Market Quality and Information Known to Market Makers

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Abstract

Market makers often have concentration of information due to their unique positions in securities markets. Whether their information sources should be made accessible to other market participants is a public policy concern. This article provides insights into the issue in theoretical perspective. We show that disclosure of market makers' information tends to increase market liquidity and decrease the costs of uninformed trading when the competition in market making is intense. When the competition is weak, however, the disclosure will decrease market liquidity and increase the trading losses of uninformed traders. The results have public policy implications for improving the quality of securities markets and promoting the interest of public investors.

I. Introduction

Market makers often have access to some information that is not accessible to other market participants. Exchange specialists, for example, exclusively handle the limit order book and see more of consolidated order flows. Over-the-counter dealers may maintain close contact with the firms whose securities they trade and can receive orders directly from customers, including institutional investors. These exclusive sources of information provide market makers a comparative advantage over other players in the marketplace. Yet, whether market makers' informational access should be open to other market participants is a public policy concern for improving the quality of securities markets and promoting the interests of public investors. Some quick thoughts seem to hint that the question may not have a simple, straightforward answer. On the one hand, exclusive possession of information by market makers may hinder the practice of fair and competitive securities trading if they pursue to profit from their privileged positions.[1] On the other hand, market makers as suppliers of liquidity or immediacy, sets the terms of trade to battle privately informed traders at the expense of uninformed traders.[2] Privileged information may enhance market makers' selection against informed traders and thus improve the terms of trade for uninformed traders. Therefore, it is not clear that opening market makers' informational access will have a positive net impact.

This article attempts to provide insights into the issue by examining the effect of opening market makers' informational access on the performance of securities markets. The analysis is based on a trading model in the spirit of Kyle (1985, 1994). In particular, a single risky security is traded by three types of risk-neutral traders: informed traders, market makers, and uninformed traders. Both informed and uninformed traders submit market orders to market makers, who set the pricing rule and absorb the net demand from the others. While uninformed trading is based on liquidity reasons, informed traders trade strategically on private information and hide it behind uninformed trading. In the current model, market makers are assumed to possess private information related to the fundamental value of the security before trading takes place. They

[1] Christie and Schultz (1994) and Christie, Harris, and Schultz (1994) present evidence that NASDAQ dealers implicitly collude to set bid-ask spreads for their stocks above competitive levels.

[2] See Glosten and Milgrom (1985), (1987), Glosten and Harris (1988), and Stoll (1989) among others for theoretical arguments and empirical evidence.

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incorporate the information into their pricing rule when trading begins. Informed traders thus face uncertainty about market makers' pricing rule when they choose order sizes. The model also assumes imperfect competition among market makers so they earn positive expected profits from market making. This assumption makes it possible to take account of possible changes of their competition intensity as well as trading profits in the analysis.

We compare the characteristics of the market as defined above, where market makers have private pre-trade information, with the characteristics of a market elsewhere identical except that market makers' pre-trade information is publicly disclosed prior to trading. Our main focus is on changes of market liquidity, the informational efficiency of equilibrium prices, and the distribution of trading profits across three types of traders as a result of the disclosure. A key argument in the analysis is that disclosure of market makers' pre-trade information has two effects working in opposite directions. First, it enhances informational strength of informed traders by eliminating their uncertainty about market makers' pricing schedule. Facing relatively strengthened informed traders, market makers are prone to increase the sensitivity of prices to total net order flows submitted by informed and uninformed traders. This tends to decrease market liquidity and increase the expected costs of uninformed trading. Second, the disclosure increases the intensity of information-based competition among informed traders, thereby weakening their collective position in the trading game. Market makers would afford to loosen the price sensitivity to total net order flows. This effect tends to increase market liquidity and decrease the expected costs of uninformed trading.

We show that the net impact of disclosure of market makers' pre-trade information depends on the intensity of competition in both informed trading and market making, measured respectively by the number of informed traders and the number of market makers. In general, the disclosure tends to enhance market liquidity and improve the terms of trade for uninformed traders in a more competitive environment. Specifically, the disclosure tends to increase market liquidity and decrease the expected costs of uninformed trading in a market with intense competition in both informed trading and market making. In this case, the expected trading profits of informed traders and market makers tend to decline. When the intensity of competition is low, however, the disclosure will decrease market liquidity and increase the trading losses of uninformed traders to the informed and market makers. These results are not qualitatively changed if the entry or exit of market participants is allowed in the model.

