Monopolistic Dealer versus Broker: Impact of Proprietary Trading with Transaction Fees

Katsumasa Nishide[a] Yuan Tian[b]

(a) *Yokohama National University*
(b) *Ryukoku University*

The latest version of this study is available at
`http://ssrn.com/abstract=2470355`.

Plan of Talk

Introduction

Background

Two types of trading system:

- Dealer market:
  - Dealer (market maker) trades with other market participants with his/her own account (proprietary trading).
- Brokered market:
  - Broker sets price just to clear orders from other market participants (no proprietary trading).
- Unclear which system is better for investors from the viewpoint of market activity, market liquidity, welfare of investors, etc.
- To answer the above question, the effect of proprietary trading needs to be examined.

Literature review (1)

Theoretical papers:

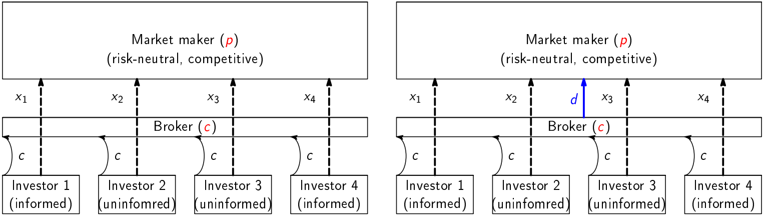
- Röell (1990), Fishman and Longstaff (1992), Sarkar (1995), Viswanathan and Wang (2002), Bernhardt and Taub (2010).
    - Agent setting the price is different from the one collecting transaction fees.
    - Price setter is risk-neutral and perfectly competitive, implying that $p = \mathbb{E}[v|\mathscr{F}_M]$.
    - Transaction fees are independent of the order amount.

Empirical papers:

- Pagano and Röell (1992, 1996), Huang and Stoll (1996), Heidle and Huang (2002).
    - Result depends on the papers.

Literature review (2)

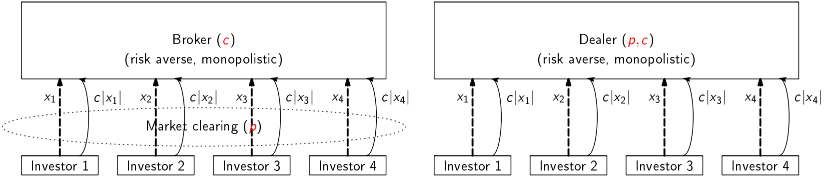
Sarkar (1995): Dual trading of investment banks, securities houses, etc.,



- In the dual trading, the broker is allowed to trade with his own account d.

Literature review (3)

Our study: Market system (dealer versus broker).



- In the dealer market, the dealer can trade with his own account with the price set by the dealer himself.

Aim of this study

In this paper, we

- construct a one-shot CARA-Normal model with
  - infinitely many investors,
  - a monopolistic and risk-averse dealer/broker who collects transaction fees.
- examine the effect of proprietary trading on equilibrium solutions.

Main results:

- Proprietary trading always increases total welfare of investors.
- Economic interpretation:
  - dealer sets a favorable price for investors to seek profits by proprietary trading.

Model Setup

Financial Market

- There is only one risky asset.
- Risk-free interest rate is assume to be zero for simplicity.
- v: (random) payoff of the risky asset.
- Two types of market participants:
    - investors,
    - a dealer or a broker.

Investors

- Let $\mathscr{I}$ denote the set of investors.
- $\{\omega_i\}_{i\in\mathscr{I}} \sim \mathrm{IID} N(\bar{\omega}, \sigma_\omega^2)$: initial endowment of investors (Kim and Verrecchia, 1991).
- $\mathscr{F}_i$: information set of investor i.

$$v\Big|_{\mathscr{F}_i} \sim N(\mu_i, \sigma_v^2).$$

  Beliefs are heterogeneous with respect to the mean of v.
- Utility of investor i:

$$U_i = -\frac{1}{a}\log\left(\mathbb{E}\left[\mathrm{e}^{-aY_i}\Big|\,\mathscr{F}_i\right]\right)$$

  where Y_i is the final wealth of investor i.

