Financial Markets, Information, and Real Investments

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Structure

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2. Models with a large strategic trader

   a. Goldstein and Guembel (2008) (full presentation)

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3. Models with small price-taking traders

   a. Goldstein, Ozdenoren, and Yuan (2013) (full presentation)

   b. Dow, Goldstein, and Guembel (2017) (short summary)

1. Introduction

Information in prices

- A basic premise in financial economics: market prices are very informative about assets fundamentals
- They gather information from many different participants, who trade on their own money
- Lots of empirical evidence supporting the idea, e.g., Roll (*AER*, 1984)
- Models of how information gets reflected in the price: Grossman and Stiglitz (*AER*, 1980), Kyle (*Econometrica*, 1985), Glosten and Milgrom (*JFE*, 1985)

The Feedback Effect

- The informativeness of prices is important, since it helps facilitate the efficient allocation of resources:

  An efficient market "has a very desirable feature. In particular, at any point in time market prices of securities provide accurate signals for resource allocation. That is, firms can make production-investment decisions ..." **Fama & Miller (1972)**

- Who learns from the price?
  - Managers, Creditors, Regulators, Customers, Employees, etc.
  - As long as there is *some* information in the price they don't know

Empirical Evidence

- Some Evidence:
  - Luo (*JF*, 2005) – Mergers are more likely to be canceled when prices react more negatively and managers are trying to learn
  - Chen, Goldstein, and Jiang (*RFS*, 2007) – Price informativeness affects investment sensitivity to price
  - Foucault and Fresard (*RFS*, 2012) – Cross listed firms exhibit stronger sensitivity of investment to price

⟶ Financial markets are not a **side show**

Implications for Theory

- A **feedback loop** emerges between market prices and firms' cash flows and fundamentals. Prices reflect *and* affect cash flows:

  "In certain circumstances, financial markets can affect the so-called fundamentals which they are supposed to reflect." **George Soros**

- Traditional models on financial markets do not capture this feedback loop
  - They take firm cash flows as given and study price formation as a result

- The "Feedback Effect" papers I will cover here break this paradigm and consider the feedback loop between prices and cash flows / fundamentals
  - Modelling can be challenging because of feedback loop

Early Literature Review: Bond, Edmans, and Goldstein (*ARFE*, 2012)

- Review theoretical and empirical literature on the real effect of (secondary) financial markets
- Two channels for real effect (both rely on information):
    - Decision makers on the real side **learn new information** from markets that guides their decisions
    - Compensation contracts for real decision makers are tied to market prices (due to their informativeness) and affect their **incentives**

- Highlight two implications for theoretical research:
  - Incorporating the feedback effect into models of trading in financial markets fundamentally **changes predictions on price formation** in financial markets (with implications for firm cash flows)
    - Giving rise to phenomena that otherwise look puzzling
  - Different notions of efficiency
    - **Forecasting Price Efficiency (FPE)**
    - **Revelatory Price Efficiency (RPE)**
    - Former is often emphasized (Market Efficiency), but latter really matters (Real Efficiency)

2. Models with a large strategic trader

Manipulation: Goldstein and Guembel (*REStud*, 2008)

