

Insider's Strategic Signal and Equilibrium Pricing

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joint work with

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Motivation

Fact: In the markets of many financial securities, there are investors that possess market power and asymmetric information.

- It is well-documented that large financial institutions possess the power to affect markets (Kojien and Yogo [2019], Rostek and Yoon [2023]).
- These large investors are also known to invest capital to acquire information (Kacperczyk and Pagnotta [2019]).

Price impact and private information make them “*insiders*”.

- The rest of the market knows → Insiders’ signal is partially revealed to uniformed traders through the equilibrium prices.
- *We assume that an insider strategically chooses the signal she reveals to the market, a fact that is recognized by the uniformed traders.*

Our goal: Study how the insider’s awareness of price impact affects:

- equilibrium prices
- information transmission
- traders’ welfare

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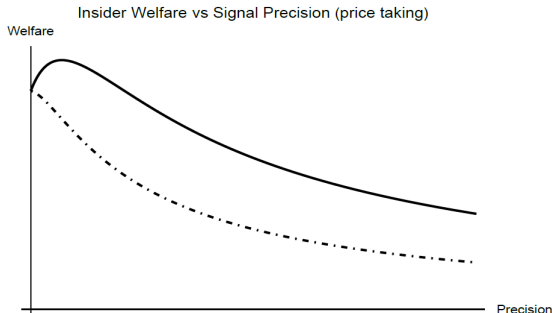
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Welfare and Signal Precision

Is it always true that the private information (even costless) is beneficial?

- ▶ Paradoxically, not. On the contrary, insider welfare may decrease with the signal precision.
- ▶ For example, in price-taking equilibrium of Grossman and Stiglitz [1980], we may have:

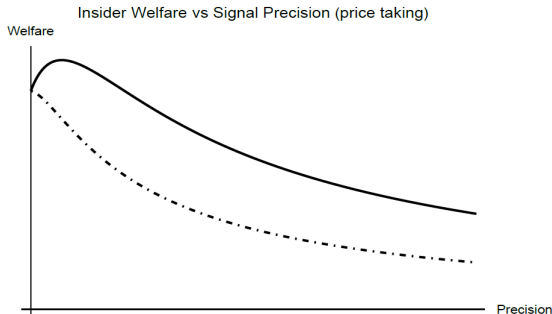


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Contributions

We adjust the single period CARA-normal setting

- by allowing an insider to **internalize her price impact** while maintaining
- the presence of **price-taking uniformed traders** and **liquidity providers**
- and consider a **linear impact equilibrium**.

Main results

- We establish existence of the price impact (PI) equilibrium (by getting the unique positive root of a certain cubic equation).
- On information transmission: Market signal becomes fuzzier (as Kacperczyk et al. [2023]) and equilibrium price less reactive to the public information (as Lou and Rahi [2023]).
- On insider's welfare: Under insider's price impact, better information always increases her welfare. While, absent a private signal, internalizing price impact always improves her welfare too.
- On the effect of private signal: Price impact may reduce the insider's welfare!
- On uniformed traders' welfare: If being at the same side of trade with the insider, their welfare increases due to price impact with and without private information.

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A Short List of Related Literature

- ▶ **Price-impact equilibria:** Vayanos [2001] and Rostek and Weretka [2015], Malamud and Rostek [2017] and Anthropolos and Kardaras [2024] Bergemann et al. [2021]
- ▶ **Information acquisition:** Vives [2011], Rostek and Weretka [2012] and Vives [2014], Nezafat and Schroder [2023], Kacperczyk et al. [2023], Lou and Rahi [2023].
- ▶ **Information sharing:** Goldstein et al. [2023] and Indjejikian et al. [2014]).

The Model

The model has **one period** and

- a **risky asset** with terminal payoff $X \sim N(0, 1)$ and supply $\Pi > 0$.
- **An insider** I who obtains a **private signal** G taking the form

$$G = X + Z_I; \quad Z_I = \frac{1}{\sqrt{p_I}} \mathcal{E}_I,$$

where $\mathcal{E}_I \sim N(0, 1)$ is independent of X and $p_I > 0$ is the signal precision.

- There is also a mass of price-takers **uniformed traders** whose representative agent is called U .
- Both I and U have **exponential preferences with risk tolerances** α_I and α_U .
- Lastly, there are **liquidity providers** (noise traders), denoted by N , with exogenous demand

$$Z_N = \frac{1}{\sqrt{p_N}} \mathcal{E}_N,$$

where $\mathcal{E}_N \sim N(0, 1)$ is independent of both X and \mathcal{E}_I .

