Information in Financial Markets and Its Real Effects

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Information in Prices

- A basic premise in financial economics: market prices are very informative about assets fundamentals
- This line of thinking goes back to **Hayek (1945)**
  - He argued that prices are key sources of information for guiding production and allocation decisions
  - Prices aggregate information from many different traders, providing information that would be hard to generate otherwise
  - While Hayek was referring to prices of all goods and services in the economy, the argument applies to financial-market prices

The Feedback Effect

- Given the information content in market prices, it is natural to expect that decision makers in the real side of the economy will make use of this information in their decisions

- **What prices** may be useful?

  - Stock prices, futures prices, bond prices; depending on the context

- **Who can learn** from prices?

  - Managers, creditors, regulators, customers, employees, etc.

  - As long as there is *some* information in the price they don't know

- Rich empirical literature focuses on managers as key decision makers

Implications for Theory

- **Bond, Edmans, and Goldstein (2012)** highlight two implications:
  - Incorporating the feedback effect into models of trading in financial markets fundamentally changes predictions on price formation in financial markets and helps understanding some observed phenomena
  - Different notions of efficiency which might be in conflict
    - Forecasting Price Efficiency (FPE), or **Market Efficiency**
    - Revelatory Price Efficiency (RPE), or **Real Efficiency**
    - Former is often emphasized, but latter really matters
  - I will now review an example for each implication

Feedback Models Helping to Explain Market Phenomena: Trading Frenzies

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**

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:

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

- Leading to the solution:

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

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

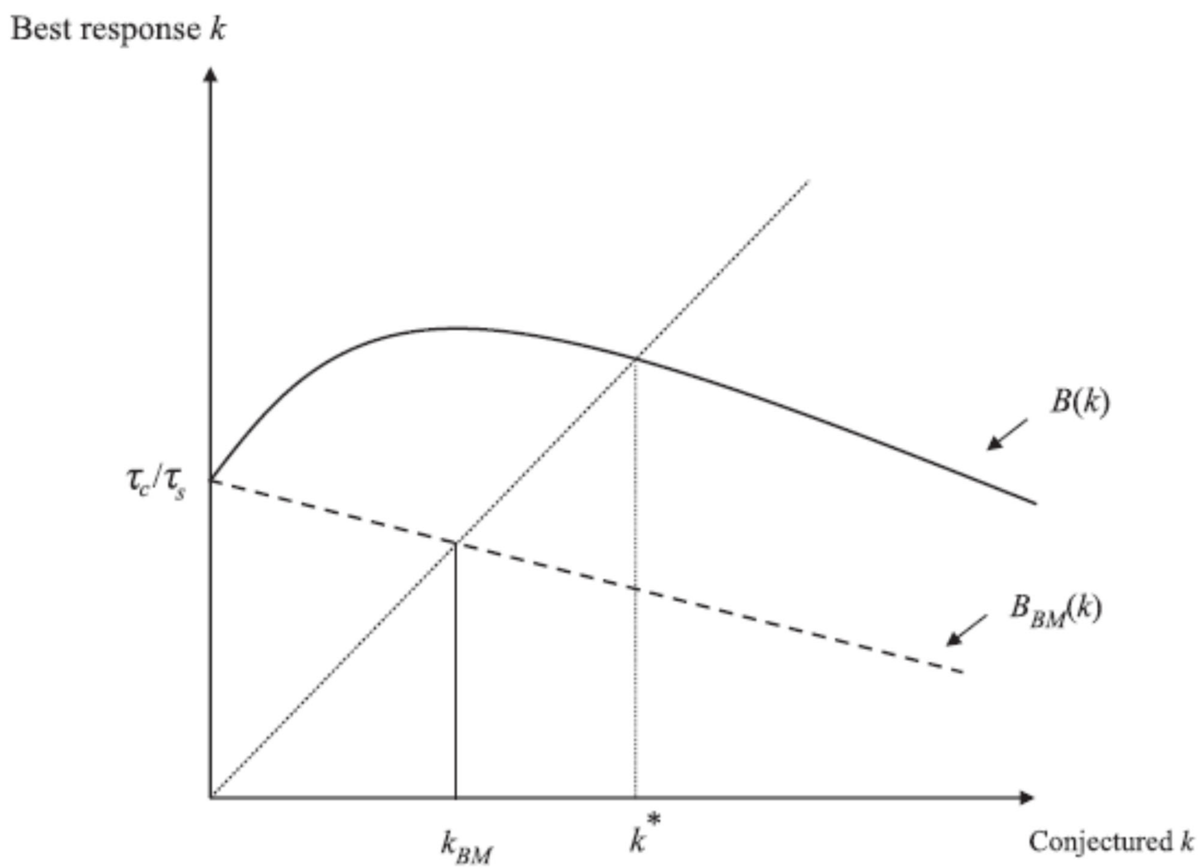
Strategic Substitutes and Complementarities