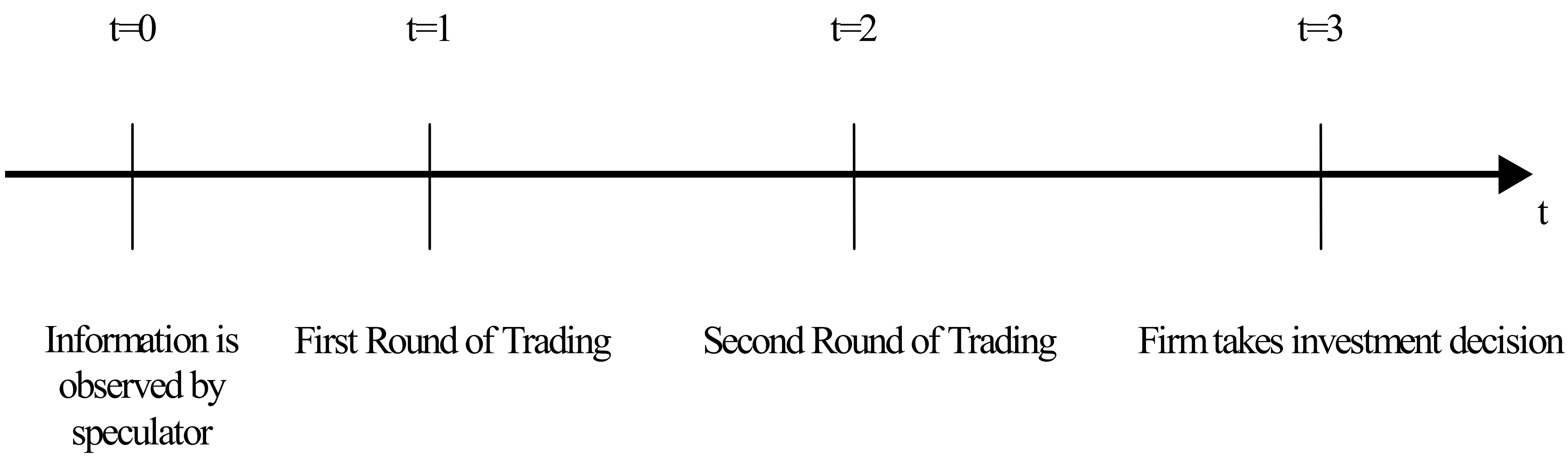
- We identify a fundamental limitation inherent in the allocational role
- The fact that prices perform an allocational role creates a scope for price manipulation, which reduces investment efficiency:
  - Uninformed traders establish short position
  - Price decreases
  - Real investment decreases
  - Value of asset decreases
  - Uninformed traders make a profit on the short position
- Note: Profitable manipulation requires two rounds of trade and short sales

Summary of Contribution

- Identifying a limitation inherent in the allocational role of prices, and discussing implications for the effect of prices on investment efficiency
- Identifying an asymmetry between sell side and buy side speculation, and providing justification for short-sales restrictions
  - This is implicitly understood by regulators as a primary reason for short-sales restrictions, which are very common
- Identifying a new mechanism for trade-based manipulation
  - Overcoming the problems raised by Jarrow (*JFQA*, 1992)

Basic setup

- Dates $t \in \{0, 1, 2, 3\}$
- Timeline:



The firm's investment problem

- Firm takes an investment decision

- Two possible states: $\omega \in \{l, h\}$ with equal probability

- NPV of investment in good (bad) state is V^+ (V^-) :

$$V^+ > 0 > V^-$$

$\Rightarrow$ The firm wants to invest when $\omega = h$, not when $\omega = l$

- The firm may learn information about ω from the stock market

Trade in the financial market

- Risk neutral speculator and noise traders submit orders to a market maker
- **Noise trade:** At each date, noise trade $n_t \in \{-1, 0, 1\}$ with equal probabilities
- **Speculator:** With probability α, learns ω: $s \in \{l, h\}$ (probability $1\text{-}\alpha$, $s=\varnothing$); submits orders $u_t \in \{-1, 0, 1\}$
- **Market maker:** Sets Prices after observing total order flow $Q_t = u_t + n_t$. $Q_t \in \{-2, -1, 0, 1, 2\}$
  - $p_t = E[V|Q_t, Q_{t-1}]$ (modification of Kyle to account for feedback loop)

Equilibrium

- Perfect Bayesian Nash Equilibrium:
  - A trading strategy by the speculator: $u_1(s)$, $u_2(s, Q_1, u_1)$ that maximizes expected payoff given the price setting rule, the firm's investment strategy, and the information he has
  - An investment strategy that maximizes firm value, given all available information and other strategies
  - A price setting rule $p_1(Q_1)$, $p_2(Q_1, Q_2)$ that allows the market maker to break even given order flows and other strategies

Equilibrium in a model with no feedback

- Suppose that the firm is fully informed about the state of the world
- The value of the firm does not depend on the trading outcomes:
  - It is V^+ when $\omega = h$, and 0 when $\omega = l$
  - The speculator may know the value and trade
- Trading strategies:
  - Positively informed speculator buys in $t=1$ with positive probability (or does not trade), and then buys again in $t=2$ unless revealed