The results have straightforward policy implications. As it has been recognized in previous studies, liquidity of a market increases assets prices (Amihud and Mendelson (1986, 1990, 1991)) and makes corporate governance more effective (Maug (1998)). The presence of uninformed traders enhances liquidity of a market with privately informed trading (Kyle (1985) and Admati and Pfleiderer (1988)). To enhance these aspects of market performance, our study suggests that it is beneficial to open market makers' exclusive informational access in the markets of actively traded securities. Easley et al. (1996) provide direct evidence that high volume stocks, normally having intense competition in market making, tend to have a higher arrival rates of informed traders. For the same reason, preserving informational privilege of market makers will enhance liquidity and protect uniformed traders in the markets of inactive securities, where the competition is in informed trading and market making is usually weak.

Several recent articles have studied closely related issues. Admati and Pfleiderer (1991) investigate the effect on market performance of the sunshine trading strategy, following which some liquidity traders identify their trades as not motivated by private information before they submit their orders. Using a noisy rational expectations model, the authors show that preannouncement typically decreases the trading costs of announcing liquidity traders and increases the informativenss of the equilibrium price. Foster and George (1995) examine how disclosure of the information on liquidity trade affects the market equilibrium when a subset of traders has better information of liquidity trading. They show that revealing the direction of liquidity trade in advance decreases the expected trading losses of liquidity traders. This result is consistent with the findings of Admati and Pfleiderer (1991). However, revealing the magnitude of trade decreases the trading losses of liquidity traders only if there is sufficient competition among informed traders. Madhavan (1992) analyzes how transparency of orders affects market behaviors and viability when order flow information is observable to both market makers and traders. Pagano and Roell (1996) consider how transparency of orders to market makers affects the trading costs of informed and uninformed traders. More recently, Lin and Zhang (2011) find that public information harms the insiders but benefits outsiders and noise traders. Kim and Mehrotra (20007) show that NASDAQ dealers make market only for stocks where they have competitive advantages in accessing order flow and in information. Abraham and Harrington (2011) find market makers use the information contained in stock buy and sell volumes to determine future stock bid and ask quotes. Our study adds to the literature. We focus on the impact of opening the exclusive informational accesses of market makers and explicitly recognize the importance of competition in both informed trading and market making.

The remainder of this article is organized as follows. Section II describes the model and derives the market equilibrium in both disclosure and non-disclosure cases. Section III characterizes changes of market performance due to the disclosure by comparing the equilibrium results of the two cases. Section IV concludes the paper.

II. The Economic Framework

A. Model description

Consider a game of one-shot trade of a risky security by three types of risk-neutral traders: *N* informed traders, *M* market makers, and an undetermined number of uninformed traders. The fundamental value of the security, *v*, is a random variable normally distributed with mean $\bar{v}$ and variance σ_v^2. Before trading takes place, informed traders become informed by observing a signal $\phi = v + \varepsilon$, where error ε is independent of *v* and is normally distributed with mean zero and variance σ_ε^2. The conditional probability distribution of *v* to informed traders thus has mean

$$E(v/\phi) = (1 - I_\phi)\bar{v} + I_\phi \phi,$$

and variance

$$Var(v/\phi) = \sigma_v^2 (1 - I_\phi),$$

where $I_\phi = \sigma_v^2 / (\sigma_v^2 + \sigma_\varepsilon^2)$, $0 < I_\phi \leq 1$. I_ϕ (= $[\sigma_v^2 - Var(v/p)]/\sigma_v^2$) reflects the extent of uncertainty about *v* being reduced on the basis of an observation of ϕ, and can thus be viewed as

a measure of the informativeness of the signal. $I_\phi = 1$ if the signal is perfectly informative ($\sigma_\varepsilon^2 = 0$), and $I_\phi \to 0$ if the signal carries little information ($\sigma_\varepsilon^2 \to +\infty$). In addition, market makers also observe a pre-trade signal $\varphi = v + \eta$, where error η is independent of v and ε and is normally distributed with mean zero and variance σ_η^2. Observing φ, market makers have

$$E(v/\varphi) = (1 - I_\varphi)\bar{v} + I_\varphi \varphi,$$

and

$$Var(v/\varphi) = \sigma_v^2 (1 - I_\varphi),$$

where $I_\varphi = \sigma_v^2 / (\sigma_v^2 + \sigma_\eta^2)$, $0 < I_\varphi < 1$, measures the informativeness of signal φ.

