 110 (“good company”) or 90 (“bad company”)
- PV of new project = PV of assets in place
- Cost of new project = 102
 - NPV = 8 if company is good
 - NPV = -12 if company is bad
- ...but decision makers don't know if company is good or bad
- The stock price reveals information about PV of assets in place, and therefore about the PV of the new project
 - More informative stock market \Rightarrow Better capital allocation









Information and capital allocation

- Consider eight such companies trading in the stock market

half with good projects    

half with bad projects    









- In a perfectly informative market

	Companies with high stock price	Companies with low stock price
	   	   
Stock price	110	90
Investment is carried out	Yes	No
Value created	$4 \times (110 - 102) = +32$	


NB: We assume the new project is not priced in, for instance because it was unexpected.

Information and capital allocation

- In a somewhat informative market

	Companies with high stock price	Companies with low stock price
	   	   
Stock price	105	95
Investment is carried out	Yes	No
Value created	$3 \times (110 - 102) + 1 \times (90 - 102) = +12$	

- In a perfectly uninformative market

	Stocks prices are unrelated to company value	
	       	
Stock price	100	
Investment is carried out	No	
Value created	0	

NB: In these examples, the market is always informationally *efficient* (i.e., the price is unbiased). What varies is price *informativeness* (i.e., its precision).

Information and capital allocation

- More informative stock prices \Rightarrow Better allocation of capital
- Valuable for other companies too
 - For companies with similar projects, in particular if not listed
 - For entrepreneurs, for PE/VC investors, etc.

Information and capital allocation

- Back to 2017: EBITDA BMW \$17 bn vs. Tesla \$0.1 bn

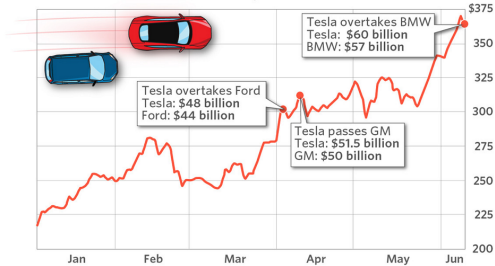
...but:

Published: June 9, 2017 at 2:50 p.m. ET

By Claudia Assis

Tesla surpassed BMW to become world's No. 3 car maker by market value

All the Tesla market cap milestones, in one chart



Source: MarketWatch

Information and capital allocation



Ford plans \$11 billion investment, 40 electrified vehicles by 2022

DETROIT (Reuters) - Ford

Motor Co F.N will

significantly increase its planned investments in electric vehicles to \$11 billion...

Jan 14, 2018



GM races to build a formula for profitable electric cars

Pam Fletcher, vice

president in charge of GM's

global electric vehicle programs, and other GM executives would not comment...

Jan 8, 2018



- How much of traditional carmakers' move to EV was triggered by Tesla's stock price?

Information and capital allocation: Evidence

- Dessaint, Foucault, Fresard and Matray, 2019, Noisy Stock Prices and Corporate Investment, *Review of Financial Studies* [\[pdf\]](#)
 - Estimate a multivariate regression model to explain capital expenditures decisions of US listed companies
 - Main result: Capex increases when the stock price increases
 - Even if the price increases because of noise traders
- ⇒ Informative prices are important for efficient allocation of capital
- Capex also increases when stock prices of similar companies increase
- ⇒ Informative price of one company matters for other companies

Road map

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Private value of information

- Private value of information in financial markets = amount of profit an investor can earn by trading on the information
- It depends on
 - A. Whether other traders have the same information
 - B. How many noise traders there are in the market

Private value of information

- Let's first illustrate point B.
- Suppose there are no noise traders in the market
 - If you have positive info and tries to buy, market makers infer you are informed and would only sell at a high price \Rightarrow you cannot profitably trade on your info
- Informed investor make higher profits when there are more noise traders in the market
 - See Problem 2 of Problem Set

\Rightarrow Implications for the value of data

1. Information is (privately) valuable only if there are noise traders
2. Informed investors should “hide” to look like noise traders (e.g., send many small orders rather than one large order – “order splitting”)

Private value of information

- Let's now illustrate point A.
 - ▶ Suppose 9 other traders have the same info as you have
 - ▶ 10 traders try to buy at the same time \Rightarrow market makers understand it's no coincidence and increase the price \Rightarrow you cannot profitably trade on the info

\Rightarrow Implications for the value of data

1. Unlikely to make money using widely available information
2. Importance of unique data
3. Importance of speed: if you can trade before the 9 other hedge funds, you can still exploit your information

Do private incentives lead to socially desirable info production?