- Negatively informed speculator sells in $t=1$ with positive probability (or does not trade), and then sells again in $t=2$ unless revealed
- Mixing in $t=1$ serves to increase profit in $t=2$

Proposition 1: In any equilibrium of the no-feedback game, the uninformed speculator never trades in $t = 1$

- Trading in $t = 1$ without information generates losses because buying (selling) pushes the price up (down), so that the expected price is higher (lower) than the unconditional expected firm value
- The uninformed trader may trade in $t = 2$. This is when $t = 1$ noise trade moves the $t = 1$ price away from its unconditional mean

Equilibrium in a model with feedback: Manipulation

- Assume that the firm has no information on ω
- Project has positive NPV:

$$\overline{V} = \tfrac{1}{2}\left(V^{+} + V^{-}\right) > 0$$

Proposition 2: In the presence of feedback, there exists equilibrium where the uninformed speculator sells in $t = 1$ with positive probability

- Condition:

$$\tfrac{\alpha}{2} V^{-} + (1-\alpha)\overline{V} < 0$$

Equilibrium strategies

- First period:

$$u_1(s=h)=1$$

$$u_1(s=l \;\; or \;\; \phi)=\begin{cases}-1 & prob \;\; 1-\mu \\ 0 & prob \;\; \mu\end{cases} \quad ; \;\; 1-\mu>\tfrac{2}{3-\alpha}$$

- Second period, positively informed:

$$u_2(s=h,Q_1,u_1=1)=\begin{cases}1 \;\; if \;\; Q_1\in\{0,1\} \\ -1,0,or\,1 \;\; if \;\; Q_1=2\end{cases}$$

- Second period, negatively informed:

$$u_2\left(s=l, Q_1, u_1=-1\right)=\begin{cases}-1 \;\; if \;\; Q_1=0 \\ -1, 0, or\, 1 \;\; if \;\; Q_1 \in \{-1,-2\}\end{cases}$$

$$u_2\left(s=l, Q_1, u_1=0\right)=\begin{cases}-1 \;\; if \;\; Q_1 \in \{0,1\} \\ -1, 0, or\, 1 \;\; if \;\; Q_1=-1\end{cases}$$

- Second period, uninformed:

$$u_2\left(s=\phi, Q_1, u_1=-1\right)=\begin{cases}-1 \;\; if \;\; Q_1=0 \\ -1, 0, or\, 1 \;\; if \;\; Q_1 \in \{-1,-2\}\end{cases}$$

$$u_2\left(s=\phi, Q_1, u_1=0\right)=\begin{cases}-1 \;\; if \;\; Q_1=1 \\ 0 \;\; if \;\; Q_1=0 \\ -1, 0, or\, 1 \;\; if \;\; Q_1=-1\end{cases}$$

Profitability of Manipulation

Three possible Scenarios:

i. Q_1 = -2 or -1: sale is revealed immediately. No investment occurs. The price and real value equal 0. The speculator makes a profit of 0

ii. $Q_1 = Q_2 = 0$: trade is never revealing. Investment occurs. The expected value is $\overline{V}$. The speculator makes a profit of $p_2(0,0) + p_1(0) - 2\overline{V} > 0$

iii. $Q_1 = 0$, Q_2 = -2 or -1: sale is revealed in second round. No investment occurs. The speculator makes a profit of $p_1(0) > 0$

Profit can be attributed to two sources; both rely on multiple rounds of trade

Manipulation and firm value

Corollary 2: The expected value of the firm is $\frac{1}{9}\overline{V}$ if the uninformed speculator sells in *t=1*, and $\frac{1}{3}\overline{V}$ if he does not trade in *t=1*. Thus, by selling in *t=1*, the speculator decreases the expected value of the firm by $\frac{2}{9}\overline{V}$

- By selling in *t=1*, the uninformed speculator causes the firm to cancel a profitable investment project
- This suggests that regulation that restricts short sales may improve value
    - Important: set a cost of short sale that drives the uninformed speculator out of the market, but not the negatively informed

