

Information Diffusion and Speed Competition

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Motivation

- ❖ Publicly available information: **diffusing gradually**
 - ✓ **heterogeneous** and **partial** information initially; varying locations and industry- or product-specific knowledge; firm complexity;
 - ✓ trading; increasing corporate diversification and globalization
- ❖ [**Fast Information**] Increasing **disclosure** requirements (*Sarbanes-Oxley Act (2002) and Dodd-Frank Act (2010)*)
- ❖ [**Fast trading**] The rise of **technology investment** on computer hardware, algorithms and connection to exchange servers
- ❖ How **information diffusion** and **speed competition** **jointly** affects **market quality**?

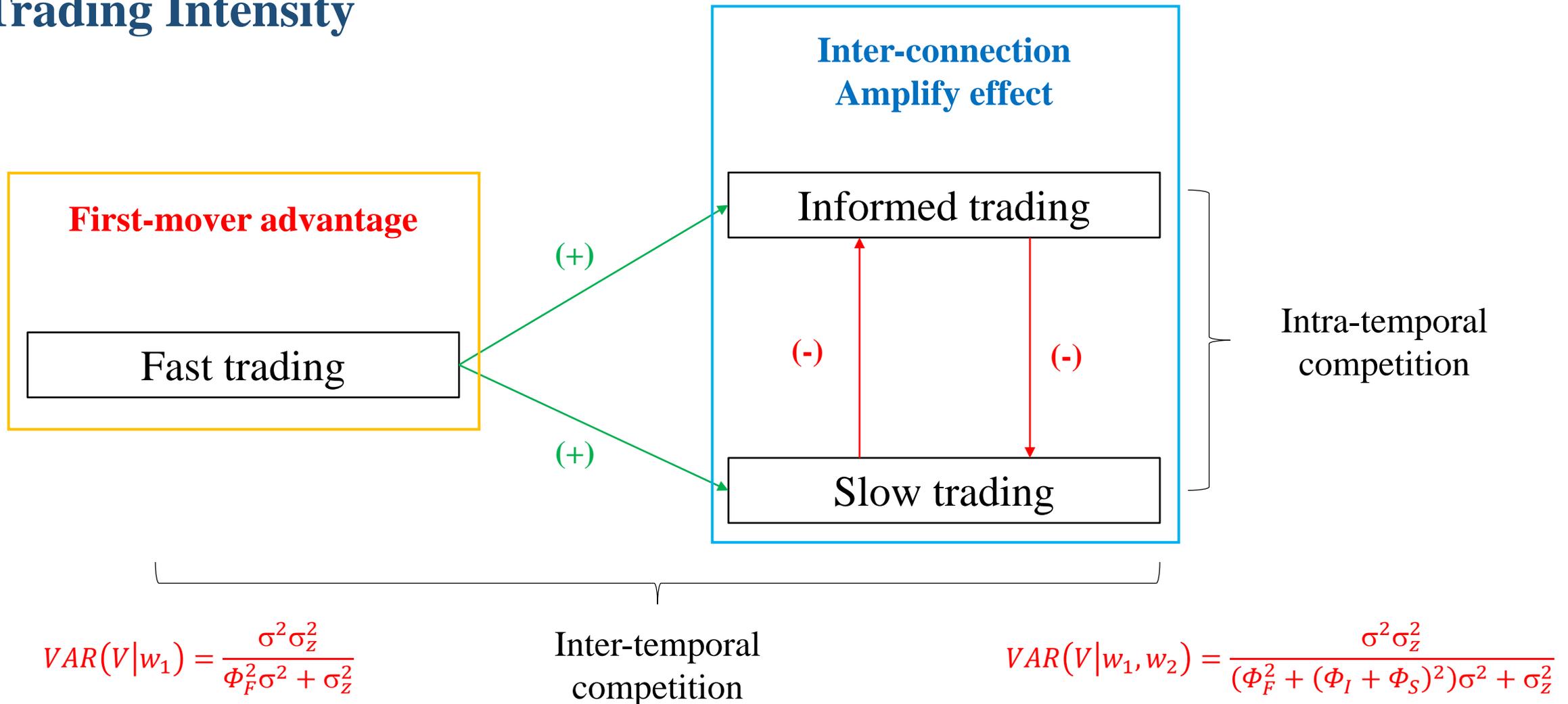
Trade-off

	Speed Hierarchies	Information Diffusion
Impact	<i>"First-mover advantage"</i>	Great information transparency
Weakening effect (+)	<p>Early period equilibrium price aggregates fast trader's information:</p> <p>information uncertainty for slow traders (-)</p> <p>adverse selection risk for market makers (-)</p>	<p>More public information:</p> <p>both fast and slow (partial) informed trader become more informative (+)</p>
Crowding-out effect (-)	<p>information rent for informed trader (-)</p>	<p>first-mover advantage for fast trader (-)</p> <p>information rent for informed trader (-)</p>
Our study (Interaction)	<p>The joint impact of fast information diffusion and trading speed competition on <i>information production</i>, <i>speed acquisition</i> and <i>market quality</i>.</p>	

Goal: Understanding the Information Transparency in HFT World

- ❖ **This paper**: introducing **partial and heterogeneous** information structure and **trading speed hierarchies** in an otherwise standard Kyle (1985) model
- ❖ **Goal**: joint impact of **fast information diffusion** and **trading speed competition**
 - ✓ Interactions between informed and fast trading?
 - ✓ Impacts on market microstructure and quality?
- ❖ **Main Message**: greater information transparency and trading speed competition can **improve market quality**, though there is a **significant crowding-out effect**
- ❖ **Mechanism**: **strategic complementarities** in information trading and fast trading, together with the **learning** of slow traders

Trading Intensity



❖ With **exogenous fraction** of informed and fast trader, faster information diffusion **improves market quality**.

Endogenous Trading---Strategic Substitute and Complement

- ❖ Both producing information and acquiring speed are **strategic substitute** (competition effect; Grossman and Stiglitz, 1980)---more informed/fast trading makes information/speed less valuable.
- ❖ Acquiring speed is a **complement** to producing information
 - Lowing the **cost of producing information** **increases** the fraction of **informed traders**, which then **increases** the fraction of **fast traders**
- ❖ Producing information can be either **complement** or **substitute** to acquiring speed
 - Lowing the **cost of being fast** **increases** the fraction of **fast traders**, which could either **increase** or **decrease** the fraction of **informed traders**

Endogenous Fractions with Faster Information Diffusion

- ❖ **[Informed trader]** with faster information diffusion, the equilibrium fraction of informed traders decreases, **dominated** by the **crowding-out effect**
 - ✓ Informed traders **loss information advantage** and expect lower trading gains;
 - ✓ Faster information diffusion also **crowds out fast trading**, generating different impact on the equilibrium fraction of informed traders (depends on whether producing information is **complement** or **substitute** to acquiring the speed).
- ❖ **[Fast trader]** the crowding-out effect of speed acquisition is **amplified** by informed trading, reducing the fraction of fast traders:
 - ✓ acquiring speed is **complement** to producing information, as more traders become informed, the value of speed increases.

Key Results (Market Quality; Surprisingly!!!)