The Model, *cont'd*

- I and U are endowed with share **initial positions** $\{\pi_{i,0}\}$, which are assumed Pareto optimal absent private information

$$\pi_{i,0} = \alpha_i \widehat{\Pi} \quad i \in \{I, U\}, \quad \widehat{\Pi} := \frac{\Pi}{\alpha_I + \alpha_U}.$$

- Writing the to-be-determined equilibrium price as p , the **terminal wealth** is

$$\mathcal{W}^{\pi_i} := \pi_{i,0} p + \pi_i (X - p); \quad i \in \{I, U\}.$$

- The **equilibrium clearing condition** is

$$\Pi = \alpha_I \widehat{\psi}_I + \alpha_U \widehat{\psi}_U + Z_N,$$

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Equilibrium Construction

We seek a **linear impact equilibrium**: The insider perceives that if she changes her position from $\pi_{I,0} = \alpha_I \psi_{I,0}$ to $\pi_I = \alpha_I \psi_I$, then the price will be an affine function of her trade combined with the noise trader demand,

$$p_L(\psi_I, Z_N) = V + M \left(\psi_I - \psi_{I,0} + \frac{Z_N}{\alpha_I} \right),$$

for constants V, M that are determined in equilibrium. The insider's optimal demand for any fixed M and V :

$$\inf_{\psi \in \mathcal{A}_I} \mathbb{E} \left[e^{-\psi_{I,0} p_L(\psi, Z_N) - \psi(X - p_L(\psi, Z_N))} \mid \sigma(G, Z_N) \right].$$

The uniformed trader's demand

$$\inf_{\psi \in \sigma(H_L)} \mathbb{E} \left[e^{-\psi(X - p_L(H_L))} \mid \sigma(H_L) \right],$$

where the public signal is

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Equilibrium Existence

Theorem

The equilibrium price is $p_\iota(H_\iota)$ for the price function

$$p_\iota(h_\iota) = p_0 + \frac{p_I \hat{y}}{(1 + p_I)(1 + 2\hat{y})} (h_\iota - p_0),$$

where p_0 is the equilibrium price without private signal and price impact and \hat{y} is the unique positive solution of a certain cubic. The insider has optimal policy $\hat{\pi}_{I,\iota} = \hat{\psi}_{I,\iota}(G, Z_N)/\alpha_I$ where

$$\hat{\psi}_{I,\iota}(g, z) = \frac{1}{1 + \hat{y}} (p_I g - (1 + p_I)p_\iota(h_\iota(g, z)) - \hat{y}p_0).$$

The uninformed agent has optimal policy $\hat{\pi}_{U,\iota} = \hat{\psi}_{U,\iota}(H_\iota)/\alpha_U$ where

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✓ Since, the uninformed trader recognizes the insider's price impact, the PT and PI equilibria *cannot coincide*.

Comparison Analysis

Our comparison analysis works in to two directions: **with and without price impact** and **with and without asymmetric information**. For this, we also consider

- the price-taking equilibrium (where insider doesn't exploit her price impact) and
- the no-signal equilibrium ($p_I \rightarrow 0$) with and without price impact.

Signals and price sensitivity

- ✓ Price impact decreases the precision of the public signal: $p_{U,i} \leq p_U$.
- ✓ The equilibrium price is less sensitive to the market signal in the price-impact equilibria (the slope of p_i wrt h_i is lower than the slope of p wrt to h).

By assuming the insider is a price taker, one overestimates the quality of the public signal and the reactivity of equilibrium prices.

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Signals and price sensitivity

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By assuming the insider is a price taker, one overestimates the quality of the public signal and the reactivity of equilibrium prices.

Comparison Analysis on Welfare

Following the standard literature, we calculate and compare the certainty equivalents (CEs) of traders at all equilibria:

For $k \in \{I, U\}$ the **interim CEs** are

$$\begin{aligned} CE_{0,k}^I &= -\alpha_I \log \left(\mathbb{E} \left[e^{-(1/\alpha_I)\widehat{\mathcal{W}}_{I,k}} \mid \sigma(G, H_k) \right] \right), \\ CE_{0,k}^U &= -\alpha_U \log \left(\mathbb{E} \left[e^{-(1/\alpha_U)\widehat{\mathcal{W}}_{U,k}} \mid \sigma(H_k) \right] \right), \end{aligned}$$

while the **ex-ante CEs** are

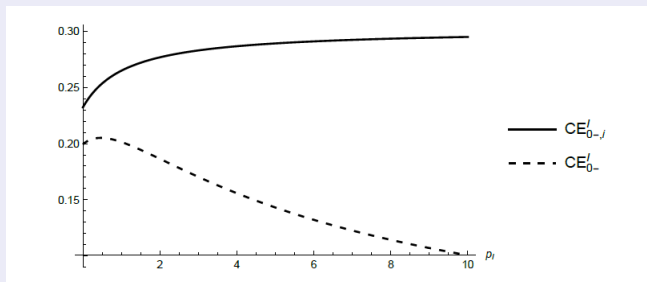
$$CE_{0-,k}^j = -\alpha_j \log \left(\mathbb{E} \left[e^{-(1/\alpha_j)\widehat{\mathcal{W}}_{j,k}} \right] \right); \quad j \in \{I, U\},$$

where $\widehat{\mathcal{W}}_{j,k}$ denotes the terminal wealth at each equilibrium.