Manipulation and price informativeness

Corollary 3: $\Pr\left(s = h \middle| Q_1 = X\right) > \Pr\left(s = l \middle| Q_1 = -X\right);\ X \in \{1,2\}$

- High prices are more informative about high fundamentals than low prices are about low fundamentals
    - The uninformed pools with the negatively informed

Corollary 4: $p_1(X) - p_1(0) > p_1(0) - p_1(-X);\ X \in \{1,2\}$

- Prices react more strongly to positive order flow than to negative one
    - Two reasons: Feedback effect and manipulation

Comparative statics

- Condition $\frac{\alpha}{2}V^{-}+(1-\alpha)\overline{V}<0$ can be rewritten as:

$$\alpha > 2\frac{\overline{V}}{\overline{V}+\Delta V}$$

Where $\Delta V = V^{+} - \overline{V}$

- Thus, manipulation is more likely when:
    - Speculators have more information
    - Projects have lower NPV
    - Projects are more uncertain

Unique equilibrium

- Taking as given the strategy of the negatively informed and positively informed traders, the uninformed trader always wants to manipulate
  - If he doesn't, $p_1(0)$ goes up, increasing his incentive to manipulate
- But, things may get complicated by changes in strategies of informed trader
  - An increase in $p_1(0)$ may lead the positively informed trader to mix, generating less cancellations, and reducing profit from manipulation

Proposition 3: If feedback is strong (low $\overline{V}$), there is always manipulation

Buy-side manipulation

- Sell-side manipulation works when the uninformed speculator makes the firm cancel a profitable investment ($\overline{V} > 0$)

- In principle, it is easy to have a model where the uninformed speculator makes the firm overinvest ($\overline{V} < 0$)
    - Such a manipulative trading strategy is feasible but not profitable

Proposition 4: If $\overline{V} < 0$, there is no equilibrium where the uninformed speculator makes a positive profit from buying in *t=1*

- Manipulation always decreases firm value, which can be profitable only with a short position

Additional uninformed trader

- Suppose there is another strategic trader (arbitrageur), who never has information. Can he make a profit by mimicking the strategy of our uninformed trader?
  - This might potentially interfere with the manipulation equilibrium

Proposition 5: There exists an equilibrium where the additional trader does not trade, and all other strategies remain as in the manipulation equilibrium

The additional trader cannot condition his trade on the signal of the speculator, and thus ends up losing money when signal is high

Limits to Arbitrage and Asymmetric Trading: Edmans, Goldstein, and Jiang (*AER*, 2015)

- Broad definition of arbitrage: trading on private information
- Limit to Arbitrage (LTA) arises because the value of the asset being arbitraged is endogenous to the act of arbitrage
  - If speculator knows that state is bad, shorting stock may convey this to the manager and induce a corrective action
  - This improves firm value and harms the profitability of a short position

- Our LTA is asymmetric
  - Trading in either direction (buying on good news and selling on bad news) improves price informativeness, increasing firm value
  - This increases the profitability of a long position, but decreases the profitability of a short position
- Price impact ends up being asymmetric too (even though market maker is rational and takes into account the LTA)
  - Bad news has a smaller impact than good news
  - Since bad news is not incorporated in prices, overinvestment arises

3. Models with small price-taking traders

Strategic Complementarities and Trading Frenzies: Goldstein, Ozdenoren, and Yuan (*JFE*, 2013)

- Trading Frenzies arise when speculators rush to trade in the same direction causing large pressure on price
  - Give rise to bear raids, financial-market runs
- What causes trading frenzies?
  - Financial markets usually generate strategic substitutes. What is the source of strategic complementarities?