- ❖ *Without speed hierarchies, faster information diffusion*
 - ✓ Constant information cost: **impeding** market quality due to crowds-out effect;
- ❖ *With speed hierarchies, even there is the **significant crowding-out effect**, market quality for both periods are improved*
 - ✓ not solely based on the population of informed and fast traders
 - ✓ but more importantly depend on
 - a) information **“leakage”** to **slow traders** via fast trading;
 - b) how **informed trading reacts** to more aggressive fast trading;
 - c) how **aggressively fast traders** trade

Outline

- *Related Literature*
- *A Model of Information Diffusion and Speed Competition*
- *Trading Intensities*
- *Equilibrium Information Production and Speed Acquisition*
- *Implication of Faster Information Diffusion*
- *Conclusion*

Related Literature---*Endogenous Information Production*

- Extension of Grossman and Stiglitz (1980):
 - ✓ *Dynamic trading*: Mendelson and Tunca (2004), Avdis (2016);
 - ✓ *Condition information acquisition decision on public signal* : Foster and Viswanathan (1993);
 - ✓ *Pre-commit to receiving signals* : Back and Pedersen (1998), Holden and Subrahmanyam,(2002);
- **Our distinguishing feature**: (partially informed) speculators can **endogenously acquire faster trading speed**, which captures fast trading speed competition:
 - ✓ *Huang and Yueshen* (2018) separate speed from information and show that speed leads to potential dysfunction of price discovery (**without considering the information transparency**).
- The **information diffusion** among **partially informed traders**, together with the **first-mover advantage** based on the partial information, provides a **nature way** for traders to trade fast and to compete for fast trading.

Related Literature---*Strategic Trading*

- Apart from the **standard substitution effect** in Grossman and Stiglitz (1980), a growing literature focusing on different channels of **strategic complementarity**:
 - ✓ *Advis (2016)*---in the presence of persistent noise trading, learning more about fundamentals makes the price more informative about noise;
 - ✓ *Goldstein and Yang (2015)*---different traders are informed of different fundamentals that affect the security value.
- Due to information diffusion and speed competition, **the nature of complementarity and the underlying mechanism are very different**
 - ✓ With information diffusion among partially informed traders, increasing in informed trading intensifies the competition in late period and increases the first-mover advantage, resulting in **more fast trading**.
 - ✓ In addition, more aggressive fast trading reduces the relative trading sensitivity of slow traders and **increases traders' incentive to become informed**.

Related Literature---*Information Transparency*

- Growing literature on **public information** and implications of **information transparency** (Verrecchia, 2001; Bond, Edmans and Goldstein, 2012 and Goldstein and Yang, 2017):
 - ✓ *including the cost of capital* (Hughes, Liu and Liu, 2007);
 - ✓ *informative prices about fundamentals* (Banerjee, Davis and Gondhi, 2017);
 - ✓ *endogenous liquidity trading* (Han, Tang and Yang, 2016);
 - ✓ *inefficient coordination on public information* (Morris and Shin, 2002);
 - ✓ *learning of manager or regulator* (Goldstein and Yang, 2017).
- We provide a framework to study the effect of information transparency under a **new market environment** where the computerization of securities trading has become the “norm”

Related Literature---*High Frequency Trading*

- Contributing to HFT literature (Menkveld, 2016):
 - ❖ 1. **What information does HFT trade on?**
 - ✓ *Hu, Pan and Wang (2017). Van Kerveland and Menkveld (2017)*
 - ❖ 2. **How does HFT incorporate information?**
 - ✓ *O'Hara, Yao and Ye (2014), Brogaard, Hendershott and Riordan (2017).*
 - ❖ 3. **What is the impact of HFT on market quality?**
 - ✓ *Budish, Cramton and Shim (2015), Yang and Zhu (2016) and Weller (2016).*
- Highlight the **effect of increasing information transparency on market quality** explored in the literature can be changed under the “new environment”
- Provide a new **strategic complementarity** mechanism

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Information Diffusion

- Publicly available information: **diffusing gradually** among investors
 - ✓ **heterogeneous** and **partial information**
 - ✓ amount of information increases with time
- It is not simply that all investor receives full information promptly; rather, the initial piece of information received from diffusion process is **distinct** and **scattered**
 - ✓ varying locations and industry-specific or product-specific knowledge
 - ✓ increasing corporate diversification and globalization
- When information **transparency improves**, it is easier for investor to interpret public information; therefore, in aggregate level, information **diffuses faster** among traders

Information Diffusion

➤ **Heterogeneous and Partial Information**---*Hong and Stein (1999)*:

- ✓ The fundamental value information V is decomposed into n independent sub-innovations with the same variance:

$$V = \sum_{i=1}^n v_i, \quad v_i \text{ iid}, \quad v_i \sim N(0, \sigma^2/n)$$

- ✓ Each trader randomly receives the information about **one of the sub-innovation**

➤ Each investor receives *partial* and *heterogeneous* but the *same amount* of information

- Providing a consistent allocation scheme for comparing aggregate results when information diffuses faster.

Information Diffusion: **Example**

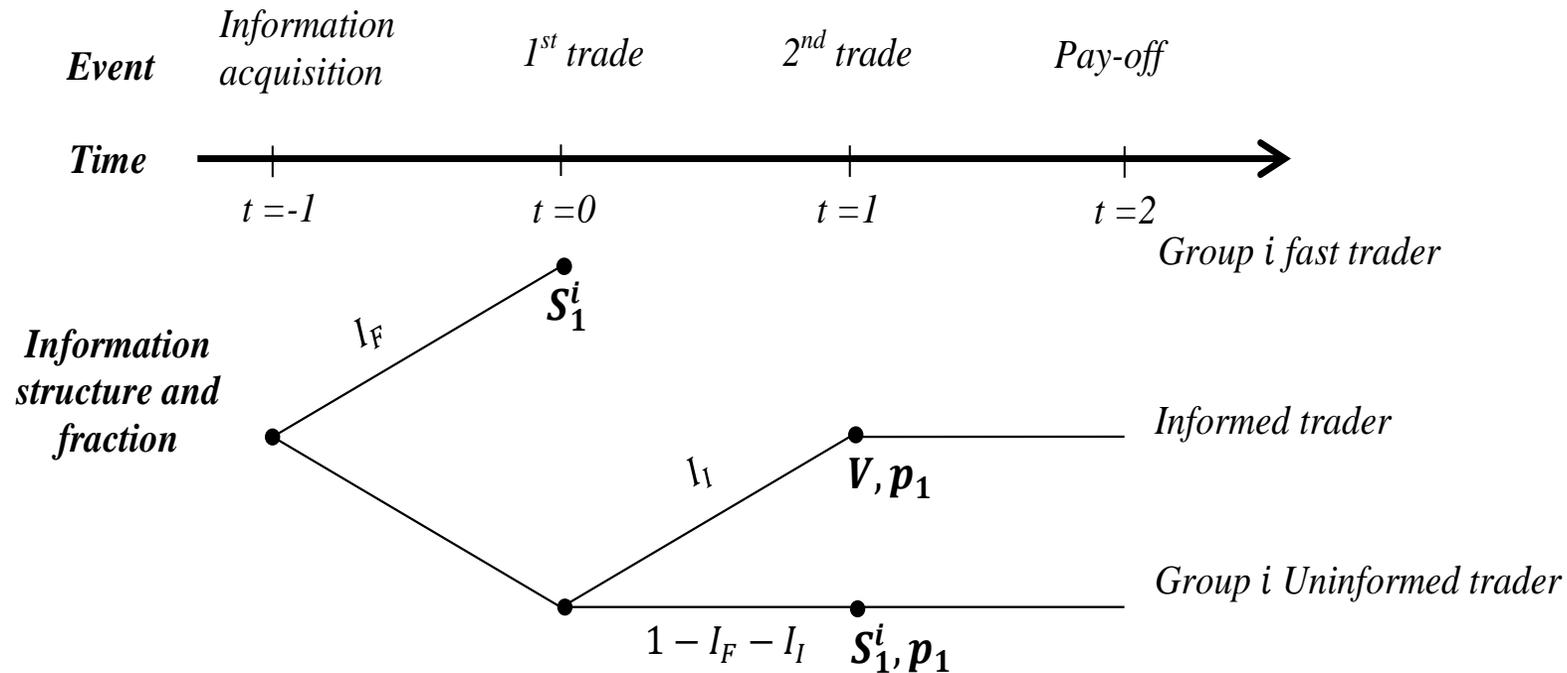
Firm's fundamental is related to corporate acquisitions, Federal Reserve policy, patent filings and marketing policy, denoted these as $\{A, B, C, D\}$:

