

Trade Disclosure Regulation in Markets with Negotiated Trades

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In dealership markets disclosure of size and price details of public trades is typically incomplete. We examine whether full and prompt disclosure of public-trade details improves the welfare of a risk-averse investor. We analyze a model of dealership market where a market maker first executes a public trade and then offsets her position by trading with other market makers. We distinguish between quantity risk and price revision risk. We show that if the market maker learns some information about the motive behind public trade, neither regime is unambiguously welfare superior. This is because greater transparency improves quantity risk sharing but worsens price revision risk sharing.

It is widely believed that greater transparency in the trading process is desirable. In this view, increasing disclosure in trading is desirable because it reduces adverse selection, encourages uninformed investors to participate in the market, and facilitates risk sharing. The purpose of this article is to examine circumstances in dealership environments in which requiring full and prompt disclosure may reduce welfare.¹ We model the market with trading in two stages, a common feature in dealership markets. In the first stage the public investor trades with a dealer. In the second stage the dealer manages her position by trading in the interdealer market. In this setting, the article asks whether full and prompt disclosure of first-stage trade details is welfare improving. As in the standard analysis, the market is a mechanism

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¹ Members of the London Stock Exchange, in which trade disclosure delays have varied considerably over time, have argued against prompt trade publication, because it reveals dealer inventories which impedes the ability to lay off positions and hampers liquidity [see Gemmill (1996) for details]. This seems, at best, a partial explanation, since increased transparency would increase the readiness of other dealers to trade with the dealer.

for risk sharing and for trading on information. However, we distinguish between two kinds of risks: quantity risk and price revision risk.

Quantity risk arises because the public investor faces an endowment shock and has to readjust his asset holdings. We find that greater transparency reduces adverse selection and leads to improved sharing of quantity risk. Greater transparency reduces the ability of the winning dealer in the first-stage to manipulate beliefs of the other dealers via her second-stage trading decision. Consequently the other dealers are more willing to share the public trade. Hence greater transparency leads to better quantity risk sharing between dealers in that the realized quantity allocations are closer to the optimal allocations.

Price revision risk arises when the investor negotiates with the dealer and in the process reveals private information about the true value of the asset (such as his motive for trading). This information causes the winning dealer in the first stage to revise her beliefs and the price at which she is willing to trade. With little transparency of first-stage trades, the prices offered by the winning dealer in the first stage reflect the private information contained in the trade. However, this first-stage price is not observed by the other dealers and hence the second-stage price reflects the private information partially. With greater transparency of first-stage trades, the other dealers are able to observe the price offered for the public trade and infer the information contained in the trade. Hence the second-stage price reflects the private information fully. This makes the first-stage price more sensitive to the information revealed during the negotiation of trade. Hence, with greater transparency, the public investor is forced to bear more of the price revision risk. Thus greater transparency reduces the welfare of the public investor, in a manner similar to the classic work of Hirshleifer (1971).²

Thus our analysis suggests that the impact of trade disclosure is intimately connected with the structure of the market. In a pure automated market, trading information is public knowledge. The agent doing a trade learns nothing that is not public knowledge. In contrast, in markets where trades are negotiated, each party may well learn about the other's motives for trading, their sense of urgency, and so on. Both parties may learn something even if no trade takes place.³ This complicates the information structure substantially. Dealers who are the counterparts to many trades have much information about the order flow that is not available to the public investor. In general, prompt trade disclosure reduces the dealer's informational advantage over

² Hirshleifer (1971) states that "the anticipation of public information becoming available in advance of trading adds a significant redistributive risk to the underlying technological risk (as to which state will obtain)." In Hirshleifer (1971), this occurs when there is a public announcement before trading. In our model, information revelation takes place through the revision of prices before the execution of trades.

³ The notion that the counterparties learn something even if no trade takes place is supported by the findings of Keim and Madhavan (1996), who report leakage of information prior to the trade date due to shopping of block trade in the upstairs market.

other public traders and therefore alters price formation and investor welfare. In particular, when the dealers are able to learn information about the motive for trade, and when the desire to insure the endowment risk is more important than adverse selection concerns, prompt trade disclosure can actually reduce the welfare of the public investor.

In addition to welfare implications of trade disclosure, our analysis has other interesting implications for the behavior of prices and investors in less transparent markets with negotiated trades. Absent risk premia and transaction costs, most models suggest that prices will equal the expected value of the asset, given all information including that contained in the order. However, in the absence of trade publication, a dealer competing for business rebates the price to reflect the profits she can make from exploiting the information. Thus, in less transparent markets, dealers will not avoid trading with informed investors, but on the contrary, will be prepared to make an apparent loss by trading with them in order to gather information which the dealers can subsequently exploit. Of interest, it also means that even if informed investors have the means to mask their identity (say, by using a broker) they would have little incentive to do so, since on average, well-informed investors enjoy lower average execution costs than the uninformed. Also, in general, well-informed investors would seek to distinguish trades which are informed from those which are not, since this improves the average price obtained by the well-informed investors.

Our model starts with a public investor trading with an arbitrarily chosen market maker (MM_0). The trade is motivated both by private information and by liquidity needs. The market maker takes a position, which she needs to manage, and she learns some information about the value of the stock, which she wishes to exploit. She therefore trades with other market participants in the second stage of trading. The price she offers to the public investor depends on her ability to manage her position, so we need to model this second stage if we are to understand how prices are set in the first stage.

In practice, a market maker can manage her position in the stock by trading with other dealers (either directly or through an interdealer broker system), or by altering her quotes, or by other means that encourage public order flow in a particular direction. We chose to model this second stage as taking place entirely in an interdealer market. This choice in part serves tractability and in part captures the primary risk-sharing mechanism in dealer markets.⁴

The outcome of trading depends on the bargaining strengths of the participants. We assume that all the bargaining power lies with the public investor

⁴ Lyons (1995) finds that interdealer trading constitutes more than 80% of trading in currency markets, while Naik and Yadav (1997a), Hansch, Naik, and Viswanathan (1998), and Reiss and Werner (1998) find it to be about 25% on the London Stock Exchange.

who manages to extract the entire surplus.⁵ This distribution of bargaining power can be enforced by assuming that the active party in each stage (the public investor in the first stage and MM_0 in the second) makes a take-it-or-leave-it offer. We also assume that the public investor does not split the trade [Glosten (1989) makes a similar assumption]. We make this assumption because simultaneous order splitting is rarely observed in practice.⁶

Our results depend on the extent to which MM_0 learns information beyond that conveyed by the order size. In practice, dealers learn the motivation behind trades imperfectly. While it is possible to model imperfect learning, doing so is cumbersome and the results fall somewhere between two extreme cases: one where she learns the information contained in the trade perfectly, and the other where she learns nothing more than the size of the trade. Therefore we focus on these two extreme cases. We show that when MM_0 learns nothing from the public investor beyond the size of the order, full and prompt public disclosure is always welfare optimal. However, when MM_0 does learn something about the motive for the trade, then trade publication can reduce welfare.

To our knowledge Lyons (1996) is the only other article that explicitly attempts to model risk sharing in the presence of asymmetric information in dealership markets. Lyons (1996) presents a “hot potato” model of the foreign exchange market that allows dealers to off-load order flow to other dealers. In the context of his model, Lyons (1996) considers the optimal transparency of interdealer trades from the perspective of the dealers as a group. In contrast, we focus on the issue of the transparency of public trades.⁷

In addition, a number of articles have considered the issue of trade disclosure in the context of financial markets. These articles include Admati and Pfleiderer (1991), Pagano and Roell (1996), and Madhavan (1995, 1996). While the basic elements of these articles are somewhat different, they all use the intuition that disclosure is good for risk-neutral uninformed investors because it reduces adverse selection. Disclosure is also an issue in models of dual trading [Roell (1990) and Fishman and Longstaff (1992)] because brokers may be able to identify certain customer trades as motivated by liquidity concerns. Our article differs from all of these articles

⁵ Our results are robust when we relax this assumption, so long as any change in bargaining power is unrelated to the changes in transparency. Empirically there is some support for the notion that investors can extract surplus in less transparent markets. For example, in an experimental market setup, Bloomfield and O'Hara (1999) find that in a low-transparency environment, the market makers pay to purchase order flow through lower bid-ask spreads.