Given the above information setting, both informed traders and market makers make strategic decisions to maximize their expected profits from trading the security. Specifically, each of the informed determines the size of his market order $x_i = X(\phi; Y)$, i = 1, 2, … N, as a function of his available information; each of the market makers, trading by limit orders, chooses his demand $y_j = Y(p, \varphi; X)$, j = 1, 2, … M, as a function of market price p and his pre-trade information. In addition, each trader's decision takes into account the strategy of other traders. Note that in the above expressions we have applied the standard symmetry result to ease the notation complexity: in equilibrium all market makers choose the same strategy function Y and all informed traders choose the same strategy function X (see, e.g., Kyle (1984) and Admati and Pfleiderer (1988)). Unlike the informed, uninformed traders trade exogenously, not motivated by information related to the fundamental value. They trade on the basis of liquidity reasons, including risk-exposure adjustment, tax planning, the desire for immediate consumption, and idiosyncratic wealth shocks. Let the total demand from uninformed traders denoted by a random variable z. z is assumed to be independent of v, ϕ, and φ, and normally distributed with mean zero and variance σ_z^2.

Our model follows the basic structure of the models in Kyle (1984, 1985). In such a model, market makers do not see individual orders but rather set a market-clearing price given the aggregate net order flow. Yet, they can infer about informed traders' private information from the aggregate order flow. On the other hand, informed traders hide their private information from market makers behind uninformed trading and incorporate their expectations on market makers' pricing rule into the decision in selecting order size and trading intensity. As in Gould and Verrecchia (1985) and Kumar and Seppi (1994), market makers in our model are treated as quasi-insiders, possessing private pre-trade information. This information setting affects the strategic decision of informed traders, who do not observe market makers' pre-trade signal. In another different aspect, the current model assumes that the market making is not perfectly competitive so market makers can earn positive expected profits. Each market maker announces a demand schedule (inverse of his pricing schedule) and other traders can allocate their orders among different market makers. The number of competing market makers measures the intensity of competition in market making. As it will be shown in Section III, the intensity of competition affects changes of market performance due to disclosure of market makers' pre-trade information.

B. Equilibrium with no disclosure of market makers' pre-trade information

In this subsection we derive market equilibrium when there is no disclosure of market makers' pre-trade information. In the trading game that our model defines, informed traders and market makers trade to maximize their expected profits at the expense of uninformed traders. Evidently, the profits of an informed trader, denoted $\Pi_i^{IT}(X,Y)$, are given by $\Pi_i^{IT}(X,Y) = x_i(v-p)$, $i = 1, 2, \ldots N$, and the profits of a market maker, denoted $\Pi_j^{MM}(X,Y)$, are given by $\Pi_j^{MM}(X,Y) = y_j(v-p)$, j = 1, 2, … *M*. Further, the aggregate losses of liquidity traders, denoted *L*(*X*, *Y*), are given by $L(X,Y) = z(p-v)$. These expressions emphasize the dependence of profits or losses on strategy functions *X*, *Y*. Also denote the price as $p = P(w; X, Y)$, where $w = \sum_{i=1}^{N} x_i + z$, is the net market orders from informed and uninformed traders. Nash equilibrium is defined as a pair of *X*, *Y*, satisfying the following three conditions:

(1) Profit maximization of informed traders: For any alternative trading strategy *X'* and for any observation ϕ,

$$E[\Pi_i^{IT}(X,Y)/\phi] \geq E[\Pi_i^{IT}(X',Y)/\phi],\ i = 1, 2, \ldots N.$$

(2) Profit maximization of market makers: For any alternative demand schedule *Y'* and for any observation φ,

$$E[\Pi_j^{MM}(X,Y)/p,\varphi] \geq E[\Pi_j^{MM}(X,Y')/p,\varphi],\ \text{j} = 1, 2, \ldots M.$$

(3) Market clearing condition:

$$\sum_{i=1}^{N} x_i + \sum_{j=1}^{M} y_j + z = 0.$$

Note that the last two conditions converge to the market efficiency condition when the number of market makers, *M*, approaches infinity. With perfectly competitive market makers the equilibrium price is set to equal the expected fundamental value conditional on all information available to market makers. The following lemma gives the unique linear equilibrium with no disclosure of market makers' pre-trade information.