- ❖ Suppose **$n=4$** , one-fourth of the investors observe $\{A\}, \{B\}, \{C\}, \{D\}$
 - ✓ researching the unfamiliar information is infeasible at initial point and takes time effort

- ❖ Suppose **$n=2$** , one-half of the investors observe $\{A, B\}, \{C, D\}$
 - ✓ information becomes more transparency now, investor is easier to interpret unfamiliar information

Speed Competition

- ✓ **F: fast (informed) traders**---who receive the partial information and trade at period-one
- ✓ **S: slow informed traders**---who receive the partial information and trade at period-two
- ✓ **I: informed traders**---who receive the full information and trade at period-two



Exogenous Equilibrium: Definition

- Given the fractions of the fast and informed traders I_F and I_I , respectively, a **perfect Bayesian equilibrium** is defined by traders' strategy profile and market makers' pricing rules $\{X_F(v_i), X_I(V, p_1), X_S(v_i, p_1), P_1(w_1), P_2(p_1, w_2)\}$ that satisfy the following conditions,

❖ **Profit maximization:**

$$\begin{aligned} X_F^*(v_i) &= \operatorname{argmax}_{x_F} E[x_F(V - p_1)|v_i]; \\ X_I^*(V, p_1) &= \operatorname{argmax}_{x_I} E[x_I(V - p_2)|V, p_1]; \\ X_S^*(v_i, p_1) &= \operatorname{argmax}_{x_S} E[x_S(V - p_2)|v_i, p_1]. \end{aligned}$$

- ❖ **Market efficiency:** the price functions $P_1(w_1), P_2(p_1, w_2)$ are determined by the rules that the market maker cleans the security market in each period for an expected zero profit;

$$\begin{aligned} E[w_2(p_2 - V)|p_1, w_2] &= 0; \\ E[w_1(p_1 - V) + w_2(p_2 - V)|w_1] &= 0. \end{aligned}$$

- ❖ All the traders have **rational expectations** in that each trader's belief about the others' strategies is correct in the equilibrium.

Linear Equilibrium

- Up on receiving the *aggregate order flow* w_t at time $t = 0, 1$, the market maker cleans the market at the *price* of

$$p_1 = \lambda_1 w_1, \quad p_2 = p_1 + \lambda_2 w_2$$

- The *strategy functions* of speculator i

$$x_F(v_i) = \beta_F v_i; \quad x_I(V, p_1) = \beta_I (V - p_1); \quad x_S(v_i, p_1) = \beta_S (v_i - p_1) + \gamma_S p_1$$

- **Equilibrium** For given $I_F > 0$ and $I_I > 0$, there exists a *unique linear Bayesian equilibrium* specified by above price and strategy functions. The coefficients $(\lambda_1, \lambda_2, \beta_F, \beta_I, \beta_S, \gamma_S)$ are given as the function of $(N, n, I_I, I_F, \sigma, \sigma_Z)$.

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Trading Intensity & Price Efficiency

- Due to **first-mover advantage**, fast trading is **not influenced** by informed and slow trading at late period:

$$\Phi_F = \frac{I_F N}{n} \frac{\partial}{\partial V} \left(\sum_{i=1}^n x_F(v_i) \right) = \frac{I_F N}{n} \beta_F = \sqrt{\frac{I_F N}{n} \frac{\sigma_Z}{\sigma}}$$

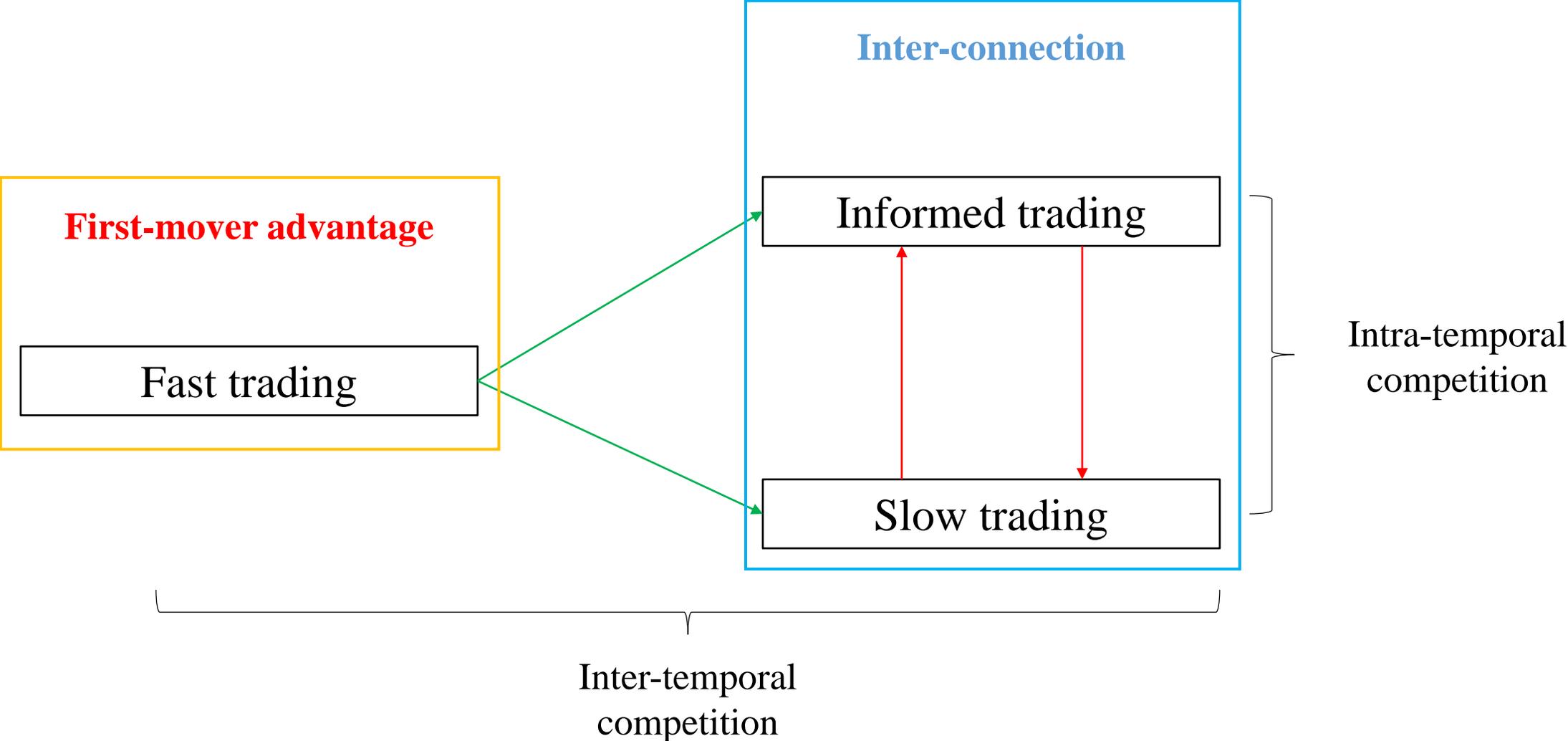
- The informed and slow trader's trading intensities are interconnected, due to **intra-temporal competition**, and are affected by fast trader's trading intensity, due to **inter-temporal competition**

$$\Phi_I = I_I N \frac{\partial x_I}{\partial V} = I_I N \beta_I; \quad \Phi_S = \frac{(1 - I_I - I_F) N}{n} \beta_S$$