⁶ On the NYSE when a brokerage house trades a block with a public investor, the latter implicitly promises not to trade again while the block is still on the broker's book. Franks and Schaefer (1992) note a similar phenomenon on the London Stock Exchange. In Seppi's (1990) theoretical model, investors can break up blocks, but choose not to.

⁷ Vogler (1997) presents a model that contrasts a dealership market with an auction market. However, the issue of asymmetric information does not arise in his setup, as all trades are public knowledge.

on disclosure in two critical ways: it explicitly models a dealership market as a two-stage trading process involving risk-averse intermediaries, and it considers risk-averse suppliers of order flow who are concerned not only about quantity risk but also about price revision risk. As we will show, this yields results and testable empirical implications that differ considerably from the literature.

Our article is organized as follows. Section 1 sets up the two-stage model and constructs the equilibrium with information transmission between the public investor and the dealer executing the trade. Section 2 endogenizes the public investors' trading strategy. Sections 3 and 4 investigate the effect of trade disclosure when no information is shared (and hence only the trade size is known) and when all the information is shared. Section 5 offers empirically testable implications arising because of information sharing in dealership markets. Section 6 concludes with suggestions for future research.

1. The Two-Stage Model

The basic structure of our model of a dealership market is as follows. We consider a dealership market where $K + 1$ identical market makers deal in a given stock. These market makers are risk averse (negative exponential utility), with a risk aversion coefficient of γ , and they possess zero starting inventory.⁸ The trading takes place in two stages. In the first stage, one out of $K + 1$ market makers receives an order of y shares which has some information associated with it. Without loss of generality, we label this market maker as MM_0 and define the order as the public investor wishing to purchase y shares. MM_0 asks for a price of p_1 (dollars per share) for the order of y shares. This price takes account of the information associated with the trade and it reflects the fact that in most dealership markets investors do not simply deal at quoted prices, but they negotiate a price for the deal. In our model, this price is determined by MM_0 's conjecture about the price that will result in the second stage of trading and the relative bargaining power of the public investor and MM_0 .

After MM_0 has executed the order, she retrades with the other K market makers in the second stage of trading. When the trade details are not disclosed, neither the order nor the associated information is known to the other market makers. In the second stage of trading, MM_0 trades a quantity q_0 shares with the other K risk-averse market makers who behave competitively with respect to the order and take up (due to symmetry) $q_i = q_0/K$ shares each at a price of p_2 dollars per share.

⁸ The zero starting inventory assumption is, in part, to capture the phenomenon in currency markets where dealers start flat and go home flat [Lyons (1995)], and, in part, to prevent the welfare comparison from being dependent on starting inventory positions.

We resolve the issue of bargaining between the public investor and MM_0 who executes the order in the first stage as follows. Since there exists a number of well-capitalized market makers, an investor who does not get a good price from a market maker once will go to other market makers. Consequently we assume that the bargaining power in the first stage rests with the public investor.⁹ We determine the first-stage price as the price that ensures that the market maker who gets the trade has the same expected utility as a market maker who does not get the trade.

When MM_0 negotiates an order from a public investor, say, for the purchase of y shares ($y > 0$), she learns some information about how much the shares are worth. The order size y alone is not a sufficient statistic for this information. We model this by treating the order as if it were the sum of two orders, x and u , where x is the informative component and u is the liquidity component.¹⁰ For expositional convenience, we call x the information contained in the order. MM_0 's private information about the order means that she knows more than what is conveyed by the order size y alone.

As discussed in the introduction, due to the nonanonymous nature of trading in dealership markets, while negotiating MM_0 learns information beyond that conveyed by the order size. In reality, this learning is imperfect. For tractability reasons, we examine two extreme cases: one where MM_0 infers the public investor's information perfectly (MM_0 observes x and u separately), and the second, where MM_0 infers nothing more than the information conveyed by order size (MM_0 observes only y). Clearly reality rests somewhere in between. We show in Section 3 that at one extreme where there is no learning (which is equivalent to anonymous trading), nondisclosure always makes the public investor worse off. However, at the other extreme, where there is perfect learning, welfare comparison with and without trade disclosure is ambiguous.

We assume that x and u are normally distributed with mean zero and variances σ_x^2 and σ_u^2 , and they are independent of each other. In the first case where MM_0 infers the public investor's information perfectly, x informs her about the true value of the shares w (the prior distribution on which is normal with mean 0 and variance σ_w^2) and hence she updates her beliefs to $E[w|x] = \phi x$. In the second case, where MM_0 learns nothing beyond the information in the order size, her conditional expectation of the payoff of the share equals $E[w|y]$.

⁹ Later in the article (see the end of Section 4), we consider a variant of our basic model in which some of the bargaining power resides with the market maker. The reason the market maker may have some bargaining power is that the public investor may be unwilling to negotiate with multiple dealers for fear his information will leak [see Seppi (1990)]. We model this by assuming that MM_0 passes only a fraction of the informational rent to the public investor. We find that the results are not substantially affected by this assumption.

¹⁰ At this stage, we assume that x and u are exogenous. In Section 2 we endogenize the public trade by endowing the public investor with a signal and liquidity shock and solve for the public investor's optimal trading strategy given the price schedule offered by the market.

Table 1
Notation in paper

Symbol	Definition
w	True value of the asset
$y = x + u$	Net order in stage 1
x	Informative component of order in stage 1, $E[w x] = \phi x$
u	Liquidity component of order in stage 1
p_1	Price (dollars/share) in stage 1 trading
p_2	Price (dollars/share) in stage 2 trading
q_0	Quantity traded by market maker 0 in stage 2
q_i	Quantity traded by MM_i , ($i = 1, \dots, K$) in stage 2
σ_I^2	MM_0 's updated estimate of variance of the share value
σ_U^2	MM_i 's updated estimate of variance of the share value

We summarize in Table 1 the notation used in this article.

We solve the model by backward induction. Suppose the initial order from the public investor is to buy y shares and MM_0 asks for a price of p_1 (dollars per share) for the trade in the first stage. We search for a linear equilibrium in the second stage of trading. We assume that MM_0 faces a price schedule from each of the K market makers (we discuss how this price schedule is arrived at later),

$$p_2 = \alpha + \beta q_i, \quad (1)$$

where p_2 is the price (dollars per share) that the i th market maker will accept for supplying a quantity of q_i shares. Then the optimization problem of MM_0 (given exponential utility and risk-aversion coefficient of γ) amounts to choosing q_0 to maximize

$$\begin{aligned} & -\frac{1}{\gamma} \log(-E[U_0(q_0)|x, u]) \\ & = (q_0 - y)\phi x + yp_1 - q_0 p_2 - \frac{1}{2}\gamma\sigma_I^2(q_0 - y)^2, \end{aligned} \quad (2)$$

where we have used the fact that MM_0 , having sold y shares in the first stage buys back q_0 shares in the second stage, which equals the sum of the shares sold by each of the other K market makers ($q_0 = \sum_{i=1}^K q_i$). Since all K market makers are identical, by symmetry, q_0 equals Kq_i . Also, we note that the conditional variance of the true value of shares according to MM_0 given her information equals $\sigma_I^2 = \sigma_w^2 - \phi^2\sigma_x^2$.¹¹

This second-stage trading equilibrium is along the lines of Subrahmanyam (1991), which implies that the other K market makers who do not receive the public order in the first stage of trading behave competi-

¹¹ For the sake of notational convenience, in this section we use ϕ and x as reduced forms. In Section 2 when we endogenize the investor's trading strategy, we specify the distributions of signal ($\tilde{v}$), endowment shocks ($\tilde{e}$), and derive explicitly optimal x and u . Expressions for ϕ and σ_I^2 in terms of the exogenous parameters can be easily obtained using Equations (13) and (16).