- What is their real effect?
  - Feedback effect turns out to be source of complementarities
  - Are trading frenzies necessarily bad?
- We study a model where a capital provider decides how much capital to provide for a new real investment
  - Decision of capital provider depends on assessment of investment productivity, based on private information and information in price
  - Capital provider, as a decision maker, generates different implications than manager as a decision maker: **Amplifying** vs. **Corrective** action

Strategic Interaction in Financial Markets

- Speculators have access to correlated and uncorrelated information
- Absent strategic interactions, relative weight is the ratio of precisions
- In equilibrium, the following strategic interactions emerge:
  - Strategic substitutes due to traditional price mechanism
    - Reduce weight on correlated information
  - Strategic complementarities due to feedback effect
    - Increase weight on correlated information: **frenzies**

Trading Frenzies and Investment Efficiency

- Frenzies might disrupt investment efficiency by generating too much weight on noise in correlated information
- But, they may also promote efficiency by overcoming noise in trading process (liquidity trading)
- Interestingly, speculators' incentives in equilibrium are in conflict with what is desirable for investment efficiency
    - Their incentive to put weight on correlated information is high (low) when coordination is undesirable (desirable)

Model Setup

- A firm has access to an investment technology that needs to be financed by a capital provider

- A financial asset whose payoff is tied to the technology's cash flow is traded in the financial market

- Timeline

  - $t = 0$: Speculators trade and the asset is priced

  - $t = 1$: Capital provider decides how much capital to provide

  - $t = 2$: Cash flow is realized; all agents receive their payoffs

Capital Provider's Problem

- The payoff from the investment is $\tilde{F}I$, where I is the amount of investment financed by the capital provider, and $\tilde{F} \geq 0$ is the level of productivity
- Capital provider must incur a cost $c(I)=\frac{1}{2}cI^2$ when investing I, and then receive a fraction β of the payoff
- Conditional on his information set, his maximization problem is:

$$I = \arg\max_{I} E[\beta\tilde{F}I - C(I)|\mathcal{F}_I].$$

- Leading to the solution:

$$I = \frac{\beta E[\tilde{F}|\mathcal{F}_I]}{c}.$$

Speculators' Problem

- A continuum of risk neutral speculators indexed by $i \in [0,1]$ trade a security, whose payoff is the cash flow from the investment $(1-\beta)\tilde{F}I$
- Speculator i can buy or short up to a unit of the asset: $x(i) \in [-1,1]$
- Based on information set, he solves the following maximization problem:

$$\max_{x(i)\in[-1,1]} x(i)E[(1-\beta)\tilde{F}I - P|\mathcal{F}_i]$$

  - P is the endogenous price of the security in the financial market (unknown to speculators when submitting trades, as in Kyle)

- Because of risk neutrality and being small speculators trade -1 or 1

Information Structure

- Prior: $\tilde{f} = ln(\tilde{F})$ is normal with mean $\bar{f}$ and variance $\sigma_f^2 \equiv 1/\tau_f$
  - Log-normal distribution is key for linear closed-form solution
- Each speculator observes two signals:
  - Private signal: $s_i = \tilde{f} + \sigma_s \widetilde{\epsilon_i}$. $\widetilde{\epsilon_i}$ is standard normal. Precision: τ_s
  - Common signal: $s_c = \tilde{f} + \sigma_c \widetilde{\epsilon_c}$. $\widetilde{\epsilon_c}$ is standard normal. Precision: τ_c
- Capital provider observes a private signal: $s_l = \tilde{f} + \sigma_l \widetilde{\epsilon_l}$. $\widetilde{\epsilon_l}$ is standard normal. Precision: τ_l. Capital provider also observes the price P

Market Clearing

- Market price is set so that demand from informed speculators equals noisy supply of the risky asset, given (for tractability) by:

$$Q(\xi, P) = 1 - 2\Phi(\tilde{\xi} - \alpha \ln P),$$

  - Where $\tilde{\xi} \sim N(0, \sigma_\xi^2)$ is a noise shock and $\sigma_\xi^2 \equiv 1/\tau_\xi$
  - Φ is the cumulative standard normal distribution function

- Noisy supply depends on the price (as otherwise price is not pinned down in equilibrium) and the parameter α stands for the liquidity of the market

Equilibrium

- A linear monotone equilibrium is an equilibrium where speculators buy one unit when a linear combination of their signal is above a threshold, and sell one unit otherwise; i.e., they buy if and only if:

$$\tilde{s}_i + k\tilde{s}_c \geq g$$

- The constants k and g are determined in equilibrium which is pinned down by the "guess and verify" approach