- **Price efficiency** improves in trading intensities

$$\text{VAR}(V|w_1) = \frac{\sigma^2 \sigma_Z^2}{\Phi_F^2 \sigma^2 + \sigma_Z^2}; \quad \text{VAR}(V|w_1, w_2) = \frac{\sigma^2 \sigma_Z^2}{[(\Phi_F^2 + (\Phi_I + \Phi_S)^2)] \sigma^2 + \sigma_Z^2}$$

Trading Complementarity versus Substitutability



Trading Complementarity versus Substitutability

- Best response functions: jointly determine the trading intensities in the equilibrium:

$$\Phi_I = h_I(\Phi_S; \Phi_F, N, n, I_I, I_F, \sigma, \sigma_Z) \quad \Phi_S = h_S(\Phi_I; \Phi_F, N, n, I_I, I_F, \sigma, \sigma_Z)$$

- For informed traders:

$$\begin{aligned} \Phi_I &= \frac{I_I N}{2(I_I N + 1)} \frac{4\Phi_F^2 \sigma^2 + 4\sigma_Z^2 + \left(\Phi_S \sigma + \sqrt{(\Phi_S^2 + 4I_I N \Phi_F^2) \sigma^2 + 4I_I N \sigma_Z^2} \right)^2}{\Phi_S \sigma^2 + \sqrt{(\Phi_S^2 + 4I_I N \Phi_F^2) \sigma^4 + 4I_I N \sigma^2 \sigma_Z^2}} - \frac{I_I N}{I_I N + 1} \Phi_S \\ &= \Phi_{I,Direct}(\Phi_F, \Phi_S) - \Phi_{I,Indirect}(\Phi_F, \Phi_S) \end{aligned}$$

- ✓ **Direct effect**---an increase in fundamental value increases the expected revenue
- ✓ **Indirect effect**---“forecasting the forecasts of others”

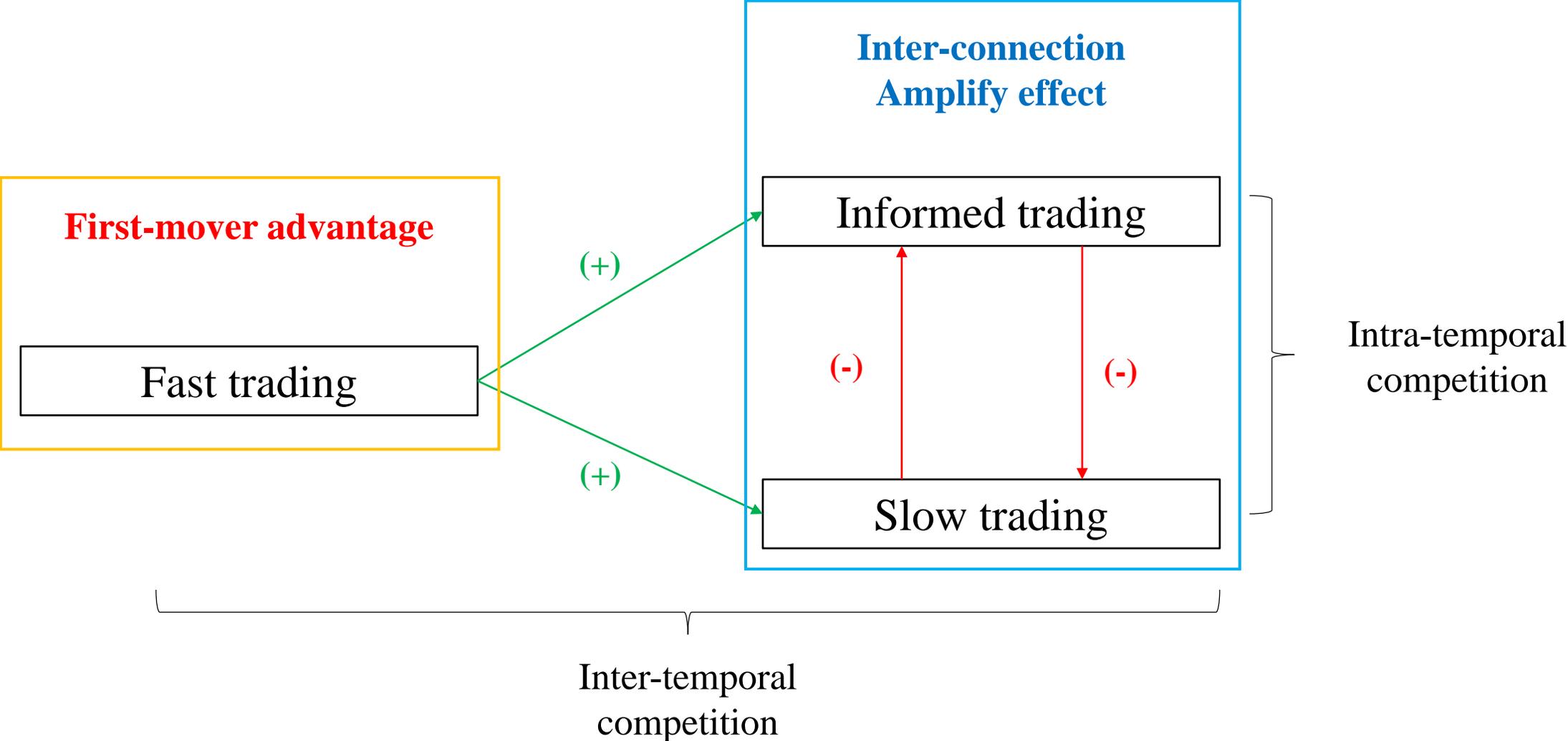
Trading **Complementarity** versus **Substitutability**

- More aggressive slow trading:

$$\frac{\partial \Phi_I(\Phi_F, \Phi_S)}{\partial \Phi_S} = \frac{\partial \Phi_{I,Direct}(\Phi_F, \Phi_S)}{\partial \Phi_S} - \frac{\partial \Phi_{I,Indirect}(\Phi_F, \Phi_S)}{\partial \Phi_S}$$

- ✓ **Asymmetry reduction effect**---reducing the market maker's adverse selection risk, which lowers price impact
 - ✓ **Competition effect**---reducing the pricing error, dominating the asymmetry reduction effect.
- Fast trading intensity: directly, similar as the asymmetry reduction effect; has no influence on the indirect effect.
 - *Informed traders' trading intensity is*
 - a *substitute to slow traders' trading intensity*;
 - a *complement to fast traders' trading intensity*.

Trading Complementarity versus Substitutability



Trading Intensity Multipliers

- The two trading intensity measures **reinforce each other** and the initial effect due to the change in the exogenous parameters is **amplified** in equilibrium
- The effect of the **increase in informed trading**

$$\frac{d\Phi_I}{dI_I} = \mathbf{M} \left(\frac{\partial h_I}{\partial I_I} + \frac{\partial h_I}{\partial \Phi_S} \frac{\partial h_S}{\partial I_I} \right)$$

- ✓ making informed trade more **aggressively** due to higher fraction
 - ✓ decreasing slow trading **intensifies** informed trading due to **substitution**
 - ✓ **amplified** by trading intensity multiplier
-
- *With either **more informed** or **more fast traders**, the **informed traders' trading intensity increases**, while **the slow traders' trading intensity decreases***

Implications of the Faster Information Diffusion

- Faster information diffusion reshapes the intra-temporal competition:
 - ✓ **Fast traders**, as a group, **trade more aggressively** due to receive more precise information;
- *Market quality*: Although, under some certain situation, the informed trader's trading intensity decreases with faster information diffusion, the period 2 market quality not only depends on informed trader but also fast and slow traders, whose trading intensities increase.
 - ✓ Netting these effects, the positive influence dominates the trade-off, leading to a **better market quality**.