tively while trading in the second stage and receive their reservation utility. Therefore we set

$$-\frac{1}{\gamma} \log(E[U_i(q_i)|q_i]) = 0. \quad (3)$$

We show that an equilibrium exists if and only if the following inequality holds (see Appendix A):

$$\frac{\phi\sigma_x}{\gamma\sigma_I^2} < \sqrt{\sigma_x^2 + \sigma_u^2}. \quad (4)$$

This inequality can be interpreted as meaning that the market breaks down if the signal-to-noise ratio in the first stage of trading is too high.¹² To see this, suppose that MM_0 was able to trade at the unconditional expected value of the shares. Then the size of the position she would take would be equal to the expected value of the share given her private information (ϕx) divided by her risk aversion (γ) and her expectation of the variance (σ_I^2). The left-hand side of the inequality therefore is a measure of the size of trade MM_0 would like to make in response to her information. The right-hand side is the standard deviation of the total order and is therefore a measure of noise in the order flow. Thus our model requires that the signal-to-noise ratio should not be too high for the equilibrium to exist.¹³

If the above inequality is satisfied, then in equilibrium we get that (see Appendix A)

$$\begin{aligned} \alpha &= 0 \\ p_2 &= \beta q_i = \frac{1}{2}(1 - \Psi) [\phi x + \gamma\sigma_I^2 y] \\ q_0 &= Kq_i = \Psi \left[y + \frac{\phi x}{\gamma\sigma_I^2} \right] \end{aligned} \quad (5)$$

where

$$\Psi = \frac{1 - 2\eta}{1 + (\sigma_U^2/K\sigma_I^2)}$$

and

$$\eta = \frac{(1 + \frac{\phi}{\gamma\sigma_I^2}) \frac{\phi}{\gamma\sigma_I^2} \sigma_x^2}{(1 + \frac{\phi}{\gamma\sigma_I^2})^2 \sigma_x^2 + \sigma_u^2}.$$

¹² Glosten (1989) discusses a related condition in the context of an auction market.

¹³ Some exchanges allow trading halts to handle situations where information comes in too quickly. Such a trading halt can be interpreted as a temporary market breakdown. Bhattacharya and Spiegel (1998) present such an argument in the context of an analysis of NYSE trading halts. Lehmann and Modest (1994) discuss such halts in the context of the Tokyo Stock Exchange.

Note that the price p_2 and the quantity traded in the second stage are linear functions of order size y and of MM_0 's expected value of the shares ϕx . The parameter Ψ lies in the range $[0, K/(K+1)]$ and depends on the signal-to-noise ratio discussed earlier.¹⁴ If the signal is small (because ϕ or σ_x are close to zero), Ψ approaches the value $K/(K+1)$. The market is deep, the price is not very sensitive to information, and the net order quantity is shared equally among all the market makers. If the signal-to-noise ratio is high, Ψ approaches zero, the second-stage price is sensitive to MM_0 's expectation of the value of the share and the quantity traded among the market makers is small.

Given these results for the second stage, we solve for p_1 by assuming that all negotiating power resides with the public investor, that is, potential competition among market makers leads to the public investor capturing all the rents. So the expected utility of MM_0 equals

$$\begin{aligned} & -\frac{1}{\gamma} \log(E[U_0(q_0)|x, u]) \\ & = (q_0 - y)\phi x + yp_1 - q_0 p_2 - \frac{1}{2}\gamma\sigma_I^2(q_0 - y)^2 = 0. \end{aligned} \quad (6)$$

This gives us the first-stage trading price p_1 implicitly as

$$yp_1 = q_0 p_2 + (y - q_0)\phi x + \frac{1}{2}\gamma\sigma_I^2(q_0 - y)^2. \quad (7)$$

The investor pays yp_1 dollars to MM_0 in return for purchase of y shares, which consists of three parts:

- an amount equal to the payment MM_0 will make in the second stage of trading to replenish her inventory, $q_0 p_2$,
- compensation for being left short $(y - q_0)$ shares when the expected value of the shares rises by ϕx , and
- compensation for the risk MM_0 takes on by selling y shares, and buying q_0 shares in the second stage, $\gamma\sigma_I^2(q_0 - y)^2/2$.

We can also express the first-stage price p_1 in terms of the primitive variables.

Proposition 1. *The price offered for a trade in a dealership market without disclosure depends on its size and its information content. The relationship*

¹⁴ We show in Appendix A that the existence condition in Equation (4) is equivalent to $\eta < 0.5$.

between price and information is not monotonic and is given by

$$p_1 = \frac{1}{2}(1 - \Psi)\gamma\sigma_I^2 y + (1 - \Psi)\phi x - \frac{1}{2} \frac{\Psi}{\gamma\sigma_I^2} \frac{(\phi x)^2}{y}. \quad (8)$$

The first term is linear in y . It compensates MM_0 for the risk of holding inventory. The greater the signal-to-noise ratio (i.e., the lower the Ψ), the less liquid is the interdealer market, the larger the fraction of trade MM_0 retains on her account, and therefore the higher is the spread.¹⁵ On the other hand, the lower the signal-to-noise ratio (i.e., the closer is Ψ to its upper bound of $K/(K+1)$), the lower the fraction of the trade MM_0 retains on her own account, namely $1/(K+1)$, and therefore the lower is the inventory component of the spread.

The second term is the compensation MM_0 needs for retaining on her account a fraction $(1 - \Psi)$ of the public order when she knows that the expected value of the share is updated from zero to ϕx . As the signal-to-noise ratio tends to zero, the proportion of the trade she retains falls, so this component of the spread declines. On the other hand, the more informative the order, the higher is this component and the higher is the spread.

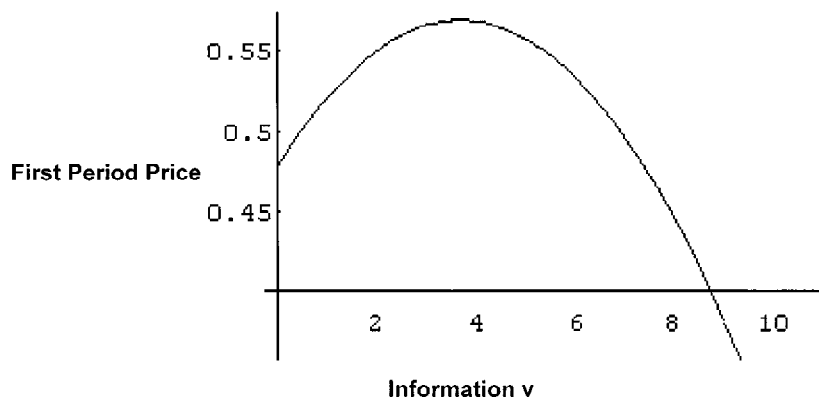
The third term can best be seen as a payment by MM_0 to the public investor for bringing information along with the trade. If an investor brings a highly informative but relatively small-size trade (due to, say, high risk aversion on the part of the public investor) then MM_0 would offer him a very attractive price. This is because MM_0 can then trade on that information in the second stage.

In order to highlight how the information and order size effects interact with each other, we consider a numerical example by specifying the following parameter values: $\sigma_y^2 = 37$, $\sigma_x^2 = 0.05$, $\gamma = 0.5$, $\phi = 0.24$, and $K = 10$. Figure 1 examines the relationship between the price in the first stage p_1 and the informativeness of the order, x , keeping the order size fixed. As discussed in the introduction, this relationship is not monotonic. Suppose we compare the price p_1 offered to public buy orders of a given size but with different information content. Then our model suggests that initially the price will increase with the information content. However, as the informativeness becomes large, the price starts to fall with the information content of the trade.¹⁶ This is because MM_0 compensates the public investor for the information contained in the trade which she exploits during subsequent trading. Hence our model implies that in a dealership market without trade disclosure orders of similar size may be executed at very different prices (depending on their information content).¹⁷

¹⁵ We define the spread as $p_1(y) - p_1(-y)$.

¹⁶ In Equation (8) the second term dominates the third term for small but not large values of x .