Dealer or broker

- Monopolistic.
- Collects transaction fees (\$$c$ per unit trade).
- Sets the price p for investors.
- $\mathscr{F}_M$: information set of dealer/broker.

$$v\Big|_{\mathscr{F}_M} \sim N(\mu_M, \sigma_M^2).$$

- Utility function:

$$U_M = -\frac{1}{\gamma}\log\left(\mathbb{E}\left[\mathrm{e}^{-\gamma R(p,c)}\Big|\,\mathscr{F}_M\right]\right)$$

where $R(p,c)$ is the final wealth of the dealer (broker).

Investor's utility maximization

- x_i: trading amount of investor i.
- Y_i is given by

$$Y_i = v\omega_i + (v-p)x_i - \mathrm{sgn}[x_i]x_i c,$$

  where sgn is the sign function.
- Since only v is random in Y_i with respect to $\mathscr{F}_i$, x_i can be solved as

$$x_i^*(p,c) = \underbrace{-\omega_i}_{\text{risk hedging}} + \underbrace{\frac{\mu_i - p - \mathrm{sgn}[x_i^*(p,c)]c}{a\sigma_v^2}}_{\text{profit seeking}}.$$

- Let $\zeta_i = \mu_i - a\sigma_v^2\omega_i$. Then, we can rewrite

$$x_i^*(p,c) = 1_{\{\zeta_i > p+c\}}\frac{\zeta_i - (p+c)}{a\sigma_v^2} + 1_{\{\zeta_i < p-c\}}\frac{\zeta_i - (p-c)}{a\sigma_v^2}.$$

  - ζ_i: investor i's subjective belief adjusted by inventory risk.

Broker's utility maximization

Assumption 1

The broker sets (p_b, c_b) to satisfy

$$\sum_{i \in \mathscr{I}} x_i^*(p,c) = 0$$

and to maximize

$$U_M = -\frac{1}{\gamma} \log \left(\mathbb{E} \left[e^{-\gamma R(p,c)} \middle| \mathscr{F}_M \right] \right)$$

where

$$R(p,c) = \sum_{i \in \mathscr{I}} c |x_i^*(p,c)|.$$

Dealer's utility maximization (2)

Assumption 2

The dealer sets $(p_{\mathrm{d}}, c_{\mathrm{d}})$ *to maximize*

$$U_M = -\frac{1}{\gamma}\log\left(\mathbb{E}\left[\mathrm{e}^{-\gamma R(p,c)}\middle|\mathscr{F}_M\right]\right)$$

where

$$R(p,c) = \sum_{i\in\mathscr{I}}\left\{(v-p)\times(-x_i^*(p,c)) + c|x_i^*(p,c)|\right\}.$$

Remark

- The utility of the dealer is higher than the one of the broker:
  - Dealer has an additional control variable (the price p).
- The effect of proprietary trading by the dealer on investors is not so apparent:
  - Dealer has a monopolistic power and may set an unfavorable price and transaction fees for investors.

Equilibrium Solutions

Infinitely many small investors

- To simplify the analysis, we assume a (continuously) infinite number of investors ($\mathscr{I} = R$).
- We also assume that
$$\mu_i \sim N(\mu_I, \sigma_I^2) \text{ in } \mathscr{I}$$
and independent of $\{\omega_i\}$.
  - Can be justified by the central limit theorem if the belief biases of investors are IID (Hellwig, 1980).
- We defined $\zeta_i = \mu_i - a\sigma_v^2\omega_i$:
$$\zeta_i \sim N(\underbrace{\mu_I - a\sigma_v^2\bar{\omega}}_{=\mu_\zeta}, \underbrace{\sigma_I^2 + a^2\sigma_v^4\sigma_\omega^2}_{=\sigma_\zeta^2}).$$
  - (risk-adjusted) belief ζ_i solely represents heterogeneity in the model.