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Characterization of the Equilibrium

- The traders can pay a fix cost to become the informed or fast if they can use it to **sufficiently increase** their expected payoff to **cover** the information and speed cost

- ✓ **Speed value:**

$$\Gamma_F(I_F, I_I^*, n) = \pi_F(I_F, I_I^*, n) - \pi_S(I_F, I_I^*, n)$$

- ✓ **Information value:**

$$\Gamma_I(I_F^*, I_S, n) = \pi_I(I_F^*, I_S, n) - \pi_S(I_F^*, I_S, n)$$

- *Suppose (I_F^*, I_I^*) is a market equilibrium, then:*
 - (a) *if $I_i^* > 0$ for some $i = F, I$, then $\Gamma_i = C_i$; and*
 - (b) *if $I_i^* = 0$ for some $i = F, I$, then $\Gamma_i \leq C_i$*

Complementarity and Substitutability

- *Acquiring speed is a **complement** to producing information*
 - ❖ More informed trading has no influence on fast trading due to the first-mover advantage
 - ❖ But intensify intra-temporal competition, affecting slow trading negatively, which increases the value of fast trading and hence more fast traders.

Complementarity and Substitutability

- Producing information can be either **substitute** or **complement** to acquiring speed
- The value of information decreases with more fast trader when

$$\min\{1 - I_F, \{I_I | G(I_I) = 0, I_I > 0\}\} < I_I < 1 - I_F.$$

- ❖ decreases the relative trading sensitivity of the slow traders (β_S/β_I)
 - ❖ reduces the information rent of the informed and hence informed traders
-
- Equilibrium fraction of informed traders can increase or decrease with higher speed cost depends on whether producing information is **substitute** or **complement** to acquiring speed

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Information Diffusion and **Speed Acquisition**

- **[Equilibrium condition]** Optimal response of I_F^* is $I_F^* = Y_F(I_I^*, n)$; optimal response of I_I^* is $I_I^* = Y_I(I_F^*, n)$. For the fast trader

$$I_F^* = Y_F(Y_I(I_F^*, n), n)$$

- Faster information diffusion crowds out fast trading

$$\frac{dI_F^*}{dn} = \frac{\overbrace{\frac{\partial Y_F(I_I^*, n)}{\partial n}}^{\text{crowding-out effect}} + \overbrace{\frac{\partial Y_F(I_I^*, n)}{\partial I_I} \frac{\partial Y_I(I_F^*, n)}{\partial n}}^{\text{informed trading effect}}}{1 - \frac{\partial Y_F(I_I^*, n)}{\partial I_I} \frac{\partial Y_I(I_F^*, n)}{\partial I_F}}$$

- ✓ reduces fast trader's first-mover advantage, **crowding-out fast traders**
- ✓ reduces trader's incentive to become **fast traders** through crowding-out effect of informed traders (complement).
- ✓ **This NEW channel amplifies the crowding-out effect on speed acquisition**

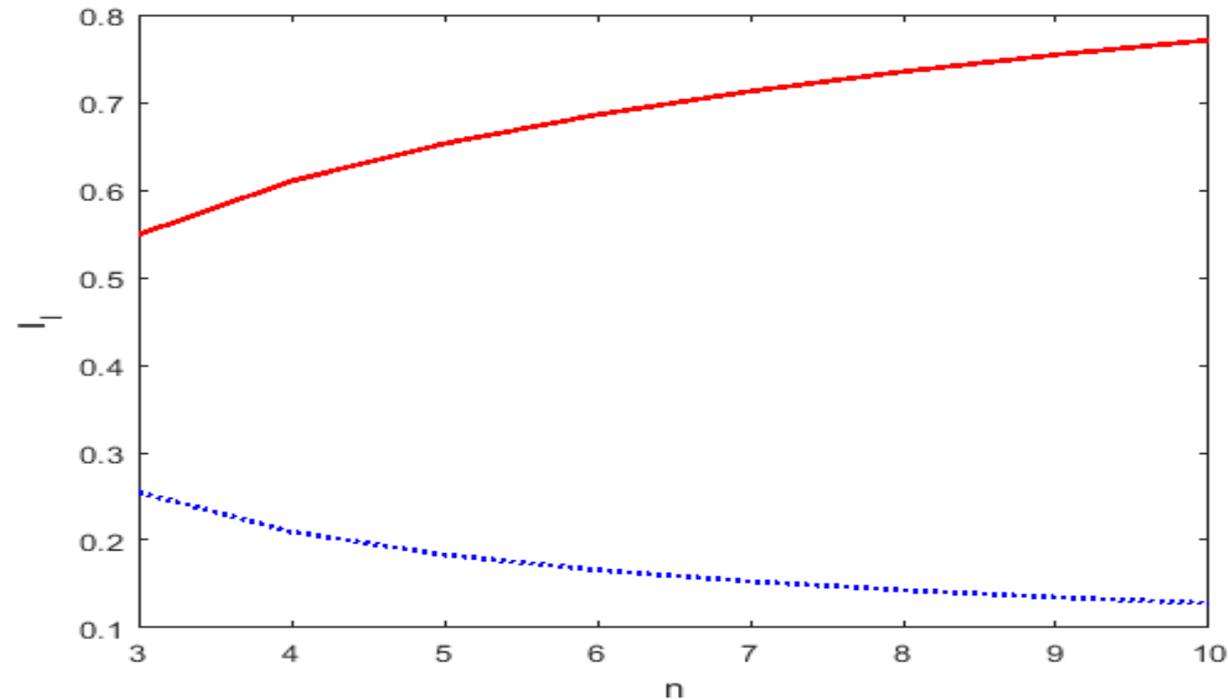
Information Diffusion and **Information Production**

➤ For informed traders

$$\frac{dI_I^*}{dn} = \frac{\overbrace{\frac{\partial Y_I(I_F^*, n)}{\partial n}}^{\text{crowding-out effect}} + \overbrace{\frac{\partial Y_I(I_F^*, n)}{\partial I_F} \frac{\partial Y_F(I_I^*, n)}{\partial n}}^{\text{fast trading effect}}}{1 - \frac{\partial Y_F(I_I^*, n)}{\partial I_I} \frac{\partial Y_I(I_F^*, n)}{\partial I_F}}$$

- ✓ The crowding-out effect and the fast trading effect on informed trading can either **strengthen** or **weaken** each other, depending on the **complementarity** and **substitutability**
- ❖ when the fraction of the informed traders is sufficiently high, information production is substitute to speed acquisition.
- ❖ since the crowding-out effect of informed trading also increases in the fraction of informed traders
- ❖ we expect that, the equilibrium fraction of fast traders still **decreases** due to the **dominance of the significant crowding-out effect** on the trade-off.

Information Diffusion and Information Production



The equilibrium fraction of the informed traders with respect to the speed of information diffusion: the information production cost $c_I = 0.1$ and the speed acquisition cost $c_F = 6$. The red solid line represents the equilibrium fraction of informed traders; while the blue dotted line represents the minimum fraction of informed trader when information production is a substitute to information acquisition.