¹⁷ This implication is consistent with Wells (1992) who finds that similar-sized orders are executed at very

**Figure 1****First-period price versus information in the order flow**

The first-period equilibrium price is plotted against the information v learned by the first market maker while negotiating for the trade. The parameters are $\sigma_y^2 = 37$, $\sigma_x^2 = 0.05$, $\gamma = 0.5$, $\phi = 0.24$, and $K = 10$. The public order size, y , is fixed at 11.

2. Investor Welfare with Endogenous Trading Strategies

Until now we have assumed that the public trade size y and its information content x were given exogenously. However, the price schedule facing the public investor is affected by the disclosure regime itself. To perform a proper welfare comparison between different regimes, we need to endogenize the public investor's trading strategy. We do this by endowing the investor with an informative signal (regarding the payoff of the shares) as well as a liquidity shock (independent of the payoff of the shares) and solve for the investor's optimal trading strategy given the price schedule. In particular, we assume that the investor receives an endowment $\tilde{e}$ of shares which is distributed normally with mean zero and variance σ_e^2 and is independent of the payoff of the shares. We also assume that the investor observes a noisy signal $\tilde{v} = \tilde{w} + \tilde{\epsilon}$ of the payoff of the share where the $\tilde{\epsilon}$ is pure noise and is distributed normally with mean zero and variance σ_ϵ^2 . Thus $E[w|v] = \xi v = (\sigma_w^2/\sigma_v^2)v$ and $\text{var}[w|v] \equiv \sigma_I^2 = (\sigma_\epsilon^2\sigma_w^2)/\sigma_v^2$.

Given the information and liquidity shocks, we solve for the public investor's optimal trading rule in a dealership market without disclosure. We assume that the public investor exhibits negative exponential utility with a risk-aversion coefficient of θ . We conjecture that in a dealership market without disclosure, the revenue schedule (the total dollar amount to be paid

different prices and with Reiss and Werner (1993), Naik and Yadav (1997a), and Hansch, Naik and Viswanathan (1999), who observe that different types of investors face significantly different trading costs.

for the purchase of y shares) is quadratic in the quantity y and the information content of the trade v (which is equivalent to the conjecture that the optimal order size is linear in information v and endowment shock e), that is,¹⁸

$$p_1(y, v)y = Ay^2 + Byv + Cv^2. \quad (9)$$

Thus the public investor maximizes

$$\begin{aligned} & -\frac{1}{\theta} \log(-E[U(y)|v, e]) \\ & = -(Ay^2 + Byv + Cv^2) + (y + e)\xi v - \frac{1}{2}\theta\sigma_I^2(y + e)^2. \end{aligned} \quad (10)$$

The first- and second-order conditions with respect to y are given by

$$-2Ay - Bv + \xi v - \theta(y + e)\sigma_I^2 = 0 \quad (11)$$

$$\text{and} \quad -2A - \theta\sigma_I^2 < 0. \quad (12)$$

Rearranging Equation (11), we can express the optimal order size y in terms of information v and liquidity shock e as

$$y = \left(\frac{\xi - B}{2A + \theta\sigma_I^2} \right) v - \left(\frac{\theta\sigma_I^2}{2A + \theta\sigma_I^2} \right) e. \quad (13)$$

If we define

$$a = \frac{\xi - B}{2A + \theta\sigma_I^2} \quad \text{and} \quad b = -\frac{\theta\sigma_I^2}{2A + \theta\sigma_I^2},$$

then we can express the optimal order quantity y in terms of x and u of Section 1 as $y = x + u$, where $x = av$ and $u = be$. Using Equation (8) and noting that $\phi x = \xi v$, we can rewrite the revenue function in Equation (8) as

$$yp_1 = \frac{1}{2}(1 - \Psi)\gamma\sigma_I^2 y^2 + (1 - \Psi)\xi v y - \frac{1}{2}\frac{\Psi}{\gamma\sigma_I^2}\xi^2 v^2. \quad (14)$$

Comparing Equations (9) and (14) we get

$$\begin{aligned} A &= \frac{1}{2}(1 - \Psi)\gamma\sigma_I^2 \\ B &= (1 - \Psi)\xi \\ C &= -\frac{1}{2}\frac{\Psi}{\gamma\sigma_I^2}\xi^2, \end{aligned} \quad (15)$$

¹⁸ Consistent with Section 1, this assumes that MM_0 learns about v (the information of the public investor) perfectly. We will shortly express v and e in terms of x and u and the coefficients A , B , and C in terms of Ψ , γ , K , and σ_I^2 , etc., in Equation (8).

and hence that

$$\begin{aligned} a &= \frac{\xi \Psi}{(1 - \Psi)\gamma\sigma_I^2 + \theta\sigma_I^2} \\ b &= -\frac{\theta\sigma_I^2}{(1 - \Psi)\gamma\sigma_I^2 + \theta\sigma_I^2}. \end{aligned} \quad (16)$$

Since $A > 0$, the second-order condition in Equation (12) is satisfied. Thus we only need to examine the existence of equilibrium in the second stage (the interdealer trading stage). We do this by expressing Equation (4) in terms of the exogenous parameters. After some algebraic manipulation we obtain that the equilibrium in the second stage of trading exists if and only if

$$\frac{\sigma_\epsilon}{\sigma_v} \frac{1}{1 + \frac{\theta}{\gamma}} \{\theta\sigma_\epsilon\sigma_\epsilon\} > 1. \quad (17)$$

The existence condition has an intuitive interpretation. The left-hand side of Equation (17) can be thought of as a product of three terms: the first term captures the noise-to-signal ratio, the second term reflects the ratio of relative risk aversions (θ/γ), and the third term captures the extent of payoff unrelated component in the public trade. The interdealer market breaks down if the signal is too informative or if the dealers are too risk tolerant relative to the public investor or if the liquidity shock is small. In essence, on average the public trades, which the K market makers do not observe in a dealership market without disclosure, should contain sufficient payoff unrelated component (i.e., noise in the signal or liquidity component of trade) in order for them to trade with MM_0 . Otherwise, any retrading by MM_0 becomes primarily due to information and we get the no-trade type of result.

3. Anonymous Trading (No Learning of Information)

In this section we examine the equilibria with and without trade disclosure in the extreme case where MM_0 observes only y and learns no additional information.

In the case where trade details are not disclosed, we solve for the equilibrium by using $E[w|y]$ instead of $E[w|x]$ and by setting $\sigma_I^2 = \sigma_U^2$ in the solution obtained in Sections 1 and 2. This yields that

$$\begin{aligned} \eta &= \frac{\xi}{\gamma\sigma_I^2} \\ \beta &= \frac{\gamma\sigma_I^2}{1 - 2\eta} \left(\eta K + \frac{1}{2} \right) \end{aligned}$$

$$q_0 = \frac{K(1-2\eta)}{1+K}y$$

$$p_1 = \left[\xi + (\beta - \xi) \frac{K}{1+K} (1-2\eta) + \frac{1}{2} \gamma \sigma_I^2 \left(\frac{1+2\eta K}{1+K} \right) \right] y, \quad (18)$$

where $\xi = \text{cov}(v, y) / \text{var}(y)$. The condition for the existence of equilibrium is that $\eta < 0.5$ as before. As one expects, the price offered to the public investor in this case is linear in the order size y .

Next we solve for equilibrium in the case where the trade details are published immediately. As a result, the order flow y becomes known to all the dealers after the first stage of trading. We use the same notation as before, but we distinguish the regime with disclosure by using hats over relevant parameters.