- The value of k is key to the equilibrium:

    - It is the extent to which speculators coordinate and act like each other

Information Content of the Price

- After some algebra, we can write down the endogenous price signal as:

$$z(P) \equiv \frac{g + \alpha\sigma_s \ln P}{1+k} = \tilde{f} + \frac{k}{1+k}\sigma_c\tilde{\epsilon}_c + \frac{1}{1+k}\sigma_s\tilde{\xi}$$
$$= \left(\frac{1}{1+k}\right)\tilde{f} + \frac{k}{1+k}\tilde{s}_c + \frac{1}{1+k}\sigma_s\tilde{\xi}.$$

- Its precision in predicting the fundamental $\tilde{f}$ is:

$$\tau_p = 1/\sigma_p^2 = \frac{(1+k)^2\tau_c\tau_\xi\tau_s}{k^2\tau_\xi\tau_s + \tau_c}.$$

- There are two sources of noise in the price: The noise in the common signal $\tilde{\epsilon}_c$ and the noisy demand $\tilde{\xi}$. k determines the weights on these two

Model Solution

- Solve for capital provider's decision, given information in the price and own private signal
- Solve for a speculator's trading strategy based on his information and given expected capital provider's decision and expected price
- Solve for parameters in price function with a lot of algebra…
- The result is that for high level of liquidity α, there exists a monotone linear equilibrium with $k^* > 0$. This equilibrium is unique when the precision of the prior τ_f is sufficiently small

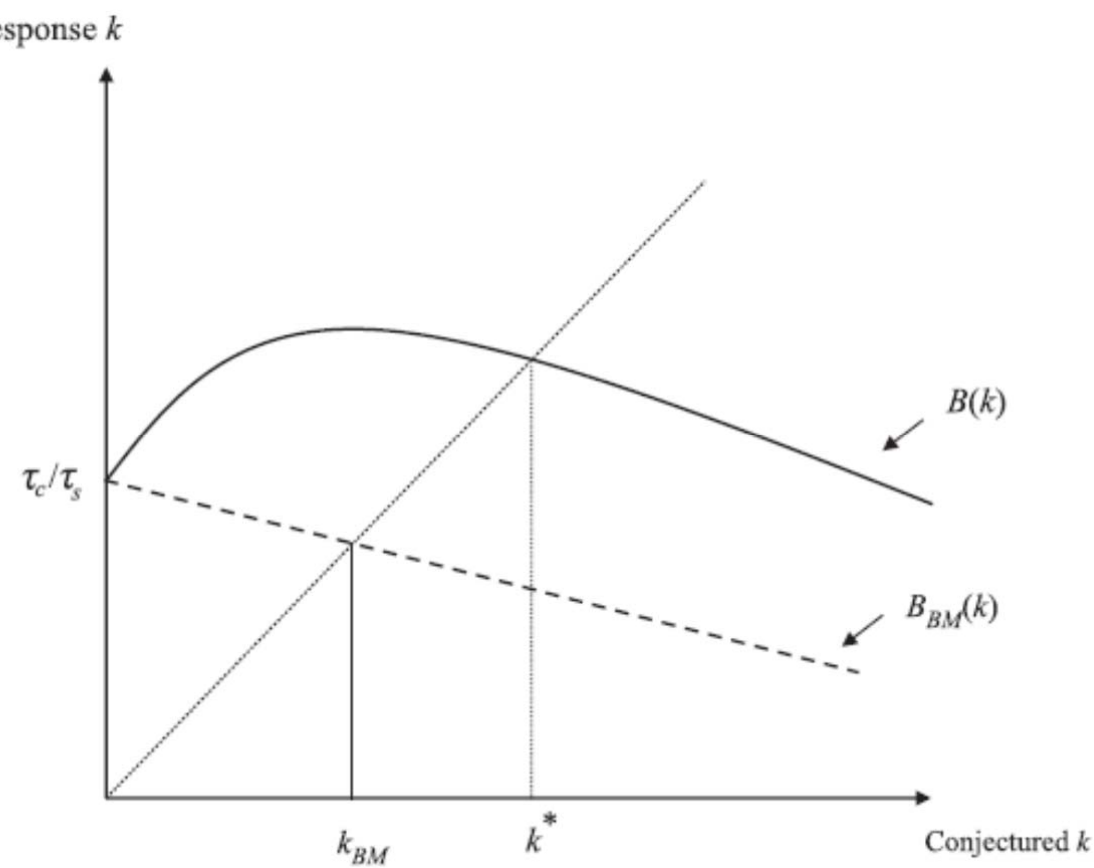
Strategic Substitutes and Complementarities