Total order amount

- Let
$$q_I(\zeta) = \frac{1}{\sqrt{2\pi\sigma_\zeta^2}} e^{-\frac{(\zeta-\mu_\zeta)^2}{2\sigma_\zeta^2}}.$$
- Under this setting, the total amount of orders is not random:
$$\begin{aligned}
&\sum_{i\in\mathscr{I}} x_i^*(p,c) \\
= &\int_{-\infty}^{p-c} \frac{\zeta-(p-c)}{a\sigma_v^2} q_I(\zeta)\mathrm{d}\zeta + \int_{p+c}^{\infty} \frac{\zeta-(p+c)}{a\sigma_v^2} q_I(\zeta)\mathrm{d}\zeta \\
= &\frac{\sigma_\zeta}{a\sigma_v^2}\left[(\phi(d_+)+d_+\Phi(d_+)) - (\phi(d_-)+d_-\Phi(d_-))\right]
\end{aligned}$$
where Φ and ϕ are the distribution and density functions of a standard normal, respectively, and
$$d_\pm = \pm\frac{\mu_\zeta-(p\pm c)}{\sigma_\zeta}.$$

Equilibrium in brokered market

- Market clearing implies $p_{\mathrm{b}} = \mu_\zeta$, and thus
$$R(\mu_\zeta, c) = \frac{2}{a\sigma_v^2}\left[\sigma_\zeta c\phi\left(-\frac{c}{\sigma_\zeta}\right) - c^2\Phi\left(-\frac{c}{\sigma_\zeta}\right)\right] = U_M.$$

Proposition 1

The equilibrium price in the brokered market, p_{b}, is given by

$$p_{\mathrm{b}} = \mu_I - a\sigma_v^2\bar{\omega}$$

and the per-unit fee by $c_{\mathrm{b}} = -\sigma_\zeta z$, where $z < 0$ is the solution of the equation

$$z + \frac{1}{2}\frac{\mathrm{d}}{\mathrm{d}z}\log\Phi(z) = 0.$$

Equilibrium in dealer market (1)

- The final wealth of the dealer is given by

$$\begin{aligned} R(p,c) = & \sum_{i\in\mathscr{I}} \left\{ (v-p)\times(-x_i^*(p,c)) + c|x_i^*(p,c)| \right\} \\ = & -(v-p-c)\frac{\sigma_\zeta}{a\sigma_v^2}[\phi(d_+)+d_+\Phi(d_+)] \\ & +(v-p+c)\frac{\sigma_\zeta}{a\sigma_v^2}[\phi(d_-)+d_-\Phi(d_-)]. \end{aligned}$$

- Utility of dealer:

$$\begin{aligned} U_M = & (\mu_M - p)\frac{\sigma_\zeta}{a\sigma_v^2}\left[\Big(\phi(d_-)+d_-\Phi(d_-)\Big) - \Big(\phi(d_+)+d_+\Phi(d_+)\Big)\right] \\ & +c\frac{\sigma_\zeta^2}{a\sigma_v^2}\left[\Big(d_+\phi(d_+)+d_+^2\Phi(d_+)\Big) + \Big(d_-\phi(d_-)+d_-^2\Phi(d_-)\Big)\right] \\ & -\frac{\gamma}{2}\frac{\sigma_\zeta^2\sigma_M^2}{a^2\sigma_v^4}\left[\Big(\phi(d_+)+d_+\Phi(d_+)\Big) - \Big(\phi(d_-)+d_-\Phi(d_-)\Big)\right]^2. \end{aligned}$$

Equilibrium in dealer market (2)

Proposition 2

The equilibrium price and the per-unit fee in the dealer market, p_{d} and c_{d}, satisfy the simultaneous equation system

$$(\mu_\zeta - \mu_M)\Phi(\hat{d}_\pm) \mp \sigma_\zeta[\phi(\hat{d}_\pm) + 2\hat{d}_\pm\Phi(\hat{d}_\pm)]$$
$$-\frac{\gamma\sigma_\zeta\sigma_M^2}{a\sigma_v^2}\Phi(\hat{d}_\pm)\left[\left(\phi(\hat{d}_+) + \hat{d}_+\Phi(\hat{d}_+)\right) - \left(\phi(\hat{d}_-) + \hat{d}_-\Phi(\hat{d}_-)\right)\right] = 0,$$

where

$$\hat{d}_\pm = \pm\frac{\mu_I - a\sigma_v^2\bar{\omega} - (p_{\mathrm{d}} \pm c_{\mathrm{d}})}{\sigma_I^2 + a^2\sigma_v^4\sigma_\omega^2}.$$

Relationship between the two systems

Corollary 1

$$\begin{pmatrix} p_{\mathrm{d}} \\ c_{\mathrm{d}} \end{pmatrix} \to \begin{pmatrix} p_{\mathrm{b}} \\ c_{\mathrm{b}} \end{pmatrix} \text{ as } \gamma \to \infty.$$

Proof.