Since the order flow y is public knowledge, the dealers do not have to infer it from the price in the second stage of trading. This leads to a second-stage price given by the condition that

$$-\frac{1}{\gamma} \log(-E[U_i(q_i)|y, q_o]) = \frac{\hat{q}_0}{K+1} (\hat{p}_2 - E[w|y]) - \frac{1}{2} \gamma \sigma_I^2 \left(\frac{\hat{q}_0}{K+1} \right)^2 = 0,$$

which yields

$$\hat{p}_2 = \xi y + \left(\frac{1}{2} \gamma \sigma_I^2 \right) \frac{\hat{q}_0}{K}, \quad \hat{\alpha} = \xi y, \quad \text{and} \quad \hat{\beta} = \frac{1}{2} \gamma \sigma_I^2. \quad (19)$$

With this price function, we substitute ξy for ϕx in our previous calculations [see Equation (A.6)], since y is the relevant information in this case, and obtain the first-order condition for MM_0 as

$$\begin{aligned} \hat{q}_0 &= K \hat{q}_i = \frac{K}{2\hat{\beta} + K\gamma\sigma_I^2} (\xi y - \hat{\alpha} + \gamma\sigma_y^2 y) \\ &= \left(\frac{K}{K+1} \right) y, \end{aligned} \quad (20)$$

where we use Equation (19) to eliminate $\hat{\alpha} = \xi y$ and $\hat{\beta} = (1/2)\gamma\sigma_I^2$. Thus, with full and prompt disclosure of first-stage trades, we find that there is complete quantity risk sharing. This is to be expected since trade publication removes all the information asymmetry in the model.

This, in turn, leads to the first-stage revenue

$$\begin{aligned} y \hat{p}_1 &= \hat{q}_0 \hat{p}_2 - (\hat{q}_0 - y) \xi y + \frac{1}{2} \gamma \sigma_I^2 (\hat{q}_0 - y)^2 \\ &= \xi y^2 + \frac{1}{2} \gamma \sigma_I^2 \frac{y^2}{K+1}, \end{aligned} \quad (21)$$

which yields the first-stage price

$$\hat{p}_1 = \left[\xi + \frac{1}{2} \gamma \sigma_I^2 \left(\frac{1}{K+1} \right) \right] y. \quad (22)$$

Thus in a dealership market with disclosure, the price the public investor obtains reflects the conditional expected value of the stock given the order size duly modified for compensation for quantity risk which gets shared equally among all the market makers. Once again, as one expects, the price offered to the public investor is linear in order size y .

Direct comparison of Equations (18) and (22) makes clear the following. When MM_0 learns no information beyond that contained in the order size y , for a public investor buy, the price in the dealership market without trade disclosure is always higher than that in the dealership market with prompt trade disclosure. Thus the welfare of a public investor is lower in a dealership market without trade disclosure even with endogenous trading strategies.

The intuition for our result is as follows. In this case where the dealers do not learn anything other than the order size, in equilibrium, the informativeness of the prices with and without trade publication is identical (in the sense that the K dealers are able to infer y perfectly even when there is no trade publication). However, there is a cost associated with nondisclosure of public trades in dealership markets. This cost arises because when there is no trade disclosure, MM_0 acts strategically and attempts to manipulate the informativeness of the interdealer market in the second stage. This results in her distorting her trade away from full quantity risk sharing [compare q_0 in Equation (18) with $\hat{q}_0$ in Equation (20)]. Because the dealership market with no trade publication involves imperfect quantity risk sharing, it results in higher prices for any given order flow relative to the dealership market with prompt trade publication.

The argument that we have outlined can be viewed in two ways. First, it presents a case for full trade disclosure. It is important to note that this argument for greater transparency depends on quantity risk sharing and hence differs from the usual arguments based on adverse selection in Pagano and Roell (1996) and related articles. Second, it provides circumstances under which prompt trade publication may be harmful, namely, if the hedging needs of the outside investor are relatively more important, and if information is communicated between the public investor and the first dealer (MM_0). Under these circumstances, as we show next, neither regime is unambiguously welfare superior.

4. Nonanonymous Trading with Perfect Learning of Information

We now consider the case where MM_0 learns the public investor's information perfectly. In Sections 1 and 2 we analyzed this case when there

is no publication of first-stage trades. As in Section 3, we distinguish the regime with trade disclosure by using hats over relevant parameters and endogenous quantities.

Suppose the price charged to the public investor in the first stage, $\hat{p}_1$, and the order quantity submitted by the public investor in the first stage, $\hat{y}$, are revealed before the second stage of trading. Given the structure of our model, revealing $\hat{p}_1$ and $\hat{y}$ amounts to revealing the informational and liquidity components of the order x and u , which in turn amounts to revealing the signal and endowment shock v and e of the public investor.¹⁹ So in the second stage of trading MM_0 cannot profit from the additional information she receives with the trade. Hence the structure of equilibrium with disclosure is similar to that in Section 2 except that the additional information is also disclosed. Hence each market maker (including MM_0) ends up with $\hat{y}/(K+1)$ number of shares (perfect quantity risk sharing) and knows the information v . We state this as Proposition 2.

Proposition 2. *If the first-stage price and quantity offered to the public investor in a dealership market are disclosed, then the price $\hat{p}_1(v, \hat{y})$ will be a linear function of order size and information and will be given by*

$$\hat{p}_1(v, \hat{y}) = \xi v + \frac{1}{2} \frac{1}{K+1} \gamma \sigma_I^2 \hat{y}. \quad (23)$$

Given this price schedule, the public investor now maximizes with respect to $\hat{y}$:

$$-\left(\xi v + \frac{1}{2} \frac{1}{K+1} \gamma \sigma_I^2 \hat{y}\right) \hat{y} + (\hat{y} + e)\xi v - \frac{1}{2} \theta \sigma_I^2 (\hat{y} + e)^2. \quad (24)$$

The standard first-order condition yields the optimal order quantity $\hat{y}$ as

$$\hat{y} = \hat{a} v + \hat{b} e$$

where

$$\hat{a} = \frac{\xi - \xi}{\frac{1}{K+1} \gamma \sigma_I^2 + \theta \sigma_I^2} = 0$$

¹⁹ The argument for this is as follows. Suppose there was an equilibrium in which the first stage $\hat{p}_1$ and $\hat{y}$ did not invert x . Then in the second stage, as $\hat{y}$ is known, the price would invert x . The equilibrium would thus be very similar to the case where there was no disclosure and no information beyond that in the order flow y , except that the inferred information in the second stage is now x . But then it must be that the first-stage price is linear in x and $\hat{y}$. Consequently the first-stage price must allow for the inference of x given $\hat{p}_1$ and $\hat{y}$. Hence there can be no manipulation of beliefs in the second stage.

and

$$\hat{b} = -\frac{\theta \sigma_I^2}{\frac{1}{K+1} \gamma \sigma_I^2 + \theta \sigma_I^2} = -\frac{\theta}{\frac{\gamma}{K+1} + \theta}. \quad (25)$$

Note that the optimal order quantity $\hat{y}$ does not depend on the realization of the signal, which implies that with full and prompt trade publication the public investor ends up bearing all the price risk. There is, however, perfect sharing of the quantity risk as the public investor and the $K + 1$ market makers end up holding shares in proportion to their respective risk tolerances. Note also from Equation (23) that the price the dealer charges the public investor fully reflects the information (ξv) together with compensation for bearing quantity risk. The classic work of Hirshleifer (1971) focuses on this ‘price revision risk’ due to the disclosure of information and argues that impact of such risk is negative from a welfare perspective. However, the analysis in Hirshleifer (1971) does not take into account the response of intermediaries to asymmetric information. Our model, on the other hand, takes into account the effect of both the price revision risk and the effect of adverse selection on sharing of quantity risk and thus is able to make welfare comparisons across the two disclosure regimes.