Comparison Analysis on Welfare, *cont'd*

Signal and insider's welfare

- ✓ $CE'_{0-,l}$ is strictly increasing in the precision p_l (this is not the case for CE'_{0-}).
- Here is a simple example



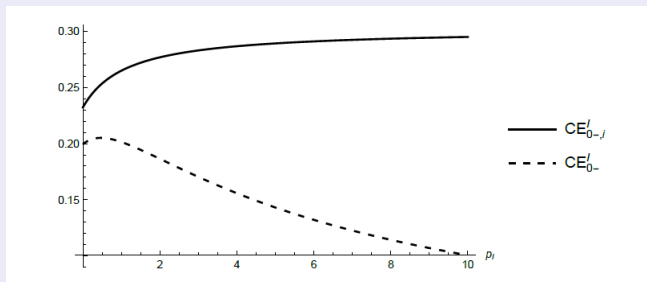
Price impact and traders' welfare

- ✓ Price impact benefits uniformed trader: $CE_{0-,l}^U \geq CE_{0-}^U$.
- ✓ Both $CE'_{0-,l} > CE'_{0-}$ and $CE'_{0-,l} < CE'_{0-}$ are possible.

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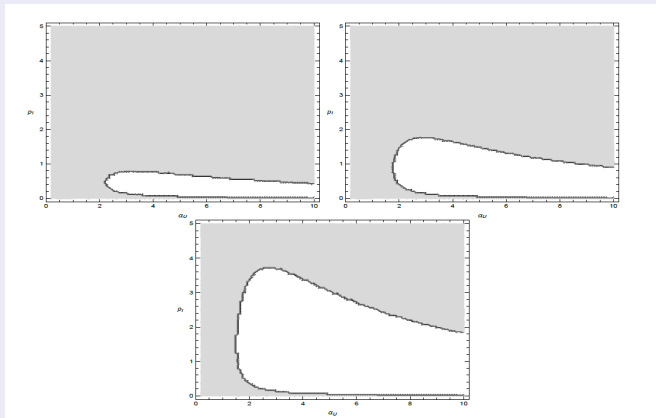


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Comparison Analysis on Welfare, *cont'd*

Price impact may reduce insider's welfare!



The white region is where $CE'_{0-,i} < CE'_{0-}$.

✓ When uninformed is close to risk neutrality and signal has modest quality, then the welfare may decrease.

This holds when insider is sufficiently risk averse and $\alpha^2_U p_N > (1/p_I) + 1$.

Comparison Analysis on Welfare, *cont'd*

Welfare in the absence of private information

$$\begin{aligned}\lim_{p_I \rightarrow 0} CE_0^I(G, Z_N) &< \lim_{p_I \rightarrow 0} CE_{0,t}^I(G, Z_N). \\ \lim_{p_I \rightarrow 0} CE_0^U(H) &< \lim_{p_I \rightarrow 0} CE_{0,t}^U(H_t)\end{aligned}$$

✓ Both traders' interim welfare a.s. increases due to price impact.

Homogeneous case

In fact, assuming no private signal and $\alpha_U = \alpha_I$, we have the following a.s. order of interim CEs

$$CE_{0,t}^U > CE_{0,t}^I > CE_0^U = CE_0^I.$$

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Qualitative Comments on Equilibrium Structure

Analysis on the prices and allocations on different equilibria indicates the following messages:

- For both the PT and PI equilibria, **private signal** is expected to **increase the insider's demand and price** (albeit with a lower change in the PI equilibrium) and decrease the uniformed trader's demand.
- **Price impact** with no signal results in a **lower** (resp. higher) equilibrium position for the **insider** (resp. uniformed trader) at a **better price**.
- Due to **price impact**, a sufficiently low (resp. high) **risk tolerant insider** is expected to **buy less** (resp. more) units at a better price, while uniformed trader buys more (resp. less).

Closing Remarks – Summary

In this paper, we study a market of risky financial assets with three types of traders: informed, uninformed and noisy traders.

- ▶ The informed trader together with her asymmetric information possesses market power due to her size.
- ▶ We model insider's price impact as her **revealing a strategically chosen signal** to the market.
- ▶ We show the **existence** of equilibrium when the uninformed traders act as price-takers (but they do take into account the insider's strategy).
- ▶ At this model, **better signal means better welfare for the insider**, while **price impact is not always a beneficial structure for her**.
- ▶ When informed and uninformed traders are at the same side of trading, **price impact increases their total welfare from trading**.
- ✓ Note that although the main analysis considers one asset and Pareto-allocated initial endowments, the paper develops the model with more assets and general traders' initial positions.

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- ▶ At this model, **better signal means better welfare for the insider**, while **price impact is not always a beneficial structure for her**.
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- ✓ Note that although the main analysis considers one asset and Pareto-allocated initial endowments, the paper develops the model with more assets and general traders' initial positions.

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In this paper, we study a market of risky financial assets with three types of traders: informed, uninformed and noisy traders.

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Thank you for your attention!
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