Information Diffusion and **Market Quality** (*Early period*)

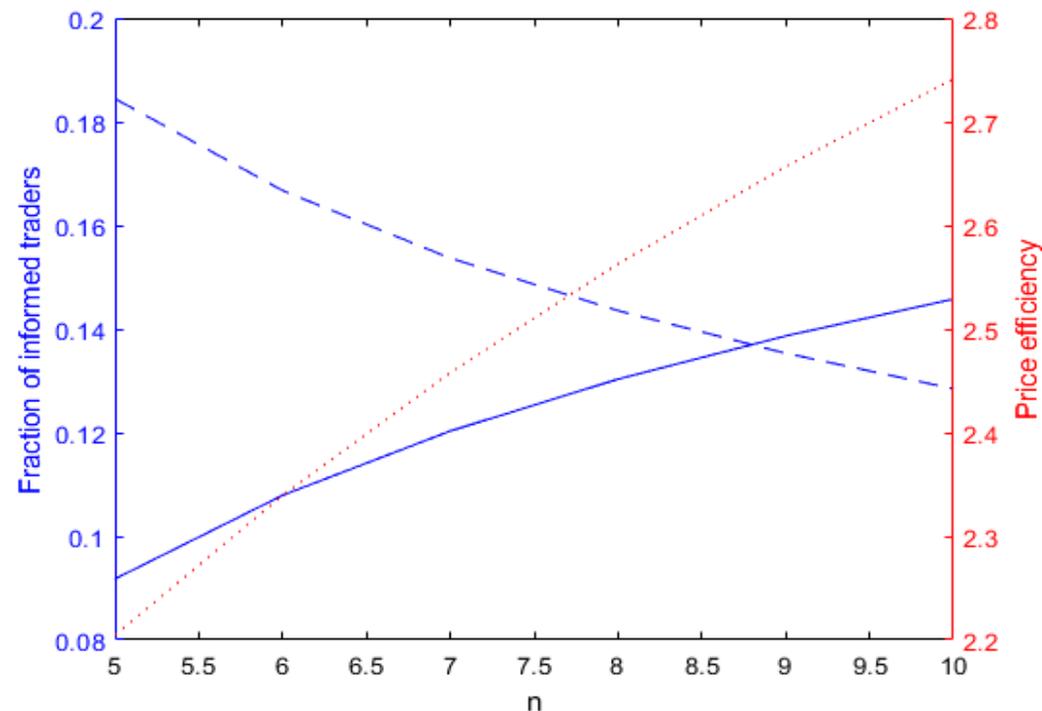
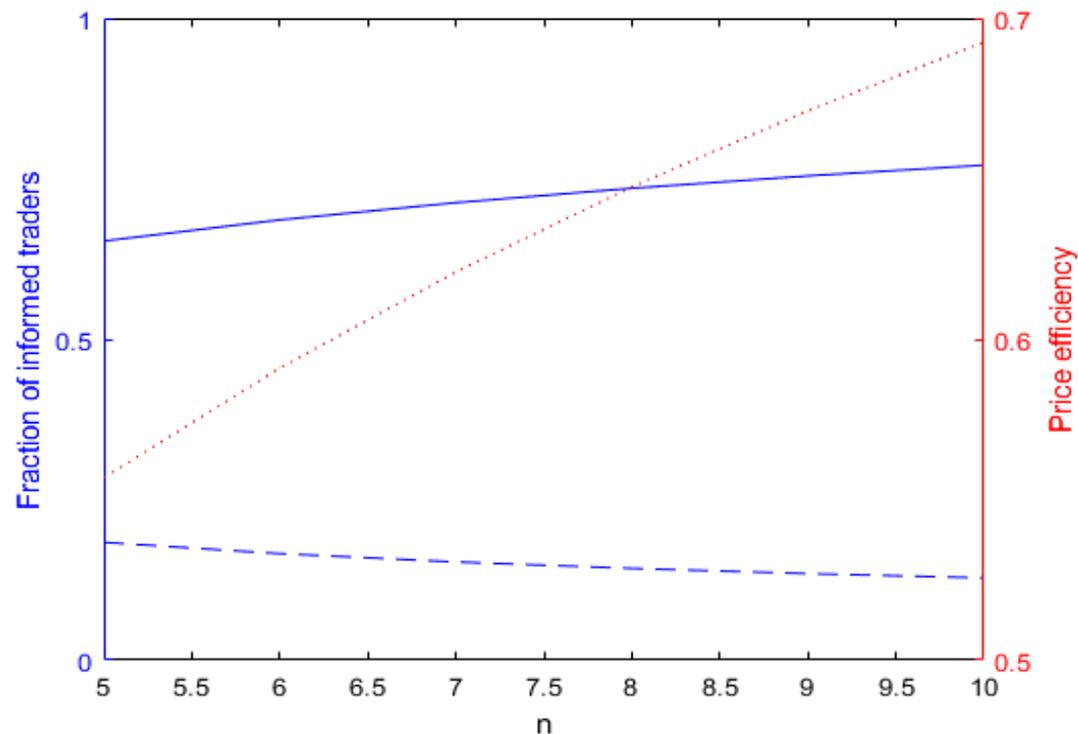
- **[Period-1]** faster information diffusion not only **brings more information to fast traders, weakening information asymmetry**, but also **reduces the trader's incentive to invest in speed technology, crowding-out fast traders**

$$\frac{d\Phi_F}{dn} = \frac{1}{2} \sqrt{\frac{N}{nI_F} \frac{\sigma_Z}{\sigma}} \frac{dI_F}{dn} - \frac{1}{2n} \sqrt{\frac{I_F N}{n} \frac{\sigma_Z}{\sigma}}$$

- fast traders' trading intensity is more sensitive to the amount of the information rather than the fraction of the fast traders
- positive information effect dominates the negative crowding-out effect, leading the **fast traders to trade more aggressively**
- intensified fast trading directly **benefits early period price efficiency**

$$VAR(V|w_1) = \frac{\sigma^2 \sigma_Z^2}{\Phi_F^2 \sigma^2 + \sigma_Z^2}$$

Information Diffusion and Market Quality (*Late period*)



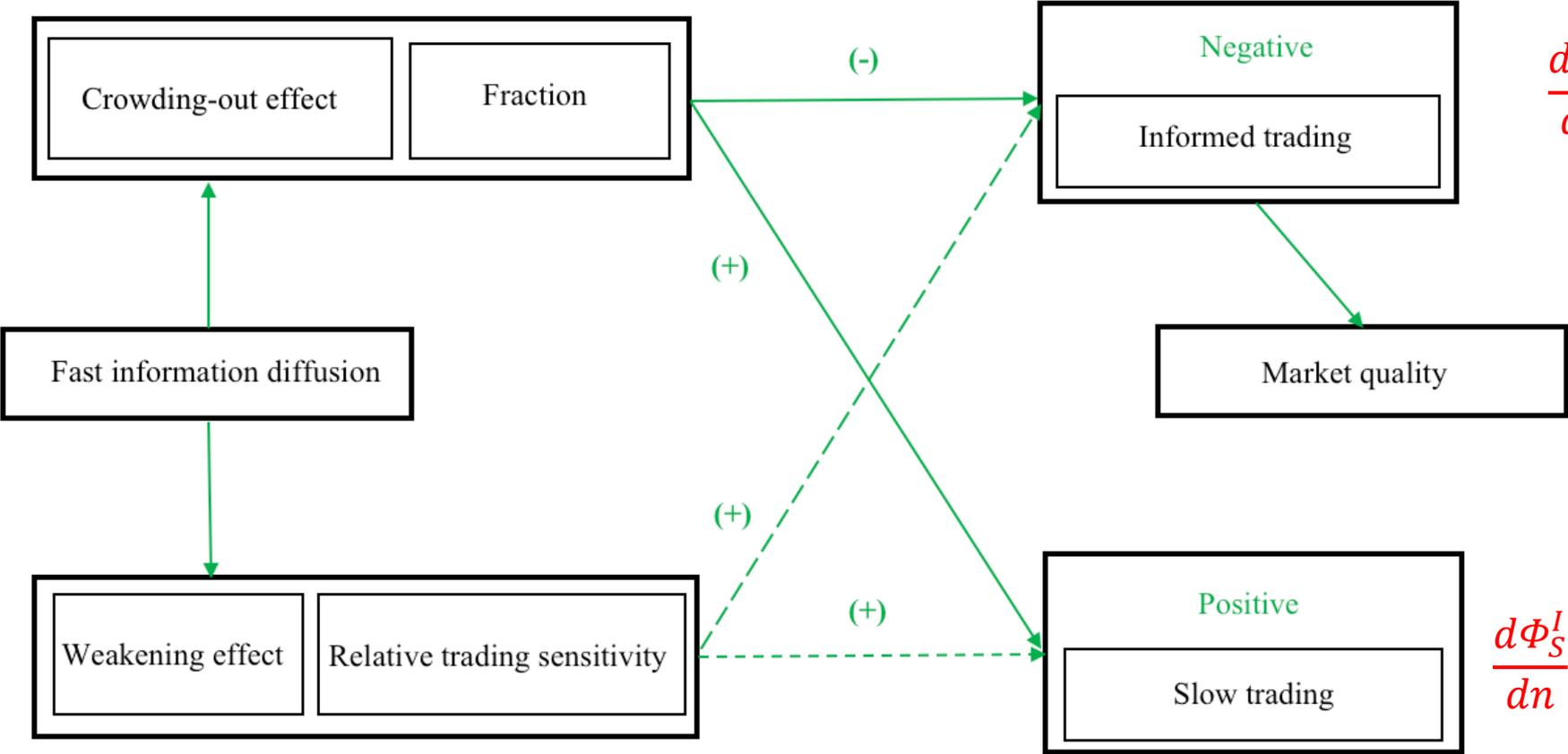
The equilibrium fraction of the informed traders and price efficiency with respect to the speed of information diffusion; the information production cost $c_t = 0.1$ (left), 0.8 (right), and the speed acquisition cost $c_F = 6$; the blue solid line represents the **equilibrium fraction of informed traders**; while the blue dashed line represents the minimum fraction of informed trader, when the information production is a substitute to the information acquisition. Red dotted line represents the condition variance, measuring the **price efficiency**.