Having solved for the price schedules in a dealership market with and without disclosure, we now compare the public investor’s objective function under the two disclosure regimes [Equations (10) and (24)] and examine if the public investor is better off under one disclosure regime compared to the other. For the regime without trade disclosure, we substitute expressions for A , B , C , a , b [from Equations (15) and (16)] and the optimal order quantity y [from Equation (13)] in the objective function [Equation (10)]. This gives us the public investor’s objective function as the following quadratic function of his signal v and his liquidity shock e and all the exogenous parameters of the model.

$$\text{Objective (nondisclosure)} = \mathcal{F} v^2 + \mathcal{G} e v + \mathcal{H} e^2$$

where

$$\begin{aligned} \mathcal{F} &= \frac{\Psi \xi^2}{2\sigma_I^2} \frac{\gamma + \theta}{\gamma\{\gamma(1 - \Psi) + \theta\}} \\ \mathcal{G} &= \frac{\xi(\gamma + \theta)(1 - \Psi)}{\gamma(1 - \Psi) + \theta} \\ \mathcal{H} &= -\frac{1}{2} \frac{\theta \sigma_I^2 \gamma(1 - \Psi)}{\gamma(1 - \Psi) + \theta}. \end{aligned} \quad (26)$$

Similarly, in the case of a dealership market with disclosure we substitute the expression for $\hat{b}$ and the optimal order quantity $\hat{y}$ [from Equation (25)]

in Equation (24) to obtain

$$\text{Objective (with disclosure)} = \hat{\mathcal{F}} v^2 + \hat{\mathcal{G}} ev + \hat{\mathcal{H}} e^2$$

where

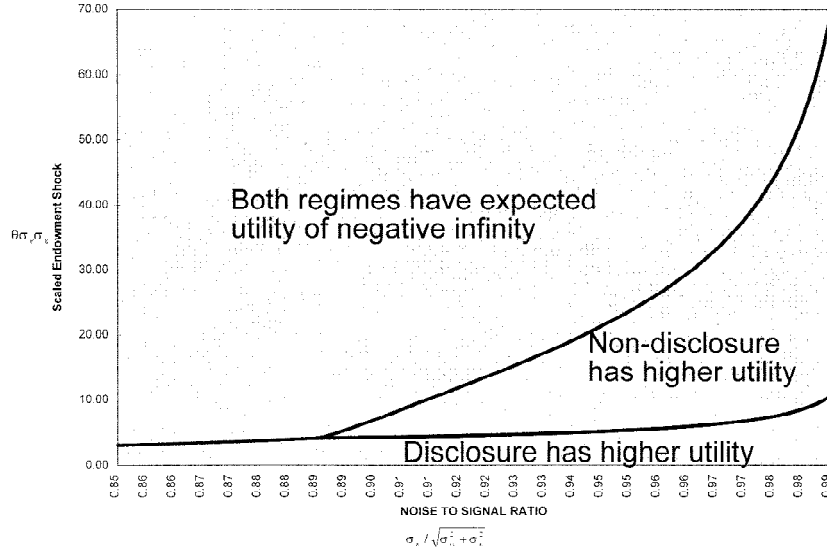
$$\begin{aligned}\hat{\mathcal{F}} &= 0 \\ \hat{\mathcal{G}} &= \xi \\ \hat{\mathcal{H}} &= -\frac{1}{2} \frac{\theta \sigma_I^2 \gamma}{\gamma + (K+1)\theta}\end{aligned}\quad (27)$$

The investor's objective function consists of three components. The first component depends on the information content of trade (v^2). Since $\mathcal{F}$ is positive, this component is increasing in v in the nondisclosure regime. This does not play any part in the regime with disclosure since there exists no information asymmetry. The second component of the objective function depends on whether the endowment shock is positive or negative when the signal is high or low. Clearly when the endowment is positive (negative) and the payoff on the risky asset is high (low), the public investor enjoys a higher utility.²⁰ The third component of the objective function depends on the liquidity shock (e^2), and utility is decreasing in this shock.

We evaluate the objective functions in Equations (10) and (24) which, under optimal trading strategies of the investor, take the form of Equations (26) and (27) for different constellations of parameter values of σ_w^2 , σ_e^2 , σ_ϵ^2 , γ , θ , and K . We find that neither the market with disclosure nor the market without disclosure dominates universally. In terms of the public investor's expected utility, for some parameter values the investor is unconditionally better off in the market with disclosure while for other parameter values the investor is better off in a dealership market with no disclosure. Figure 2 shows the regions where the dealership market with no disclosure dominates the market with disclosure and vice versa. Figure 2 sets $\sigma_w^2 = 0.1$, $K = 100$, and $\theta = \gamma = 1$. The x-axis measures the noise-to-signal ratio ($\sigma_\epsilon / [\sigma_w^2 + \sigma_\epsilon^2]^{(0.5)}$), while the y-axis measures the endowment scaled by the risk aversion ($\theta \sigma_e \sigma_\epsilon$). For a given value of the noise-to-signal ratio in the region 0.89 to 0.99, the welfare of the public investor is higher under a nondisclosure regime for high values of endowment shock. Hence we show that the traditional view that trade disclosure is welfare superior, expressed in the work of Pagano and Roell (1996), does not carry through to a world where investors are risk averse and care about price revision risk.²¹

²⁰ Note that $\mathcal{G} > \hat{\mathcal{G}} > 0$ and $\mathcal{H} < \hat{\mathcal{H}} < 0$. This is because $0 < \Psi < \frac{K}{K+1}$ (see end of Section 1).

²¹ For a high enough endowment shock, expected utility under both regimes is negative infinity and hence a utility comparison is not feasible.

**Figure 2****Welfare comparison of two disclosure regimes**

The region where the nondisclosure regime dominates the disclosure regime (and vice versa) is shown for different values of the endowment scaled by the risk aversion ($\theta\sigma_e\sigma_e$) and the noise-to-signal ratio ($\sigma_e/(\sigma_w^2 + \sigma_e^2)^{(0.5)}$). The parameters are $\sigma_w^2 = 0.1$, $K = 100$, and $\theta = \gamma = 1$.

Our welfare comparison is conducted on an unconditional basis. On a conditional basis, the welfare comparison is always ambiguous. If the signal is near the mean (v equals zero or close to zero), the public investor is better off in a regime with disclosure. If the signal is far from the mean, a regime without disclosure provides higher utility. Furthermore, for any given liquidity shock, there exists a signal level v^* where the public investor obtains the same utility in the two regimes, and this signal level is increasing in the magnitude of the endowment shock.

We examine the robustness of our results to the relaxation of the assumption that the public investor is able to capture all the informational rent. Recall that in Equation (8), the third term consists of the profits made by MM_0 by trading on the information in the public trade. If we assume that MM_0 passes a fraction ρ (where $0 \leq \rho \leq 1$) of this profit, then we can rewrite Equation (8) as

$$p_1 = \frac{1}{2}(1 - \Psi)\gamma\sigma_I^2 y + (1 - \Psi)\phi x - \left[\frac{1}{2} \frac{\Psi}{\gamma\sigma_I^2} \frac{(\phi x)^2}{y} \right] \rho. \quad (26)$$

Thus passing on a part of the profits only affects the last term in Equa-

tion (14), which now looks like

$$yp_1 = \frac{1}{2}(1 - \Psi)\gamma\sigma_I^2 y^2 + (1 - \Psi)\xi v y - \left[\frac{1}{2} \frac{\Psi}{\gamma\sigma_I^2} (\xi v)^2 \right] \rho. \quad (28)$$

We recompute the public investor's optimal trading strategy [Equations (13), (15), and (16)] and find that A and B do not change. Also, since a and b are independent of parameter C in Equation (9), the investor's optimal trading strategy (i.e., coefficients a and b) remains unaffected. The only parameter that changes is C in Equation (14) which gets scaled by ρ . We substitute these in Equation (9) to obtain the following amended version of Equation (26):

$$\text{Objective (nondisclosure)} = \mathcal{F}' v^2 + \mathcal{G} e v + \mathcal{H} e^2$$

where

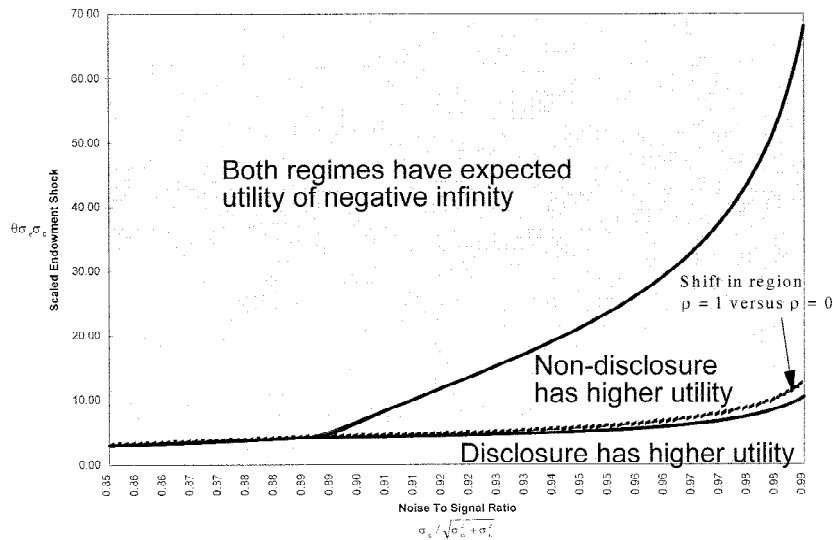
$$\begin{aligned} \mathcal{F}' &= \frac{\Psi \xi^2 [\Psi + \rho(1 - \Psi)]\gamma + \rho\theta}{2\sigma_I^2 \gamma \{\gamma(1 - \Psi) + \theta\}} \\ \mathcal{G} &= \frac{\xi(\gamma + \theta)(1 - \Psi)}{\gamma(1 - \Psi) + \theta} \\ \mathcal{H} &= -\frac{1}{2} \frac{\theta \sigma_I^2 \gamma (1 - \Psi)}{\gamma(1 - \Psi) + \theta}. \end{aligned} \quad (29)$$