Lemma 1: *When market makers' pre-trade signal, φ, is not disclosed prior to trading, the equilibrium demand functions of informed traders and market makers are given as follows:*

$$X(\phi;Y) = \beta(\phi - \bar{v})$$

$$Y(p,\varphi;X) = -\frac{1}{M\lambda}[p - E(v/\varphi)] - \frac{(M-2)N\beta}{(M-1)M}[E(v/\varphi) - \bar{v}],$$

with the equilibrium linear pricing schedule given by:

$$P(w;X,Y) = E(v/\varphi) + \lambda\{w - \frac{(M-2)N\beta}{M-1}[E(v/\varphi) - \bar{v}]\},$$

where

$$\beta = [\frac{M-2}{(M+N-1)N}]^{1/2} \frac{\sigma_z}{\sigma_v} I_\phi^{1/2} \quad (1)$$

$$\lambda = [\frac{(M+N-1)N}{(M-2)(N+1)^2}]^{1/2} [1 - \frac{(M-2)NI_\varphi I_\phi}{(M-1)(N+1)}]^{-1} \frac{\sigma_v}{\sigma_z}(1-I_\varphi)I_\phi^{1/2}. \quad (2)$$

Proof of Lemma 1: Assume the demands of informed traders and market makers are given by:

$$X(\phi;Y) = \alpha + \beta\phi$$
$$Y(p,\varphi;X) = \gamma_0 + \gamma_1 p.$$

In equilibrium, the market clearing condition can be written as:

$$N(\alpha + \beta\phi) + M(\gamma_0 + \gamma_1 p) + z = 0.$$

Solving for p, we obtain

$$p = -\frac{\gamma_0}{\gamma_1} - \frac{1}{M\gamma_1} w,$$

where $w = N(\alpha + \beta\phi) + z$, is the net orders from informed and uninformed traders submitted to market makers. To market makers, w is informationally equivalent to p.

Each market maker takes into account the impact of his own demand, y, on the equilibrium price. Taking the strategies of informed trader and other market makers as given, he solves

$$\underset{y}{Max}\, E[y(v - p) / w, \varphi]$$

Note that

$$E[y(v - p) / w, \varphi] = E\{y[v + \frac{\gamma_0}{\gamma_1} + \frac{1}{(M-1)\gamma_1}(w + y)] / w, \varphi\}.$$

Each informed trader, taking the strategies of other informed traders and the expected demand schedule of market makers as given, faces the following maximization problem:

$$\underset{x}{Max}\, E[x(v - p) / \phi].$$

Note

$$E[x(v - p) / \phi] = E[x\{v + \frac{\gamma_0}{\gamma_1} + \frac{1}{M\gamma_1}[(N-1)(\alpha + \beta\phi) + x + z]\} / \phi].$$

Then all parameters in Lemma 1 can be derived from the solutions of the above maximization problems. The details of the derivation have been excluded but are available from the authors upon request.

In Lemma 1 the trading strategy of informed traders is captured by parameter β, which measures their trading intensity in response to private signal ϕ. β increases in both the signal's informativeness, I_ϕ, and the variance of uninformed trading, σ_z^2. This reflects a well-known fact that informed traders trade on private information behind uninformed trading. It is worthwhile noting that the equilibrium price schedule depends on market makers' observation of signal φ. This dependence has implications for the behavior of informed traders. Since they do not observe the signal, informed traders face uncertainty about not only the execution price but also the location of the equilibrium price schedule. As a result, informed traders are unable to fully anticipate the response of market prices to changes of the total net order flows.

The slope of the market makers' aggregate demand function, λ^{-1}, characterizes their strategic behavior. In fact λ^{-1} is commonly viewed as a measure of market liquidity, or depth, since λ is the parameter measuring the sensitivity of equilibrium prices to net order flows. From

expression (2), this measure of market liquidity decreases with the informativeness of informed traders' signal and increases with the variance of uninformed trading. It is a well-documented result that market makers respond to strengthening informed trading (uninformed trading) by making the market less (more) liquid. In the current mode, λ^{-1} also increases with the informativeness of market makers' pre-trade signal, I_{φ}. This implies that better-informed market makers provide a more liquid market, other things held constant. Obviously, the driving force behind this is the competition among market makers themselves.

