# Strategic Informed Trading and the Value of Private Information

Michail Anthropelos, University of Piraeus
joint work with
Scott Robertson (Boston University)

EEA-ESEM at Rotterdam
August 2024

# Motivation

**Fact**: In many financial markets, there are investors who possess market power and asymmetric information.

- It is well-documented that large financial institutions possess the power to affect markets (Koijen 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 $\rightarrow$ *Insiders' signal is partially revealed to uniformed traders through the equilibrium prices.*
- *In this paper: 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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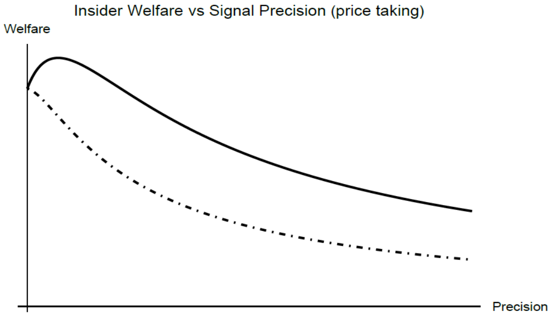
# Welfare and Signal Precision

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

- Paradoxically, not. On the contrary, in several models 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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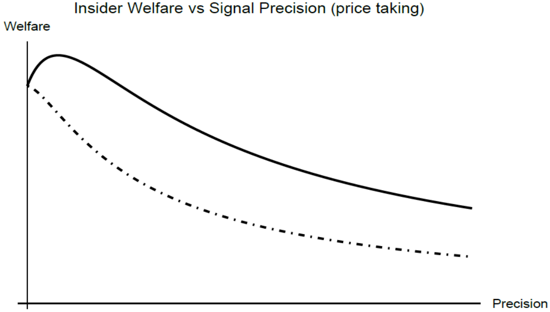


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# Contributions

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 in Kacperczyk et al. [2023]) and equilibrium price less reactive to the public information (as in 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 Anthropelos 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

There is **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

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

  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** $\alpha_I$ and $\alpha_U$.
- 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

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

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

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

- The **equilibrium clearing condition** is

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

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$$\widehat{\psi}_i := \frac{\widehat{\pi}_i}{\alpha_i}; \qquad i \in \{I, U\}.$$

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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,

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

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

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

The uniformed trader's demand

$$\inf_{\psi \in \sigma(H_\iota)} \mathbb{E}\left[e^{-\psi(X - p_\iota(H_\iota))} \middle| \sigma(H_\iota)\right],$$

where the public signal is

$$H_\iota := G + \Lambda_\iota Z_N = X + Z_I + \Lambda_\iota Z_N.$$

Note that it has the same form as insider's signal $G$ (except with lower precision).

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# Equilibrium Existence

## Theorem

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

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

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

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

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

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# Comparison Analysis

Our comparison analysis works in 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 ($p_I \to 0$) with and without price impact.

### Signals and price sensitivity

✓ Price impact decreases the precision of the public signal: $p_{U,\iota} \leq p_U$.

✓ The equilibrium price is less sensitive to the market signal in the price-impact equilibria: The slope of $p_\iota$ wrt $h_\iota$ is lower than the slope of $p$ wrt to $h$.

Hence,

*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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# Comparison Analysis on Welfare

Following the standard literature, we calculate and compare the certainty equivalents (CEs) of traders at all equilibria:
For $k \in \{\ , \iota\}$ the interim CEs are

$$\mathrm{CE}^{I}_{0,k} = -\alpha_I \log\left(\mathbb{E}\left[e^{-(1/\alpha_I)\widehat{\mathcal{W}}_{I,k}} \middle| \sigma(G, H_k)\right]\right),$$
$$\mathrm{CE}^{U}_{0,k} = -\alpha_U \log\left(\mathbb{E}\left[e^{-(1/\alpha_U)\widehat{\mathcal{W}}_{U,k}} \middle| \sigma(H_k)\right]\right),$$