Information Diffusion and **Market Quality** (*Late period*)

- **Surprisingly, with faster information diffusion, the market quality improves**
- What is driving the results ?
 - ❖ not solely based on the population of informed and fast traders,
 - ❖ but more importantly depend on
 - ✓ how much of fundamental information “**leaks**” to slow informed
 - ✓ how informed trading **reacts** to more aggressive fast trading
 - ✓ how aggressively fast traders, as a group, trade on information
- Fast trading, resulted from speed hierarchies, affects the **trade-off** between informed trading and slow trading with faster information diffusion

What is driving the main result?

❖ **The baseline trade-off without speed hierarchies** $VAR(V|w_1, w_2) = \frac{\sigma^2 \sigma_z^2}{(\Phi_F^2 + (\Phi_I + \Phi_S)^2) \sigma^2 + \sigma_z^2}$



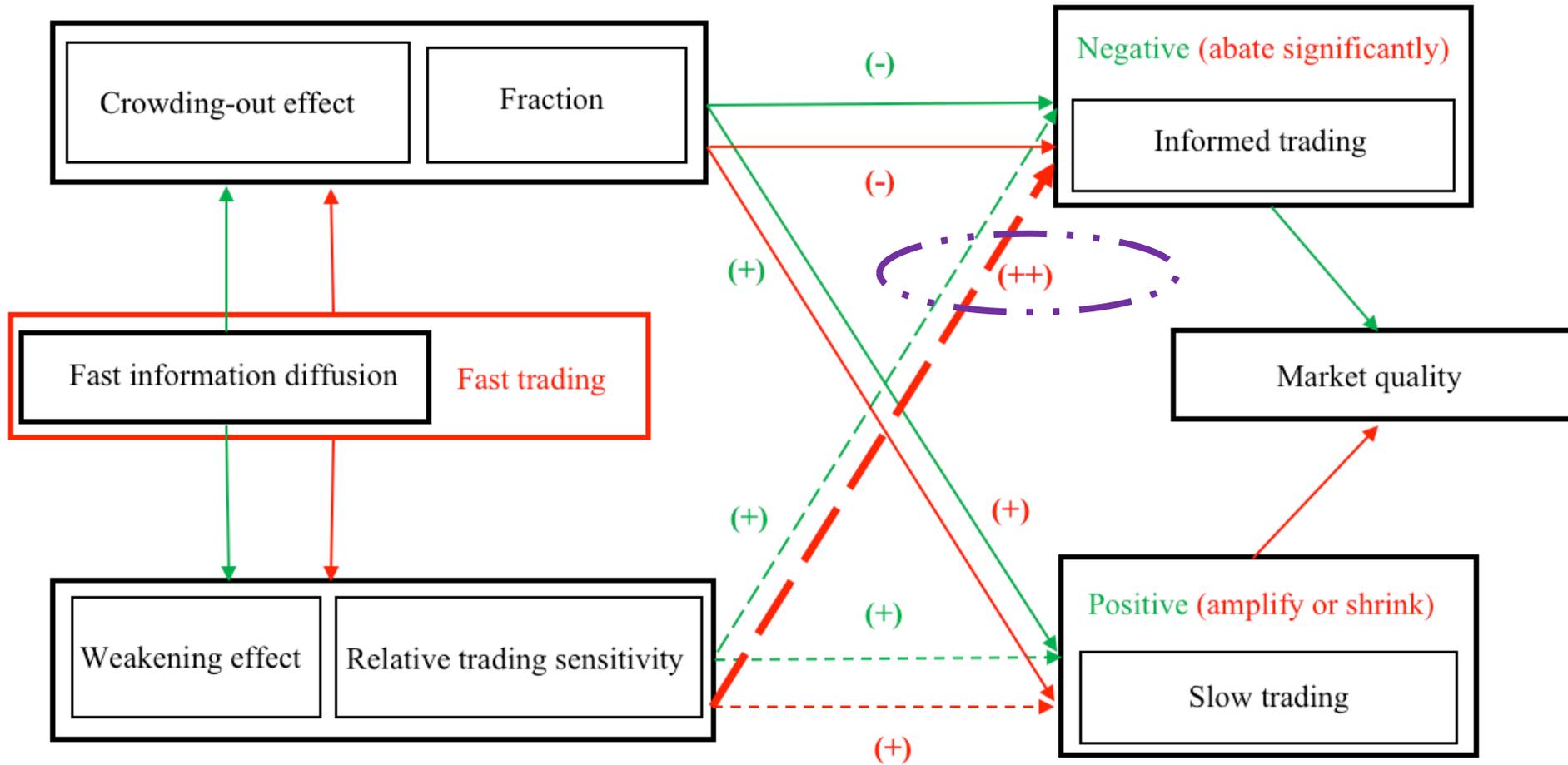
$$\frac{d\Phi_I^I}{dn} = \frac{\partial I^I N}{\partial n} \beta_I^I + \frac{\partial \beta_I^I}{\partial n} I^I N$$

$$\frac{d\Phi_S^I}{dn} = \frac{\partial (1 - I^I) N}{\partial n} \frac{\beta_S^I}{n} + \frac{\partial}{\partial n} \left(\frac{\beta_S^I}{n} \right) (1 - I^I) N$$