The calculation of the expected trading profits or losses of traders is straightforward. The expected total losses of uninformed traders are given by:

$$\begin{aligned} E[L(X,Y)] &= E[z(p-v)] \\ &= \lambda\sigma_z^2. \end{aligned} \tag{3}$$

The expected total profits of informed traders and that of market makers are given respectively by:

$$\begin{aligned} E[\Pi^{IT}(X,Y)] &= NE[x(v-p)] \\ &= \frac{M-2}{M+N-1}\lambda\sigma_z^2, \end{aligned} \tag{4}$$

and

$$\begin{aligned} E[\Pi^{MM}(X,Y)] &= ME[y(v-p)] \\ &= \frac{N+1}{M+N-1}\lambda\sigma_z^2. \end{aligned} \tag{5}$$

Both informed traders and market makers generally make positive expected profits at the expense of uninformed traders. When the number of market makers, *M*, approaches infinity, the increasing competition in market making will ultimately drive the expected trading profit earned by each market maker to zero. However, uninformed traders still incur losses to non-competitive informed traders even when market making is perfectly competitive. The expected profit of each informed trader declines as N increases.

We analyze the extent to which the equilibrium security price reflects the fundamental value of the security. This is important because it indicates the performance of a market as a price discovery mechanism. To be consistent with the measure of information in this study, the informativeness of prices is defined as $I_p \equiv \frac{\sigma_v^2 - Var(v/p)}{\sigma_v^2}$. I_p measures the extent to which an observation of the equilibrium price decreases an uninformed individual's uncertainty about the security's value *v*. Also among our concerns are variability of equilibrium prices and variability of price changes after trading, measured respectively by *Var(p) and Var(v-p)*. These aspects of market performance have been extensively examined in recent studies. In this article we focus only on the direction of changes in these variables as a result of disclosing market makers' pre-trade information.

C. Equilibrium with disclosure of market makers' pre-trade information

We now consider traders' behaviors when the pre-trade information of market makers is publicly disclosed before trading takes place. Observing both public signal φ and private signal ϕ, informed traders have

$$E(v/\varphi,\phi) = E(v/\varphi) + \frac{Cov(v,\phi/\varphi)}{Var(\phi/\varphi)}[\phi - E(v/\varphi)]$$
$$= (1-\hat{I}_\phi)E(v/\varphi) + \hat{I}_\phi\phi,$$

and

$$Var(v/\varphi,\phi) = Var(v/\varphi)(1-\hat{I}_\phi),$$

where $\hat{I}_\phi \equiv \frac{Var(v/\varphi)}{Var(v/\varphi)+\sigma_\varepsilon{}^2}$, $0 < \hat{I}_\phi \le 1$, measures the informativeness of signal ϕ when φ is public information. In this case, the size of an informed trader's market order $\hat{x}_i = \hat{X}(\varphi,\phi;\hat{Y})$, i = 1, 2, … N, is a function of both ϕ and φ, given the demand schedule of market makers, $\hat{Y}$. Similarly, $\hat{y}_j = \hat{Y}(\hat{p},\varphi;\hat{X})$, j = 1, 2, … M, denotes the demand of a market maker in this case.

The Nash equilibrium of the strategic behaviors of informed traders and market makers can be defined identically under the information disclosure. Trading strategies $\hat{X}$, $\hat{Y}$, are chosen to satisfy the profit maximization conditions of each informed trader and each market maker and to satisfy the market clearing condition. The following lemma presents equilibrium result under the disclosure.

Lemma 2*: When market makers' pre-trade signal φ is disclosed prior to trading, the equilibrium demand functions of informed traders and market makers are given as follows:*

$$\hat{X}(\varphi,\phi;\hat{Y}) = \hat{\beta}[\phi - E(v/\varphi)]$$
$$\hat{Y}(\hat{p},\varphi;\hat{X}) = -\frac{1}{M\hat{\lambda}}[\hat{p} - E(v/\varphi)] - \frac{(M-2)N\hat{\beta}}{(M-1)M}[E(v/\varphi) - \bar{v}],$$

with the equilibrium pricing schedule given by:

$$\hat{P}(\hat{w};\hat{X},\hat{Y}) = E(v/\varphi) + \hat{\lambda}\hat{w},$$

where

$$\hat{\beta} = [\frac{M-2}{(M+N-1)N}]^{1/2}[\frac{\sigma_z{}^2}{Var(v/\varphi)}]^{1/2}\hat{I}_\phi{}^{1/2} \quad (6)$$

$$\hat{\lambda} = [\frac{(M+N-1)N}{(M-2)(N+1)^2}]^{1/2}[\frac{Var(v/\varphi)}{\sigma_z{}^2}]^{1/2}\hat{I}_\phi{}^{1/2}. \quad (7)$$

Proof of Lemma 2: Assume $\hat{X}(\phi;\hat{Y}) = \hat{\alpha} + \hat{\beta}\phi$ and $\hat{Y}(\hat{p},\varphi;\hat{X}) = \hat{\gamma}_0 + \hat{\gamma}_1\hat{p}$. Then the market clearing condition leads to $\hat{p} = -\frac{\hat{\gamma}_0}{\hat{\gamma}_1} - \frac{1}{M\hat{\gamma}_1}\hat{w}$.