Note that for $\rho = 1$, $\mathcal{F}'$ in Equation (29) reduces to $\mathcal{F}$ in Equation (26). Thus in the case where MM_0 passes on only a fraction of the rent to the public investor, this reduces the welfare of the investor and the region where nondisclosure dominates disclosure becomes smaller. This is illustrated in Figure 3, which shows the change in the region where nondisclosure dominates disclosure when one changes ρ from 1 (investor captures all informational rents) to 0.0 (dealer keeps all the profit made on information trading in the second stage).²² The change in the region is small, indicating the robustness of our results.

5. Empirical Implications

In classical models of dealership markets, trading is anonymous and the dealer sets prices which equal his conditional expectation of the value of the share given the size and direction of trade, modified appropriately to reflect order handling costs and to compensate the dealer for the risk arising from the trade. In contrast, our model focuses on the fact that trades are often

²² Note that the value of ρ does not affect welfare under the regime of prompt disclosure since in this case there is no passing of informational rent.

**Figure 3****Welfare comparison of two disclosure regimes ($\rho = 1$ and $\rho = 0$)**

The figure shows the change in the region where nondisclosure dominates disclosure (and vice versa) when ρ changes from 1 (investor captures all informational rents) to 0.0 (market maker keeps all the profit made by trading on information in the second stage). This is shown for different values of the endowment scaled by the risk aversion ($\theta\sigma_\epsilon\sigma_\epsilon$) and the noise-to-signal ratio ($\sigma_\epsilon/[\sigma_w^2 + \sigma_\epsilon^2]^{(0.5)}$). The parameters are $\sigma_w^2 = 0.1$, $K = 100$, and $\theta = \gamma = 1$.

negotiated and argues that while negotiating the dealers learn something about the identity of the investor and the motivation for the trade.²³ In particular, it argues that if dealers can themselves profit from the private information which comes with a trade, then competition for order flow will imply that the price offered for a trade will reflect the profit they anticipate from trading on their own account. Thus it offers testable implications which differ significantly from the classical models of dealership markets.

If dealers do use private information gathered from market making to trade on their own account, and if this phenomenon is of economic significance, one would expect to see evidence of it in the market. For example, if a public investor is seen to be buying shares at an unusually low price, our model suggests that the low price may be due to the dealer's belief that the trade is informative and that the low price reflects a payment to the investor for the information. If the informed investor is buying, that suggests that the price of the share would rise and the dealer MM_0 , who sold shares, would

²³ There is strong empirical evidence in support of this implication of our model. The studies of block trades in upstairs market by Keim and Madhavan (1996) and Madhavan and Cheng (1997) find significant reputation effects and price impacts that are linked to the likelihood that the trade is information motivated.

try to buy on her own account. This is in contrast with a more traditional view which explains a low execution price for a public buy as reflecting the dealer's low expectation of the share value. That suggests that the share is overvalued and the dealer is more likely to try to sell than to buy and the price of the share would fall over time.

Thus our model provides the following testable implications regarding share price movement and dealers' trading behavior subsequent to a public buy order executed at an unusually low price (by symmetry the opposite holds for public sell order).

Implication 1. If a dealer sells to a public investor shares at an unusually low price (compared to the price charged for similar trades executed by that dealer in the recent past), then over time the price of the share will rise.

Implication 2. The greater the price improvement the dealer offers to the public buy trade, the greater will be the extent of subsequent buying of shares by that dealer (as a fraction of the size of public trade).

Implication 3. Trades by company directors, insiders, successful active fund managers (or public investors who are perceived to be informed) will typically receive better, not worse, execution in less transparent negotiated markets. Thus even if informed traders have the means to mask their identity (say, by using a broker), they would have little incentive to do so.

Although our model is a stylized version of dealer markets, the intuition behind the model suggests that the informed dealer would wish to trade more rapidly and more clandestinely to minimize leakage of information. This provides us with the following additional testable implications:

Implication 4. The greater the price improvement offered to the public buy trade, the more rapid will be the extent of subsequent buying activity by that dealer in that stock.

Implication 5. Having executed an informed trade, the dealer is more likely to use channels where she does not have to reveal to other market participants the direction of her trades. For instance, the dealer would avoid changing her posted quotes and would rather attract public order flow by offering competitive prices on one side of the market.²⁴

Implication 6. Finally, if the private information has implications for other stocks (e.g., for stocks belonging to the same industry), then one would expect the dealer to exploit the information by trading in those stocks as well.

There is strong empirical evidence in support of several implications of our model. For example, the studies of block trades in the NYSE upstairs

²⁴ Lyons (1995) reports (in the last paragraph on page 344 of his article) a conversation with a dealer who stresses the importance of not shading prices, as it gives other dealers a sense of the dealer's inventory position.

market by Keim and Madhavan (1996) and Madhavan and Cheng (1997) find significant reputation effects and price impacts that are linked to the likelihood that the trade is information motivated. Analysis of large trades on the London Stock Exchange by Naik and Yadav (1997b) documents a strong relation between layoff and price changes and a weak relation between price improvement and subsequent price changes. Finally, Naik and Yadav's (1998) analysis of trades of individual dealers across correlated stocks finds evidence consistent with Implication 6 listed above.

6. Summary and Concluding Remarks

In this article we focus on the communication of information between the investor and the dealer due to the nonanonymous nature of trading in financial markets and examine the implications of prompt disclosure of public trades on an investor's trading strategies and welfare. We present a two-stage model of trading in a dealer market where the market maker executing a public trade learns information beyond that conveyed by the order size. The nondisclosure of the first-stage trade details allows the market maker who receives the order first to profit from the information that is learned; at least a part of this profit is then passed on to the public investor. This market structure differs considerably from the standard auction market and provides testable implications which are significantly different from those implied by the extant microstructure literature.

We believe that communication of information beyond that contained in the order size alone is an important feature of markets where trades are negotiated. If this were not to be the case, we show that prompt and complete trade disclosure is always optimal. This is because, in the absence of trade disclosure, optimal quantity risk sharing is not achieved as the dealer who executes the public order attempts to manipulate the beliefs of other market participants. However, when some information about the motive for trade is learned by the first dealer, we show that the welfare comparison with and without full and prompt trade disclosure is ambiguous. This is because a lack of trade disclosure worsens quantity risk sharing but improves price revision risk sharing, while full and prompt trade disclosure improves quantity risk sharing but worsens price revision risk sharing. This causes the welfare comparison to be ambiguous.

The traditional belief that full and prompt public disclosure of trades is always optimal is based on the idea that such disclosure reduces "adverse selection" and lowers the costs of trading for uninformed investors. We show that this reduction in adverse selection also leads to better quantity risk sharing. However, the standard adverse selection-based argument ignores the issue of "price revision risk" first analyzed in the classic work of Hirshleifer (1971). Disclosure reduces the ability of the market to offer insurance against price revision risk to investors who wish to hedge their en-

dowment shocks. Consequently there exists a tension between the adverse selection effect and the Hirshleifer effect, leading to an ambiguous welfare comparison.