Note that

$$R(p,c) = (p-v)\sum_{i\in\mathscr{I}} x_i^*(p,c) + c\sum_{i\in\mathscr{I}} |x_i^*(p,c)|$$

and $\mathbb{V}[R(p,c)]$ must be zero if $\gamma \to \infty$. □

Numerical Analysis

Welfare analysis

- Basecase parameters:

a	σ_ω	σ_v	μ_I	σ_I	μ_M	$\bar{\omega}$	γ	σ_M
1	1	0.5	1	1	1	1	0.5	0.25

- Note that

$$\mu_\zeta = .75 < \mu_M = 1.$$

- X: trading volume defined by

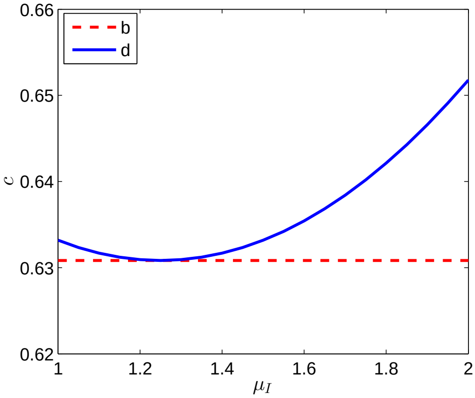
$$X = \sum_{i \in \mathscr{I}} |x_i^*| = \int_{\mathscr{I}} |x_i^*(\zeta)| q_I(\zeta) \mathrm{d}\zeta.$$

- We define the total welfare of investors by

$$U_I = \int_{\mathscr{I}} U_i(\zeta) q_I(\zeta) \mathrm{d}\zeta.$$

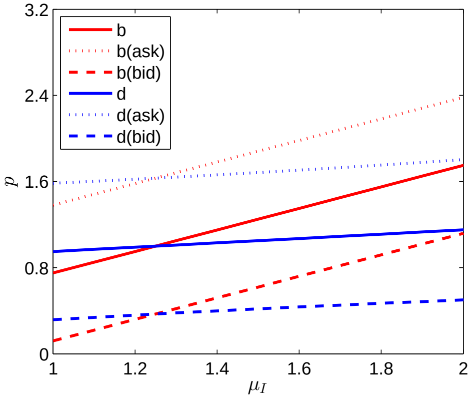
Effect of μ_I (1)

μ_I: mean of $\mathbb{E}[v|\mathscr{F}_i]$, c: per-unit fee.



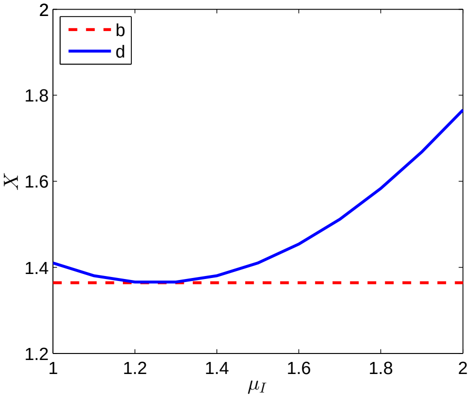
Effect of μ_I (2)

μ_I: mean of $\mathbb{E}[v|\mathscr{F}_i]$, p: asset price.



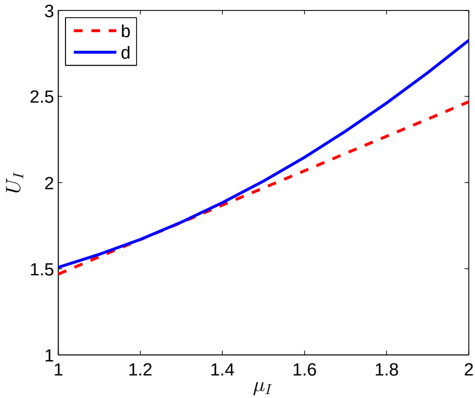
Effect of μ_I (3)

μ_I: mean of $\mathbb{E}[v|\mathscr{F}_i]$, X: trading volume.