- 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
τ_c/τ_s
$B(k)$
$B_{BM}(k)$
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

Relation to Recent Events

- Such frenzies rattled financial markets recently, generating calls for big changes in market regulation due to market volatility
- Maybe more interesting are the effects such frenzies might have on **capital allocation** in the real economy
- Recent events demonstrated the fast feedback effects frenzies might have on capital allocation:
  - **AMC** and later **GameStop** actively raised new capital based on attractive prices

  - This was critical for AMC's survival enabling it to avoid bankruptcy
  - **American Airlines** had a similar, perhaps less dramatic, experience
- **Information structure** is key for the emergence of frenzies:
  - "A large volume of activity in such [internet] forums could suggest that speculators have more common information than private information and so trading frenzies become more likely to occur"
- **Feedback effects** are also key:
  - Feedback effects provide fuel to trading frenzies, pushing prices further away from fundamentals with damaging real effects

Real Efficiency vs. Market Efficiency: Different Types of Information

Implications for Disclosure

- Literature in accounting and finance studies the implications of disclosure of public information (See recent survey by Goldstein and Yang (*ARFE*, 2017))
  - Disclosure can improve **liquidity** and **market efficiency**
  - But, it can **crowd out** private information, which might generate the opposite effect
  - Ultimately, one should care about real efficiency
  - For this, it is important to consider the interaction between disclosure and feedback effects

Good Disclosure, Bad Disclosure: Goldstein and Yang (*JFE*, 2019)

- The paper studies the real-efficiency implications of public disclosure in a model with feedback effect

- The model differentiates between **different types of information** and shows that implications can be different depending on what is being disclosed, how precise the disclosure is, how efficient the market is, etc.
- Note earlier work exploring the relation between feedback and disclosure, e.g., Gao and Liang (*JAR*, 2013) and Bond and Goldstein (*JF*, 2015)

Model Setup (slightly adjusted)

- A firm has access to an investment technology that needs to be financed by capital providers
- A financial asset whose payoff is tied to the technology's cash flow is traded in the financial market by speculators
- Agents (speculators, capital providers) have access to two types of information: Private information and public disclosure
- Timeline
    - t = 0: Speculators trade and the asset is priced
    - t = 1: Capital providers decide how much capital to provide
    - t = 2: Cash flow is realized; all agents receive their payoffs

Technology and Investment

- The payoff from the investment is $\tilde{A}\tilde{F}k_j$, where k_j is the amount of investment financed by a capital provider; $\tilde{A} \geq 0$ and $\tilde{F} \geq 0$ are mutually independent shocks
- Capital provider must incur a cost $c(k_j)=\frac{1}{2}c{k_j}^2$ when investing, and then receive a fraction β of the payoff
- Prior distributions:
  - $\tilde{f} = ln(\tilde{F})$ is normal with mean 0 and variance $\sigma_f^2 \equiv 1/\tau_f$
  - $\tilde{a} = ln(\tilde{A})$ is normal with mean 0 and variance $\sigma_a^2 \equiv 1/\tau_a$

Financial Market

- A continuum of risk neutral speculators indexed by $i \in [0,1]$ trade a security, whose payoff is cash flow from the investment $(1-\beta)\int \tilde{A}\tilde{F}k_j$
- Speculator i can buy or short up to a unit of the asset: $d(i) \in [-1,1]$
- Noisy supply in the financial market with underlying normally-distributed shock $\tilde{\xi}$ with precision τ_ξ
- Price P is set by market clearing condition, so that speculators' demand is equal to noisy supply:
  - Speculators do not condition on price, but noise is sensitive to price