- Recall that speculator solves:

$$\max_{x(i)\in[-1,1]} x(i)E[(1-\beta)\tilde{F}I-P|\mathcal{F}_i]$$

- Strategic substitutes: price mechanism
  - When speculators put weight on common signal, it is strongly reflected in the price, and the incentive to put weight on it decreases
- Strategic complementarities: feedback effect
  - When speculators put weight on common signal, it is strongly reflected in cash flow, and the incentive to put weight on it increases

- The equilibrium k^* reflects both forces on top of the precisions of both signals:
  - Without strategic interactions, $k = \tau_c/\tau_s$; ratio of precisions
  - In a benchmark model without feedback, $k = k_{BM} < \tau_c/\tau_s$
  - In our model with feedback, when the market is sufficiently liquid (high level of α), $k = k^* > \tau_c/\tau_s$
- Overall, tendency for frenzy (trading based on common signal) increases when the market is more liquid, as there is less price impact and strategic substitute is weakened



Best response k
$B(k)$
τ_c/τ_s
$B_{BM}(k)$
k_{BM}
k^*
Conjectured k

Impact of Information Structure and Noise Trading

- As expected, k^* increases when
  - The capital provider's signal or the speculators' private signals are less precise
  - The speculators' common signal is more precise
- k^* decreases when there is more noise trading (higher σ_ξ^2)
  - In this case, capital provider relies less on the price, and so feedback effect weakens and there is less coordination among speculators

Efficient Level of Coordination

- Denote the optimal level of coordination by k_{OP}, and choose it to maximize expected value of investment:

- The optimal level of coordination is $k_{OP} = \tau_c / \tau_s \tau_\xi$, which maximizes τ_p:the information in the price about the fundamental

- Price is a signal affected by noise in common signal and noise trading:

$$z(P) \equiv \frac{g + \alpha\sigma_s \ln P}{1+k} = \tilde{f} + \frac{k}{1+k}\sigma_c\tilde{\epsilon}_c + \frac{1}{1+k}\sigma_s\tilde{\xi}$$
$$= \left(\frac{1}{1+k}\right)\tilde{f} + \frac{k}{1+k}\tilde{s}_c + \frac{1}{1+k}\sigma_s\tilde{\xi}.$$

- Coordination increases the effect of noise in the common signal and decreases the effect of noise trading

- Optimal coordination is high when noise in common signal is less harmful (τ_c is high) and when noise trading is more harmful (τ_ξ or τ_s are low)
  - Speculators coordinate when noise trading is less volatile because then there is a strong feedback effect
  - But their coordination is desirable when noise trading is more volatile, because this is when coordinated informed trading is needed to guide investments

Feedback and Information Production: Dow, Goldstein, and Guembel (JEEA, 2017)

- Speculators choose whether to become informed in a model where prices affect real investment due to the feedback effect

- If investment is not undertaken, information about the investment loses its speculative value

  - Speculators are more likely to produce information when investment is more likely to be undertaken

- New amplification mechanism: High productivity → More information (because investment is more likely to be undertaken) → Higher productivity (because of higher informativeness)

- Amplification is strengthened by endogenous strategic complementarities in information production (that originate from feedback)

  - When investments are ex-ante not very profitable, they will not be undertaken without information in prices

  - More information increases likelihood that investment will be undertaken, increasing the incentive to produce information

- Realized productivity as a function of initial shock (dashed line: exogenous information; solid line: endogenous information):