- Incentives to produce information depends on the profits one can earn with it, i.e., its private value
- However, private value of info \neq social value of info
- Therefore, there can be too much information produced from a social perspective
 - If private value $>$ social value
- ... or too little
 - If private value $<$ social value
- Which case prevails in practice depends on the nature of info

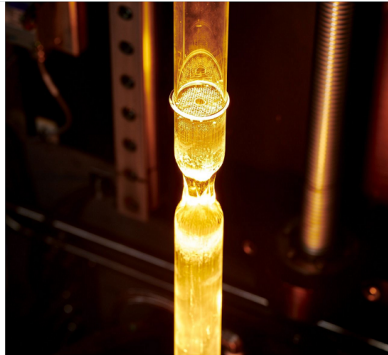
Do private incentives lead to socially desirable info production?

THE WALL STREET JOURNAL

MARKETS

High-Frequency Traders Push Closer to Light Speed With Cutting-Edge Cables

Firms aim to gain nanoseconds of advantage over rivals by using hollow-core fiber to convey data



A glass structure called an assembly is heated to ultrahigh temperatures, then stretched to form hollow-core fiber.

High-frequency trading

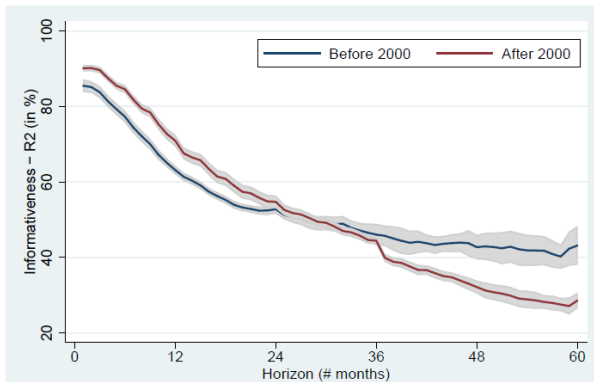
- HFT strategy: react to information faster than other market participants
- Being faster has high private value \Rightarrow private incentives to make large investments for a tiny speed advantage
 - \$300 million fiber-optic cable between Chicago and Wall Street to gain 3 milliseconds; quickly supplanted by microwave links; and so on
- However, information being reflected in stock prices a few seconds earlier has little social value

\Rightarrow Likely to be over-production of short-term information

Trends in information production

Dessaint, Foucault and Frésard, 2021, Does Alternative Data Improve Financial Forecasting? The Horizon Effect [\[pdf\]](#)

Figure IV: The term-structure of analysts' forecasts' informativeness over time



- Earnings forecasts are more precise at short horizon
- Short-term forecasts have become more precise and long-term forecasts less precise in the last two decades

Trends in information production

- Blog post on: Does AI make financial markets more informative?
<https://johanhombert.github.io/blog/20210405-AI-informative-markets>

Conclusion: How financial markets create value

- Primary markets: financing of real economy \Rightarrow social value created
 - For companies: receive financing
 - For households: invest and earn returns on their savings
- Secondary markets: trading
 - For liquidity and risk rebalancing purposes \Rightarrow social value created
 - For information purposes \Rightarrow zero-sum game, but...

Conclusion: How financial markets create value

- Secondary markets: information production \Rightarrow social value created
 - Paradox: private incentives to produce information come from exploiting less-than-rational traders, which in itself creates no social value, but...
 - Informative stock prices improve capital budgeting decisions \Rightarrow information has social value
 - Private incentives may lead to too much or not enough information produced