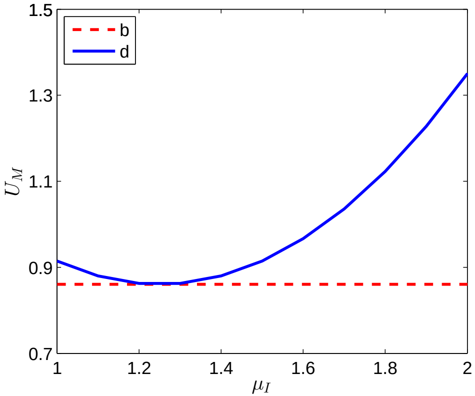
Effect of μ_I (4)

μ_I: mean of $\mathbb{E}[v|\mathscr{F}_i]$, U_I: total welfare of investors.



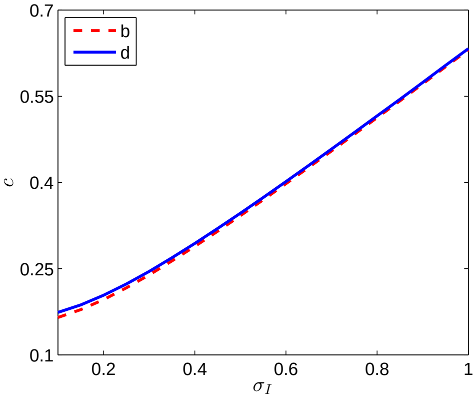
Effect of μ_I (5)

μ_I: mean of $\mathbb{E}[v|\mathscr{F}_i]$, U_M: utility of dealer/broker.



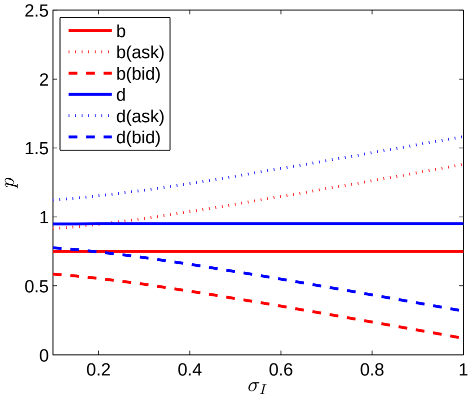
Effect of σ_I (1)

σ_I^2: variance of $\mathbb{E}[v|\mathscr{F}_i]$, c: per-unit fee.



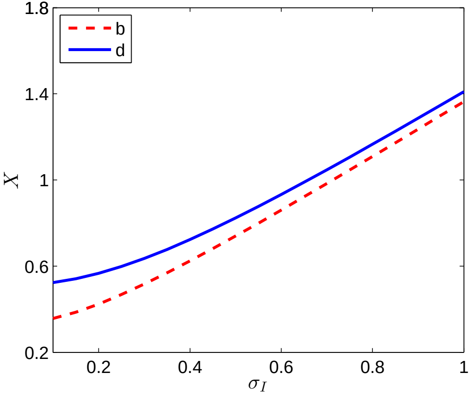
Effect of σ_I (2)

σ_I^2: variance of $\mathbb{E}[v|\mathscr{F}_i]$, p: asset price.



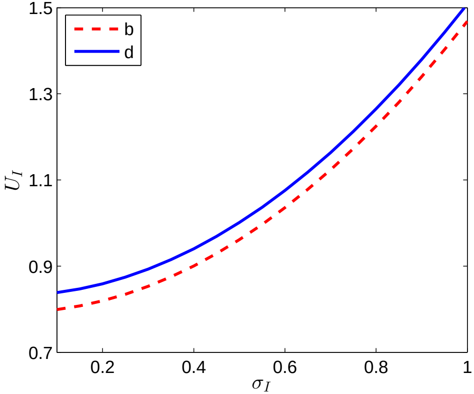
Effect of σ_I (3)

σ_I^2: variance of $\mathbb{E}[v|\mathscr{F}_i]$, X: trading volume.