Information

- Speculators observe private noisy signals about fundamental shocks:
  - $\tilde{x}_i = \tilde{a} + \tilde{\varepsilon}_{x,i}$, where $\tilde{\varepsilon}_{x,i}$ is normally distributed with precision: τ_x
  - $\tilde{y}_i = \tilde{f} + \tilde{\varepsilon}_{y,i}$, where $\tilde{\varepsilon}_{y,i}$ is normally distributed with precision: τ_y
- Capital providers know $\tilde{a}$; they want to learn $\tilde{f}$
  - They partly rely on the information in the price *P*
- Public disclosure about shocks available to all: $\tilde{\omega} = \mu_a \tilde{a} + \mu_f \tilde{f} + \tilde{\varepsilon}_\omega$
  - $\tilde{\varepsilon}_\omega$ is normally distributed with precision τ_ω

Trading Equilibrium

- A linear monotone 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:

$$\tilde{x}_i + \phi_y \tilde{y}_i + \phi_\omega \widetilde{\omega} > g$$

  - The constants ϕ_y, ϕ_ω, and g are determined in equilibrium which is pinned down by the "guess and verify" approach
  - The value of ϕ_y is key to the equilibrium: It is the extent to which speculators put weight on what capital providers want to learn

Disclosure and Real Efficiency

- How does quality of disclosure τ_ω affect the real efficiency
  - Real efficiency is defined as the expected surplus from real investment: $RE = E\left[\int \tilde{A}\tilde{F}k_j - C(k_j)\right]$

- Real efficiency boils down to the quality of information available to capital providers about $\tilde{f}$:
  - $RE \propto \frac{1}{Var\left(\tilde{f}\middle|\tilde{a},\tilde{P},\tilde{\omega}\right)}$.

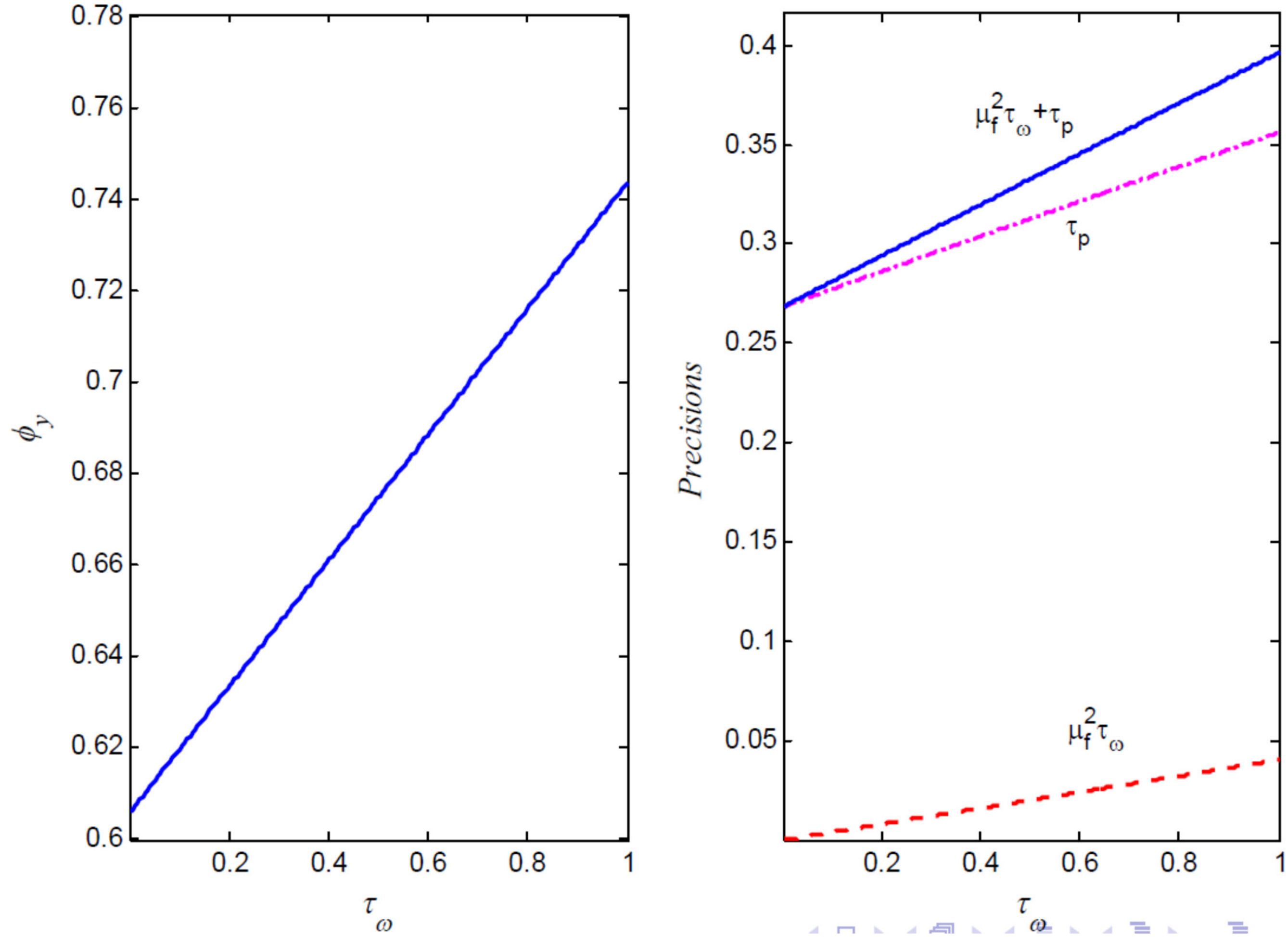
Direct and Indirect Effect of Disclosure