The maximization problem of each market maker can be solved in the same way as in the case without the information disclosure.

Informed traders, now observing φ, faces no uncertainty about the strategic parameters of market makers. That is, both $\hat{\gamma}_0$ and $\hat{\gamma}_1$ are deterministic to them. Each speculator, taking the strategies of other informed traders and market makers as given, solves the following problem:

$$\underset{\hat{x}}{Max}\, E[\hat{x}(v - \hat{p}) / \varphi, \phi].$$

Note

$$E[\hat{x}(v - \hat{p}) / \varphi, \phi] = E[\hat{x}\{v + \frac{\hat{\gamma}_0}{\hat{\gamma}_1} + \frac{1}{M\hat{\gamma}_1}[(N-1)(\hat{\alpha} + \hat{\beta}\phi) + x + z]\} / \varphi, \phi].$$

Then all parameters in Lemma 2 can be derived from the solutions of the above maximization problems. A more detailed derivation is available from the authors.

In general, the equilibrium properties of traders' strategic behaviors remain unchanged. Yet, some differences arise as a result of disclosure of market makers' pre-trade information. First, informed traders incorporate the information provided by signal φ into their trading strategy, reflecting in increased trading intensity $\hat{\beta}$. Second, the equilibrium price schedule under the disclosure is deterministic to informed traders because φ is public information. In this case the zero-volume price $\hat{P}(0; \hat{X}, \hat{Y})$ is equal to the market makers' pre-trade conditional expectation $E(v/\varphi)$. Finally, the value of market liquidity measure λ^{-1} may change due to the information disclosure. Detailed discussions will be presented in Section III.

The expected trading losses of uninformed traders and the expected trading profits of informed traders and market makers are derived as follows:

$$E[\hat{L}(\hat{X}, \hat{Y})] = \hat{\lambda}\sigma_z^{\,2} \tag{8}$$

$$E[\hat{\Pi}^{IT}(\hat{X}, \hat{Y})] = \frac{M-2}{M+N-1}\hat{\lambda}\sigma_z^{\,2} \tag{9}$$

$$E[\hat{\Pi}^{MM}(\hat{X}, \hat{Y})] = \frac{N+1}{M+N-1}\hat{\lambda}\sigma_z^{\,2}. \tag{10}$$

The last expression shows that non-competitive market makers are still expected to make profits on the basis of information provided by the total net orders even though they have no private pre-trade information. Under the information disclosure, the informativeness of equilibrium prices is similarly defined as $\hat{I}_p \equiv \frac{\sigma_v^{\,2} - Var(v/\hat{p})}{\sigma_v^{\,2}}$. Variability of equilibrium price and variability of price changes after trading are measured by $Var(\hat{p})$ and $Var(v - \hat{p})$, respectively.

III. Impact of the Disclosure of Market Maker's Pre-trade Information on Market Performance

In this section we compare the equilibrium results with and without disclosure of market makers' pre-trade information about the fundamental value. We have shown that the strategic behaviors of informed traders and market makers depend on their available information and their relative informational strength. Subsequently, the information setting among all participants in

the market plays an important role in determining market liquidity, the distribution of profits across traders, and the informational efficiency of equilibrium price. Disclosure of market makers' pre-trade information is likely to affect these measures of market performance since it alters the information asymmetries between informed traders and market makers.

Apparently, disclosure of market makers' pre-trade information has two effects on market liquidity. First, it increases the relative informational strength of informed traders. As shown in Section II.C, observing φ improves informed traders' estimation of the security value and resolves their uncertainty about the equilibrium price schedule. This makes the informed able to infer the exact impact of net order flows on the equilibrium price. The disclosure thus effectively enhances the position of informed traders in dealing with market makers and adversely affects the selection of market makers against the informed. Accordingly, market makers are prone to increase the sensitivity of prices to net order flows, and this tends to decrease market liquidity.