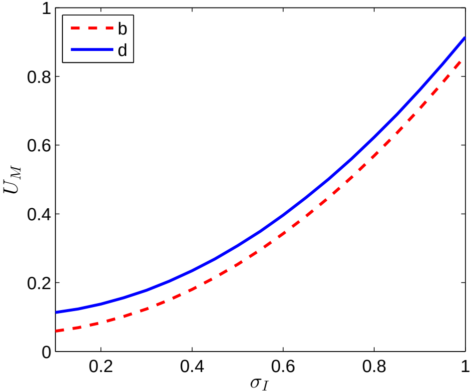
Effect of σ_I (4)

σ_I^2: variance of $\mathbb{E}[v|\mathscr{F}_i]$, U_I: total welfare of investors.



Effect of σ_I (5)

σ_I^2: variance of $\mathbb{E}[v|\mathscr{F}_i]$, U_M: utility of dealer/broker.



Comparison with Sarkar (1995)

	Sarkar (1995)	our study
Fee	$c_{\mathrm{b}} > c_{\mathrm{d}}$	$c_{\mathrm{b}} < c_{\mathrm{d}}$
Trading volume	$X_{\mathrm{b}} > X_{\mathrm{d}}$	$X_{\mathrm{b}} < X_{\mathrm{d}}$
Welfare	$U_{I\mathrm{b}} > U_{I\mathrm{d}}$ (if informed)	$U_{I\mathrm{b}} < U_{I\mathrm{d}}$ (on average)
	$U_{I\mathrm{b}} < U_{I\mathrm{d}}$ (if uninformed)	

Implication

- The final wealth of dealer/broker:

$$R(p,c) = \underbrace{(p-v)\sum_{i\in\mathscr{I}} x_i^*(p,c)}_{\text{random payoff}} + \underbrace{c\sum_{i\in\mathscr{I}} |x_i^*(p,c)|}_{\text{certain payoff}}$$

- Profit by proprietary trading (random payoff) can have a positive effect on the ex-ante utility of an investor, while fee revenue (certain payoff) always has a negative effect.
- Proprietary trading is always beneficial to investors in average.
  - Dealer sets a favorable price for investors to seek profits by proprietary trading.

Conclusion

Conclusion

- Research question:
  How does proprietary trading affects a financial market with a monopolistic dealer/broker?
- Answer:
  It has a positive effect on both a monopolistic dealer and investors.
- Why?
  Profit seeking by dealer with proprietary trading induces a more favorable price for the average investor.

References I

- Bernhardt, D. and B. Taub (2010), "How and When Is Dual Trading Irrelevant?", *Journal of Financial Markets*, **13**(2), 295–320.
- Heidle, H.G. and R.D. Huang (2002), "Informed-Based Trading in Dealer and Auction Markets: An Analysis of Exchange Listings", *Journal of Financial and Quantitative Analysis*, **37**(3), 391–424.
- Hellwig, M.F. (1980), "On the Aggregation of Information in Competitive Markets", *Journal of Economic Theory*, **22**(3), 477–498.
- Huang, R.D. and H.R. Stoll (1996) "Dealer versus Auction Markets: A Paired Comparison of Execution Costs on NASDAQ and the NYSE", *Journal of Financial Economics*, **41**(3), 313–357.
- Kim, O. and R.E. Verrecchia (1991), "Trading Volume and Price Reaction to Public Announcement", *Journal of Accounting Research*, **29**(2), 302–321.

References II

- Pagano, M. and A. Röell (1992), "Auction and Dealership Markets. What Is the Difference?", *European Economic Review*, **36**(2-3), 613–623.
- Pagano, M. and A. Röell (1996), "Transparency and Liquidity: A Comparison of Auction and Dealer Markets with Informed Trading", *Journal of Finance*, **51**(2), 579–611.
- Röell, A. (1990), "Dual-Capacity Trading and the Quality of the Market", *Journal of Financial Intermediation*, **1**(2), 105–124.
- Sarkar, A. (1995), "Dual Trading: Winners, Loser, and Market Impact", *Journal of Financial Intermediation*, **4**(1), 77–93.
- Viswanathan, S. and J.J.D. Wang (1995), "Market Architecture: Limit-Order Books versus Dealership Markets", *Journal of Financial Markets*, **5**(2), 127–167.

Thank you for your attention