- **Direct effect:** More disclosure entails higher precision of information about $\tilde{f}$

- **Indirect effect:** More disclosure changes the precision of the price signal about $\tilde{f}$, denoted as τ_p
  - Precision of the price signal about $\tilde{f}$ is determined by ϕ_y, which is the weight speculators put on their signal about $\tilde{f}$ when they trade
  - This effect can be positive or negative

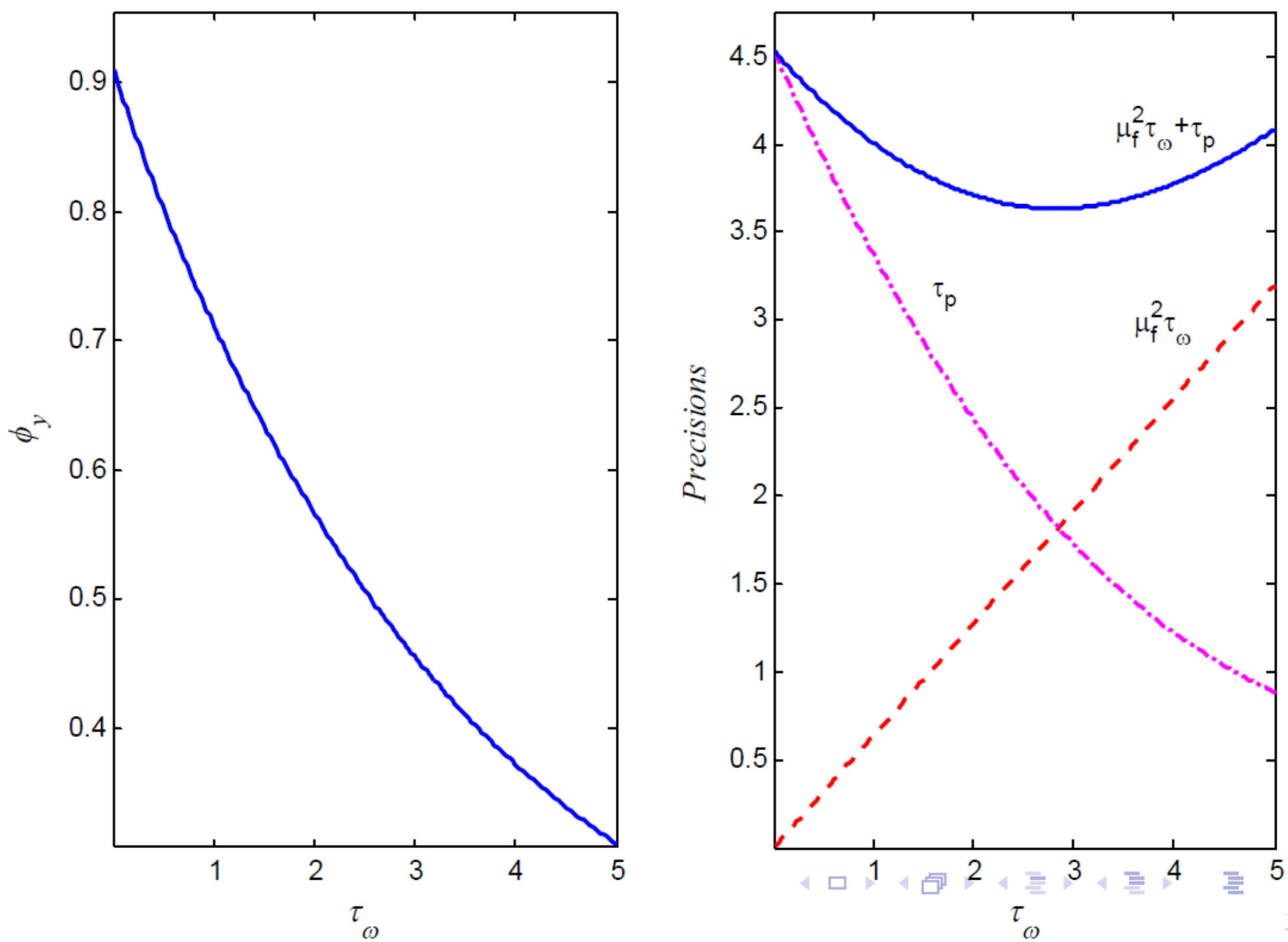
Public Signal is Mostly about *A*

- Indirect effect is positive:
  - When public signal provides more precise information about $\tilde{a}$, speculators put more weight on their information about $\tilde{f}$
  - Price provides more precise signal about $\tilde{f}$
  - This is amplified via feedback effect; real value is affected more by $\tilde{f}$, encouraging speculators to put even more weight on this signal
- Both direct and indirect effects are positive; disclosure clearly improves real efficiency (see picture on next slide)


0.78
0.76
0.74
0.72
0.7
0.68
0.66
0.64
0.62
0.6
ϕ_y
0.2
0.4
0.6
0.8
1
τ_ω
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
Precisions
$\mu_f^2\tau_\omega+\tau_p$
τ_p
$\mu_f^2\tau_\omega$
0.2
0.4
0.6
0.8
1
τ_ω

Public Signal is Mostly about *F*

- Indirect effect is negative:
  - When public signal provides more precise information about $\tilde{f}$, speculators put less weight on their information about $\tilde{f}$
  - Price provides less precise signal about $\tilde{f}$
  - This is amplified via feedback effect
- Direct and indirect effects are opposite
- Indirect effect dominates when market is efficient; high τ_{ξ} (see picture)


0.9
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Precisions
$\mu_f^2\tau_\omega+\tau_p$
τ_p
$\mu_f^2\tau_\omega$
1
2
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4
5
τ_ω

Some Implications

- It is important to pay attention to **multiple dimensions of information** and consider **what disclosure is about** when evaluating its desirability