Second, the disclosure increases the intensity of information-based competition among informed traders. From expression (1) and (6), it is easy to show $\hat{\beta} > \beta$, *i.e.*, the intensity of informed trading increases due to the disclosure. In other words, informed traders compete more aggressively on their private information in response to the public disclosure, though signal ϕ becomes less informative ($\hat{I}_\phi < I_\phi$). The intensified competition weakens the collective position of informed traders in dealing with market makers and improves market makers' selection against the informed traders. Hence, market makers are prone to decrease the price sensitivity to net order flows due to the competition pressure in market making. As a result, market liquidity tends to increase.

Given the two effects working in the opposite directions, we need to identify the determinants of their relative magnitude in order to characterize the net impact of the disclosure. The following proposition provides the necessary and sufficient condition for the positive effect of the disclosure on market liquidity to dominate the negative effect. The proof is straightforward.

Proposition 1: *Under the assumptions of the current model,* $\hat{\lambda}^{-1} > \lambda^{-1}$ *if and only if*

$$\Delta \equiv 1 - \frac{(M + N - 1)^2}{(M - 2)^2 N^2} - I_\varphi I_\phi > 0, \tag{11}$$

where $0 < I_\varphi < 1,\ 0 < I_\phi \leq 1$. *In addition,* $\frac{\partial \Delta}{\partial M} > 0,\ \frac{\partial \Delta}{\partial N} > 0.$

Proposition 1 shows that the nature of the net impact of the disclosure on market liquidity depends upon the number of informed traders and the number of market makers for a given level of informativeness of each signal. In the model, the number of traders in each group measures the intensity of competition among traders in that group. Thus, the proposition virtually states that the net impact of the disclosure is dependent upon the intensity of competition in informed trading and in market making. Moreover, the comparative static analysis indicates that the disclosure tends to increase market liquidity in a market with more intense competition among market makers or among informed traders. This result can be intuitively explained by the tradeoff between the two opposite effects of the disclosure. As argued before, the disclosure of

market makers' pre-trade information has a positive effect on market liquidity through intensifying the information-based competition among informed traders and a negative effect by reducing relative informational strength of market makers. The competition effect is absent when private information is held monopolistically, but it is significant when the number of competing informed traders is large. The information effect, on the other hand, diminishes when the number of market makers is increasing, since the greater competition in market making weakens market makers' position in the first place. Therefore, the positive competition effect tends to be dominating when the competition in informed trading or in market making is intense and it tends be dominated when the intensity of competition is weak.

The impact of the disclosure on market liquidity also depends on the degree of informativeness of each signal, I_φ, I_ϕ. By Proposition 1, there are $\frac{\partial \Lambda}{\partial I_\phi} < 0$, $\frac{\partial \Lambda}{\partial I_\varphi} < 0$. That is, increasing informativeness of either signal tends to adversely affect the net impact of the disclosure on market liquidity. In other words, for a given level of competition, the disclosure works more in the direction to decrease market liquidity when a signal is more informative. This result can similarly be explained by the tradeoff between two opposite effects of the disclosure. When informed traders or market makers are well privately informed prior to trading, the disclosure of market makers' pre-trade information tends to become less effective in intensifying the competition among informed traders than in reducing market makers' informational strength. Thus, in the presence of more informative signals, a greater level of competition in informed trading or in market making is required for the disclosure to increase market liquidity.

Changes of the distribution of profits across three types of traders can be examined by comparing expression (3)-(5) with expression (8)-(10) in Section II. It is easy to show:

$$E[\hat{L}(\hat{X},\hat{Y})] - E[L(X,Y)] = (\hat{\lambda} - \lambda)\sigma_z^{\,2}$$

$$E[\hat{\Pi}^I(\hat{X},\hat{Y})] - E[\Pi^I(X,Y)] = \frac{M-2}{M+N-1}(\hat{\lambda} - \lambda)\sigma_z^{\,2}$$

$$E[\hat{\Pi}^M(\hat{X},\hat{Y})] - E[\Pi^M(X,Y)] = \frac{N+1}{M+N-1}(\hat{\lambda} - \lambda)\sigma_z^{\,2}.$$

These expressions show that given *M*, *N*, and $\sigma_z^{\,2}$ the change in the expected losses of uninformed traders as well as the changes in the expected profits of informed traders and market makers are inversely related to the change in market liquidity. This result, together with Proposition 1, leads to:

Proposition 2: *Under the assumptions of the current model, disclosure of market makers' pre-trade information will decrease the expected losses of uninformed traders as well as the expected profits of informed traders and market makers if and only if*

$$1 - \frac{(M+N-1)^2}{(M-2)^2 N^2} - I_\varphi I_\phi > 0,$$

where $0 < I_\varphi < 1,\ 0 < I_\phi \le 1.$

As shown in Proposition 2, the competition affects the changes of the distribution of profits across traders. The disclosure will reduce the expected losses of uninformed traders to informed traders and market makers only when the competition in both informed trading and market making is intense. This result, along with Proposition 1, will be reinforced by the

presence of discretionary uninformed traders, who can choose to trade in alternative markets and during different time periods. When the disclosure increases liquidity and decreases the expected costs of uninformed trading in a market, more discretionary uninformed traders enter the market for lower transaction costs. More concentrated uninformed trading makes the market more liquidity and thus reduces the cost of uninformed trading further.