while the ex-ante CEs are

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

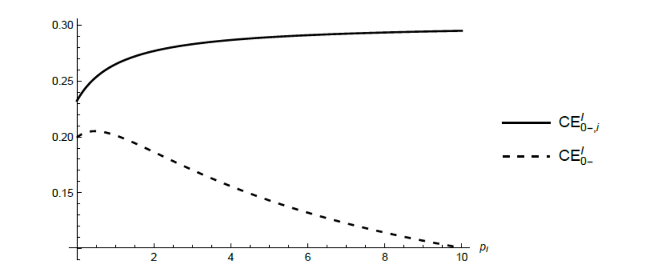
where $\widehat{\mathcal{W}}_{j,k}$ denotes the terminal wealth at each equilibrium.

# Comparison Analysis on Welfare, *cont'd*

## Signal and insider's welfare

✓ $\mathrm{CE}^{I}_{0-,\iota}$ is strictly increasing in the precision $p_I$ (this is not the case for $\mathrm{CE}^{I}_{0-}$).

- Here is a simple example




## Price impact and traders' welfare

✓ Price impact benefits uniformed trader: $\mathrm{CE}^{U}_{0-,\iota} \geq \mathrm{CE}^{U}_{0-}$.

✓ Both $\mathrm{CE}^{I}_{0-,\iota} > \mathrm{CE}^{I}_{0-}$ and $\mathrm{CE}^{I}_{0-,\iota} < \mathrm{CE}^{I}_{0-}$ are possible.

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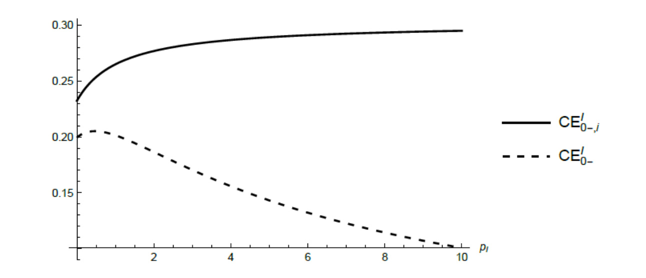


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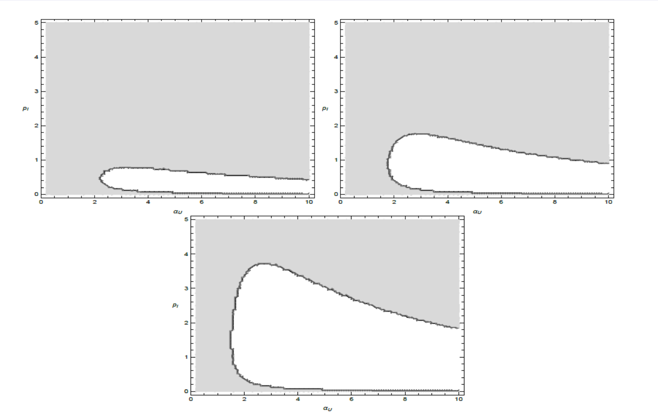


The white region is where $\mathrm{CE}^I_{0-,\iota} < \mathrm{CE}^I_{0-}$.

✓ 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 $\alpha_U^2 p_N > (1/p_I) + 1$.

# Comparison Analysis on Welfare, *cont'd*

## Welfare in the absence of private information

$$\lim_{p_I \to 0} \mathrm{CE}_0^I(G, Z_N) \quad < \quad \lim_{p_I \to 0} \mathrm{CE}_{0,\iota}^I(G, Z_N).$$
$$\lim_{p_I \to 0} \mathrm{CE}_0^U(H) \quad < \quad \lim_{p_I \to 0} \mathrm{CE}_{0,\iota}^U(H_\iota)$$

✓ 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

$$\mathrm{CE}_{0,\iota}^U > \mathrm{CE}_{0,\iota}^I > \mathrm{CE}_0^U = \mathrm{CE}_0^I.$$

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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 uniformed 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 uniformed 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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Thank you for your attention!

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The latest version of the paper is available at ssrn.