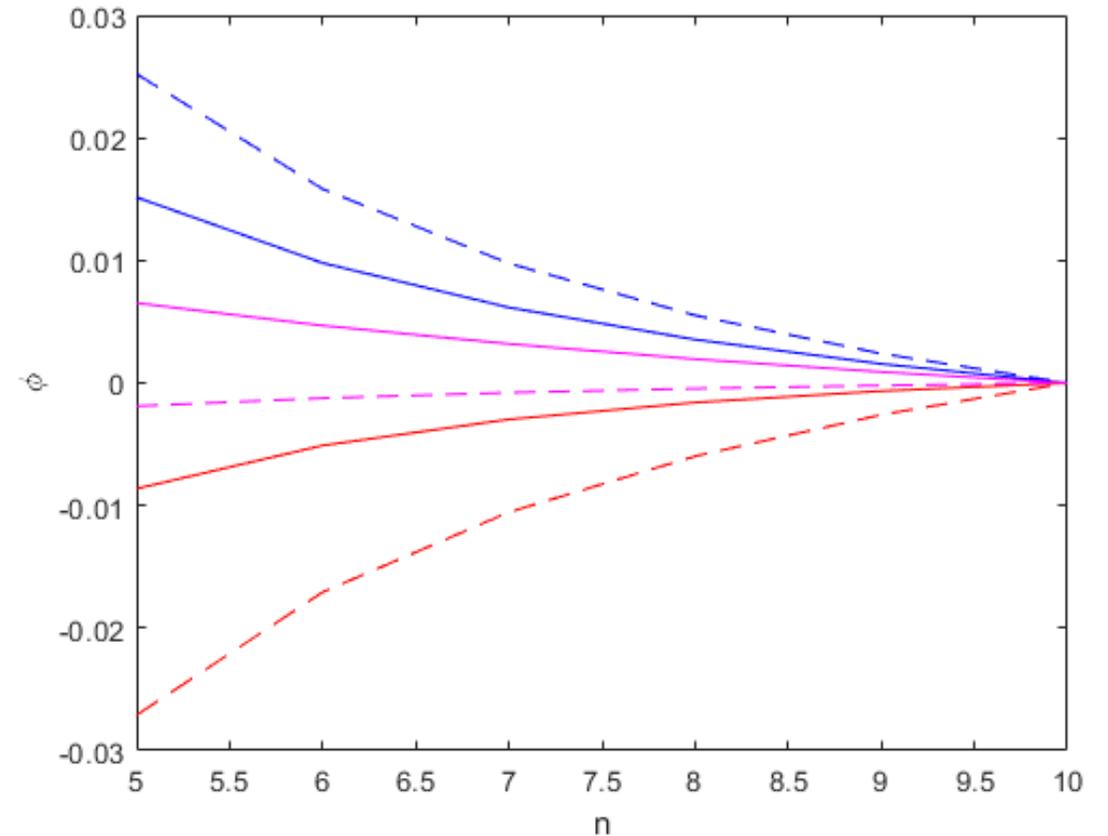
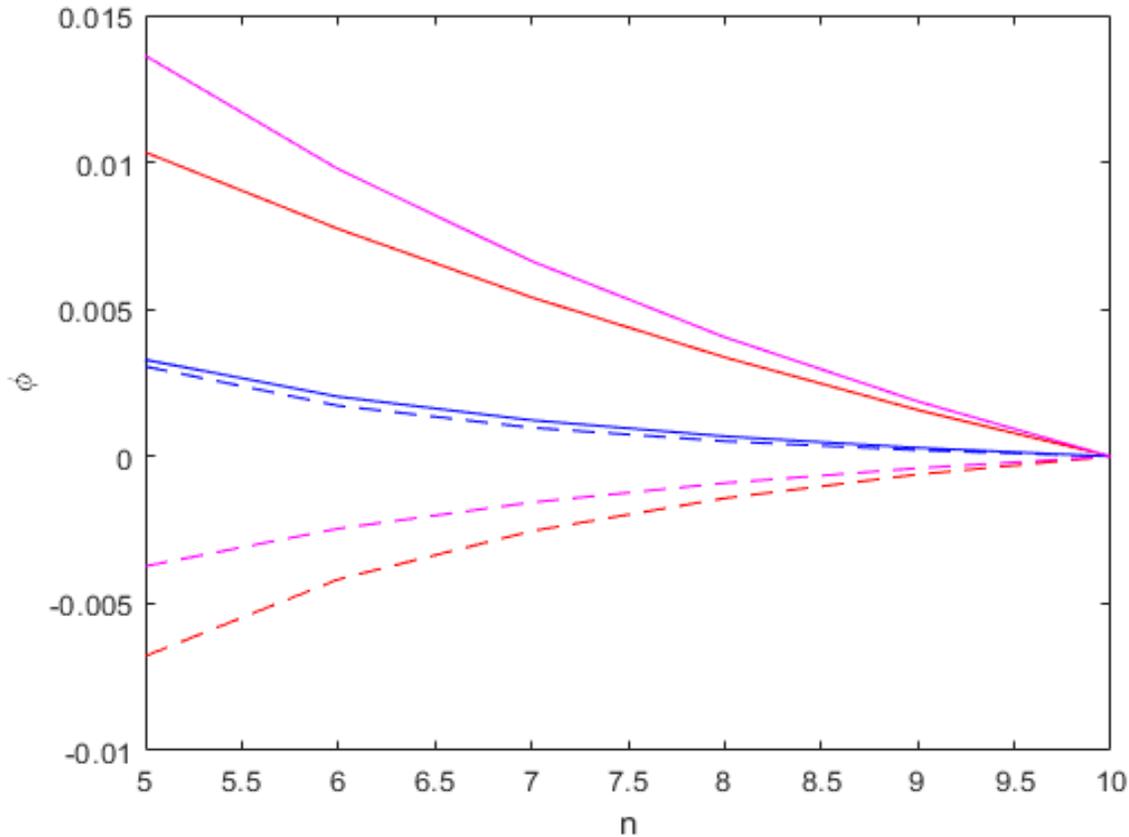
What is driving the main result?

$$VAR(V|w_1, w_2) = \frac{\sigma^2 \sigma_Z^2}{(\Phi_F^2 + (\Phi_I + \Phi_S)^2) \sigma^2 + \sigma_Z^2}$$

❖ **Fast trading re-shapes the baseline trade-off !!! (relative strength)**



What is driving the main result?



The equilibrium changing of trading intensities with respect to the speed of information diffusion: $c_I = 0.1$ (left), 0.8 (right, $c_F = 6$). The blue, red and pink lines represent that changing of trading intensity for slow, informed and aggregate, respectively. The dashed and solid lines represent the cases with and without speed heterogeneity.

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Contribution (Modelling)

- ❖ This is the first paper to examine the **joint** effect of **improving information transparency** and **fast trading competition** on strategic trading behaviour and market quality.
- ❖ The **nature of complementarity** and the **underlying mechanism** in our economy are very **different** from previous papers.
- ❖ With **speed hierarchies**, greater information transparency **improves** market quality.
 - ✓ Existing literature focus on crowding-out effect **without** considering the **speed's** influence
 - ✓ Providing a better understanding about information transparency under the **“new environment”**.

Contribution (Economics)

- ❖ Our analysis points out *strategic interaction between fast trader (HFT) and informed trader (Institutional investors and hedge fund)* :
 - ✓ *Substitute or complement* between the fast and informed trading
 - ✓ *Crowding-out effect* of faster information diffusion
 - ✓ *Trade-off mechanism* on market quality
- ❖ Our results lead to *implications* to market design, policy, and practice.
 - ✓ Improving information transparency under old market environment: Traditionally, information disclosure might crowd out private information, impeding market quality
 - ✓ *Improving information transparency under new market environment*: always improves both earlier period and later period market quality, supporting regulator's policy of more information transparency under new market environment.

Conclusion

- ❖ New channel---*the speed of information diffusion*
- ❖ Characterizing the *strategic substitute or complement* between speed acquisition and information production under both endogenous and exogenous situation
- ❖ Characterizing conditions under which the fraction of informed and fast traders can *increase* with faster information diffusion.
- ❖ The joint effect of faster trading competition and information transparency can cause *different influence* of information disclosure on market quality
- ❖ Some important implications to *market design, policy, and practice*.

Thanks 😊 😊 😊