In addition, the above results are not qualitatively affected by the entry or exit of market makers and informed traders. To illustrate, consider the entry or exit by market makers. Suppose the expected trading profits of each market maker in the equilibrium under no disclosure is equal to a "reservation value" R , *i.e.*,

$$E[\Pi_j^{MM}(X,Y)] = \frac{N+1}{M(M+N-1)}\lambda\sigma_z^{\,2} = R, \quad \text{j = 1, 2, …, } M.$$

If the competition in the market is sufficiently intense so that the inequality (11) holds, the disclosure results in $\hat{\lambda}^{-1} > \lambda^{-1}$ in the absence of the entry or exit. When the entry or exit by market makers is allowed, some market makers will exit the market because

$$E[\hat{\Pi}_j^{MM}(\hat{X},\hat{Y})] = \frac{N+1}{M(M+N-1)}\hat{\lambda}\sigma_z^{\,2} < R.$$

From expression (7) in Lemma 2, $\hat{\lambda}$ increases as M declines. That is, market liquidity (after the disclosure) will decrease as market makers exit the market. This in turn increases the expected profits of each market maker who remains in the market. The process will continue until the expected profits earned by each market maker rise back to the reservation value. Denote the number of remaining market makers as $\hat{M}$. In equilibrium we have

$$\frac{N+1}{\hat{M}(\hat{M}+N-1)}\hat{\lambda}\sigma_z^{\,2} = \frac{N+1}{M(M+N-1)}\lambda\sigma_z^{\,2}. \qquad (12)$$

In the last equation, since $\hat{M} < M$, $\hat{\lambda}^{-1} > \lambda^{-1}$.

From (3) and (8), $E[\hat{L}(\hat{X},\hat{Y})] > E[L(X,Y)]$.

From (5), (10), and (12):

$$E[\hat{\prod}^{MM}(\hat{X},\hat{Y})] = \frac{N+1}{\hat{M}+N-1}\hat{\lambda}\sigma_z^{\,2} = \frac{\hat{M}}{M}\cdot\frac{N+1}{M+N-1}\lambda\sigma_z^{\,2} < E[\prod^{MM}(X,Y)].$$

From (4), (9), and (12):

$$E[\hat{\prod}^{IT}(\hat{X},\hat{Y})] = \frac{\hat{M}-2}{\hat{M}+N-1}\hat{\lambda}\sigma_z^{\,2} = \frac{\hat{M}(\hat{M}-2)}{M(M-2)}\cdot\frac{M-2}{M+N-1}\lambda\sigma_z^{\,2} < E[\prod^{IT}(X,Y)].$$

Following the same procedure, we can show that our conclusion also holds when the entry or exit by informed traders is allowed.

IV. Conclusion

This article examines the possible changes of market characteristics as a result of disclosing information known to market makers prior to trading. In the model, a signal risky security is traded among three types of risk-neutral traders: privately informed traders, uninformed traders, and

market makers that possess pre-trade information from their exclusive access. The strategic interaction between informed traders and market makers and the competition among the participants within each group determines the characteristics of the market. It is shown that disclosure of market makers' pre-trade information weakens the relative informational strength of market makers but intensifies the information-based competition among informed traders. The net effect depends on the competition environment of the market. Specifically, the disclosure tends to increase market liquidity and decrease the trading losses of uninformed traders to the informed and market makers only when the competition in both informed trading and market making is intense.

Our results provide insights into the issue on market makers' exclusive informational accesses in theoretical perspective. But the results are by no means presenting the solution to the issue. In practice, market makers' informational accesses are differential and delicate. In some cases, implementing and reinforcing the policy or rule suggested in this study would be formidably difficult, if not impossible. Nevertheless, this study adds to our understanding of the relationship between the performance of securities markets and the information known to market makers. Further research needs to concentrate on specific informational accesses of market makers under different trading mechanisms.

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