- There is a clear **benefit in providing public information about what decision makers already know**, as it pushes the market to focus on the information that decision makers care to learn
- **Providing public information about something decision makers wish to learn might backfire** when the market works efficiently and the public disclosure is not super precise

Example

- Capital providers finance a firm's investment in a new line of products
  - They have information about the **quality of the technology** and the products (easy to verify from the firm), but not about the **competition the firm faces with other firms**
  - Information about the competitive landscape can be aggregated by financial markets (this information tends to benefit from aggregation)
  - Public disclosure emerges from credit rating agencies or mandatory disclosure requirements from firms

- Having public disclosure focused on the quality of technology and products is always beneficial
- However, providing public disclosure on competition with other firms might not be desirable if the market is efficient and the public disclosure is of low precision (likely when aggregation is beneficial)

- Result provides rationale for accounting metrics that are based on **backward looking information** and not **forward looking assessments**

- Note difference between cases where information is disclosed by a third party (discussed in the model) and where it is disclosed by the decision maker (no direct effect)

Conclusion

- Understanding the real effects of information in financial markets, and the feedback loop that results from it, is important for several reasons:
  - Obtain new insights on the price formation process to understand **observed market phenomena**
  - Connect financial-markets research with corporate-finance research for more **unified frameworks** in our field
  - Analyze the implications of the current **information revolution** for financial markets and the real economy