There is a branch of the literature which relates informational efficiency with economic efficiency and studies the effect of more informative price systems on the quality of investment decisions of the managers and thereby the value of the firm [see, e.g., Dow and Gorton (1996), Habib, Johnson, and Naik (1997), and Dow and Rahi (1998)]. This is an interesting point for future research as one would expect a change in transparency to affect the informational efficiency of prices, which in turn would affect the quality of investment decisions, the value of the firms, and investor welfare.

In our model, we specified the number of market makers to be exogenous. One could argue that different disclosure regimes would affect the willingness of market participants to participate in risk sharing (via limit orders or becoming a market maker), which in turn could affect prices and investor welfare. Also, in our model we assumed that the public investor is endowed with a signal. If, in contrast, we had assumed that the public investor had to spend effort to collect information, different disclosure regimes would provide very different incentives for collecting information. In particular, a less transparent regime would provide an incentive to gather information as opposed to a more transparent regime which would offer little or no incentive. This would have a direct impact on the informativeness of the price system, the quality of investment decisions of managers, the value of the firms, and therefore investor welfare. We believe that these are important issues that future research needs to address.

Appendix A: Solving for the Equilibrium in Section 1

We solve for the equilibrium along the lines of Subrahmanyam (1991). In the second stage of trading MM_0 faces a price schedule from each of the K market makers,

$$p_2 = \alpha + \beta q_i, \quad (\text{A.1})$$

where p_2 is the price (dollars per share) the i th market maker will accept for trading a quantity of q_i shares. Thus the optimization problem of MM_0 (given exponential utility and a risk aversion coefficient of γ) amounts to maximizing:

$$\begin{aligned} & -\frac{1}{\gamma} \log(E[U_0(q_0)|x, u]) \\ & = \left(\sum_{i=1}^K q_i - y \right) \phi x + y p_1 - \sum_{i=1}^K [q_i(\alpha + \beta q_i)] - \frac{1}{2} \gamma \sigma_I^2 \left(\sum_{i=1}^K q_i - y \right)^2 \\ & = (K q_i - y) \phi x + y p_1 - (K q_i)(\alpha + \beta q_i) - \frac{1}{2} \gamma \sigma_I^2 (K q_i - y)^2, \end{aligned} \quad (\text{A.2})$$

where we have used the fact that MM_0 , having sold y shares in the first stage buys back q_0 shares in the second stage which equals the sum of the shares sold by each of the other K market makers ($q_0 = \sum_{i=1}^K q_i$). Since all K market makers are identical, by symmetry, $q_0 = Kq_i$. Also, we note that the conditional variance of the true value of shares according to MM_0 given her information equals $\sigma_I^2 = \sigma_w^2 - \phi^2 \sigma_x^2$.

The first-order condition with respect to q_i for the optimization in Equation (A.2) is

$$K\phi x - K\alpha - 2K\beta q_i - \gamma\sigma_I^2(Kq_i - y)K = 0 \quad (\text{A.3})$$

and the second-order condition (which we will come back to later) is

$$2\beta + K\gamma\sigma_I^2 > 0. \quad (\text{A.4})$$

The first-order condition can be rearranged to obtain

$$q_0 = \frac{K}{2\beta + K\gamma\sigma_I^2}(\phi x - \alpha + \gamma\sigma_I^2 y). \quad (\text{A.5})$$

Thus each of the other K market makers receives an order

$$q_i = \frac{1}{2\beta + K\gamma\sigma_I^2}(\phi x - \alpha + \gamma\sigma_I^2 y) \quad (\text{A.6})$$

and hence equivalently observe

$$z \equiv \phi x + \gamma\sigma_I^2 y. \quad (\text{A.7})$$

Therefore we can rewrite

$$q_i = \frac{\Psi(z - \alpha)}{K\gamma\sigma_I^2} \quad \text{where} \quad \Psi = \frac{1}{1 + \frac{2\beta}{K\gamma\sigma_I^2}}. \quad (\text{A.8})$$

Each of the other K market makers condition on the order that they receive from MM_0 and determine the price that they set for the order using a zero expected utility condition. Thus

$$E[w|q_i(x, u)] = E[w|z] = \eta z, \quad (\text{A.9})$$

where η is given by

$$\begin{aligned} \eta &= \frac{\text{cov}(w, z)}{\text{var}(z)} \\ &= \frac{(\phi + \gamma\sigma_I^2)\phi\sigma_x^2}{(\phi + \gamma\sigma_I^2)^2\sigma_x^2 + (\gamma\sigma_I^2)^2\sigma_u^2} \\ &= \frac{(1 + J)J\sigma_x^2}{(1 + J)^2\sigma_x^2 + \sigma_u^2} \end{aligned} \quad (\text{A.10})$$

where $J = \phi/(\gamma\sigma_I^2)$. Hence the utility that MM_i obtains is

$$\begin{aligned} -\frac{1}{\gamma} \log(E[U_i(q_i)|q_i]) &= q_i(p_2 - \eta z) - \frac{1}{2}\gamma\sigma_U^2 q_i^2 \\ &= q_i[p_2 - \eta(\frac{K\gamma\sigma_I^2}{\Psi}q_i + \alpha)] - \frac{1}{2}\gamma\sigma_U^2 q_i^2 \end{aligned} \quad (\text{A.11})$$

and the conditional variance given the information revealed in the second stage is $E[w|z] \equiv \sigma_U^2 = \sigma_w^2 - \eta^2 \sigma_z^2$, where from Equation (A.7) $\sigma_z^2 = [(\phi + \gamma \sigma_I^2)^2 \sigma_x^2 + (\gamma \sigma_I^2)^2 \sigma_u^2]$.

Equating the expected utility to the reservation value of zero for the market makers we obtain

$$p_2 = \eta \alpha + \left(\frac{\eta K \gamma \sigma_I^2}{\Psi} + \frac{1}{2} \gamma \sigma_U^2 \right) q_i. \quad (\text{A.12})$$

Comparing Equations (A.1) and (A.12) we get $\alpha = 0$ [since from Equation (A.10) we know that η is nonzero], and since $\Psi = \frac{1}{1 + (2\beta/K\gamma\sigma_I^2)}$ we get

$$\beta = \frac{\gamma[\eta K \sigma_I^2 + (1/2)\sigma_U^2]}{1 - 2\eta}. \quad (\text{A.13})$$

Using the expression for β above we obtain

$$\begin{aligned} q_i &= \frac{\Psi}{K} \left(y + \frac{\phi x}{\gamma \sigma_I^2} \right) \\ q_0 &= K q_i = \Psi \left(y + \frac{\phi x}{\gamma \sigma_I^2} \right) \\ p_2 &= \beta q_i = \frac{1}{2} (1 - \Psi) [\phi x + \gamma \sigma_I^2 y], \\ \text{where } \Psi &= \frac{1 - 2\eta}{1 + (\sigma_U^2/K\sigma_I^2)}. \end{aligned} \quad (\text{A.14})$$

Now we come back to the second-order condition [Equation (A.4)] and simplify it by substituting the expression for β from Equation (A.13) to give

$$\begin{aligned} 2\beta + K\gamma\sigma_I^2 > 0 &\iff \frac{2\gamma[\eta K \sigma_I^2 + (1/2)\sigma_U^2]}{1 - 2\eta} + K\gamma\sigma_I^2 > 0 \\ &\iff \frac{(\sigma_U^2/2) + K\gamma\sigma_I^2}{1 - 2\eta} > 0 \\ &\iff \eta < \frac{1}{2}. \end{aligned}$$

This can be further simplified to obtain Equation (4) as follows:

$$\begin{aligned} \eta < \frac{1}{2} &\iff 2(1 + J)J\sigma_x^2 < (1 + J)^2\sigma_x^2 + \sigma_u^2 \\ &\iff J < \sqrt{1 + \frac{\sigma_u^2}{\sigma_x^2}} \\ &\iff \frac{\phi\sigma_x}{\gamma\sigma_I^2} < \sqrt{\sigma_x^2 + \sigma_u^2}, \end{aligned}$$

which is the sufficient condition for the existence of equilibrium.

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