PUBLIC DISCLOSURE AND BROKERAGE SEARCH

W. David Zhang* and Mojtaba Seyedian

Subjecting corporations to a higher standard of financial disclosure affects the welfare of public investors in several ways. By examining the interaction between a large public investor and dealers, we show that disclosure affects the equilibrium transaction price in two ways: (1) Disclosure increases the precision of all market participants' signals regarding the value of the risky asset and increases the equilibrium price; (2) Disclosure reduces the adverse-selection risk counter-party traders associate with a large size trade and reduces the equilibrium price. The net, overall effect of trade disclosure depends on the interaction of these two effects. Further, we show that in order for a rational expectations equilibrium to exist, the quality of firm-specific information resulting from disclosure has to be modest relative the perceived need for non-information trading.

1. INTRODUCTION

Recent concerns about the adequacy of corporations' public disclosure of financial information and the behavior of corporations with respect to those disclosures have renewed interest in new regulations that would reduce the information asymmetry between insiders and investors. Considerable attention has been focused on whether present accounting standards mandate sufficient revelation on the financial well-being of firms[1]. Currently, there are a number of proposals before Congress that seek to raise the level of accounting standards governing public disclosure of financial information and increase the level of transparency with regard to the true value of public corporations. The recently enacted Sarbanes-Oxley Act of 2002 is but one example.

This paper presents a simple model to examine the interaction between a large investor (e.g. a manager of a mutual fund or pension fund) and dealers in the context of a price search process. In particular, we look at the impact of greater market transparency resulting from a higher standard of disclosure of publicly held firms. A key factor underlying our results is that the impact of public disclosure on the welfare of the investor results in an interaction between public information and risk sharing. While the objective of this paper is to provide a theoretical analysis of the impact of disclosure on public welfare, which is important in its own right, our results also have testable empirical implications.

*Corresponding address: Dr. Wei David Zhang, W317 Thompson Hall, School of Business, State University of New York–Fredonia, Fredonia, New York, 14063. phone: 716-673-4603, email: wei.zhang@fredonia.edu

One aspect of financial markets that has received little attention in studies on the issue of market transparency is its effect on the search behavior of large investors in connection with a brokerage service. In reality, the search for optimal prices and information by liquidity traders before executing a large trade is a fact of life. Over the last several decades, the participation of institutions, especially mutual funds and pension funds in securities markets has been increasing. The participation of financial institutions is evidenced by the substantial fraction of block trades in the market.[2] Relatively small portfolio adjustments by large financial institutions are often too large for a specialist to absorb. These large blocks of trade are often brought to the "upstairs market" maintained by large broker-dealer firms. These "blocks" are then "chopped" and searches are initiated for counter-parties. These trades are reported to the relevant specialists on the floor, i.e. "downstairs market", after counter-parties are located and deals struck. A number of authors have studied the price effect associated with block trades. Burdett and O'Hara (1987) analyzed the economic role and behavior of a block trader in a Bayesian sequential decision framework and demonstrate that the trading process may generate information effects on security prices. Grossman (1992) developed a model of upstairs versus downstairs markets and showed that equilibrium liquidity in both markets is characterized by the trade-off between the benefits of information about unexpressed demand and the cost to the customer of trading in a fragmented market. Using transaction data from upstairs trades, Keim and Madhavan (1996) find that price movements prior to the trade date are significantly and positively related to trade size, consistent with information leakage as the block is "chopped" upstairs. Recently, Wu and Zhang (2002) examined the effect of disclosure of securities market performance when liquidity traders are able to acquire information through learning. They found that liquidity traders do not necessary benefit from increased transparency. Zhang et al. (2004) examine the interaction of brokerage search with the Bayesian learning behavior of competitive dealers under asymmetric information. They show that both spread revision and price volatility are dependent upon the optimal search process, inventory fluctuation, and search cost. Most recently, Zhang (2004) has examined the interaction of risk aversion and disclosure and shows that, under a disclosure requirement, an insider would camouflage his trades with a noise component so that his private information is revealed slowly and linearly. The common theme of these works suggests that a large order is believed to contain more information and there is a positive relation between trade size and price impact. The impact of public disclosure on a liquidity trader's search strategy and the brokerage-search process, however, has not been considered.

In this paper, we extend the analysis of previous studies on large trades by developing a simple model in the rational expectation frameworks of Kyle (1985) and Grossman (1992). We examine the brokerage search process within the context of a large trade by an investor and effect of information from public disclosure on his welfare. Our article differs from previous articles on block trading in two critical ways. First, the trade initiator in our model is an uninformed liquidity trader who, through the services of a broker, obtains a signal regarding the value of a risky asset and contacts an optimal number of counter-party traders. The precision of this liquidity trader's signal depends on the availability of specific information about the risky security in the market resulting from public disclosure. In practice, such disclosure would take the form of outside auditing of a firm's financial information. Second, the welfare of the large investor is examined with respect to disclosure and its interaction with the brokerage search process. In particular, we examine the impact of public disclosure on different aspects of the equilibrium price of the risky asset. Our result suggests that disclosure affects the equilibrium price in two ways: (1) Public disclosure increases the precision of all market participants' signals regarding the value of the risky asset and increases the equilibrium price; (2) Public disclosure reduces the adverse-selection risk counter-party traders associate with a large trade and reduces the equilibrium price. The net, overall effect of trade disclosure depends on the interaction of these two effects.

The remainder of article is organized as follows. Section 2 presents the general framework of the model. Section 3 discusses the trading sequence and trading strategies of each type of trading agent. Section 4 derives the equilibrium price and the condition under which such an equilibrium exists. Section 5 examines the effect of public disclosure on the welfare of the large investor and discusses the empirical implications of our results. Section 6 summarizes the article.

2. THE BASIC FRAMEWORK

We consider an economy in which a risky asset (e.g. the stocks of a firm), whose value is uncertain, is traded. There are three types of agents in this model: a larger investor (e.g. the manager of a mutual fund and a pension fund) who initiates a large trade for portfolio hedging and/or other non-information reasons (i.e. a liquidity trader), a broker who facilitates the trade, and dealers who take the other side of the trade. Each agent maximizes his utility given his conjecture regarding the strategic behavior of other agents and his information about the true value of the risky security. We consider a dealership market where there are many identical dealers with homogeneous expectations dealing in the risky security. We assume that the risky security has a post trade full-information value of $\tilde{v}$ and a prior distribution that is normally distributed with a normalized mean zero[3] and a variance σ_v^2. Uncertainty can be represented by a random variable of any variety, but the normal distribution is well-behaved mathematically and understood at an intuitive level by most researchers. Dealers are risk averse with negative exponential utility and possess zero starting-inventory. The negative exponential utility function has desirable qualities for a utility function: it is increasing and concave in the consumable good (the risky asset), implying that dealers prefer more to less, but to a decreasing degree. The true appeal of the negative exponential utility function, however, is that when it is used in conjunction with the normal distribution, it results in a tractable analysis. Both the normal distribution and the negative exponential utility are standard in the paradigms of Kyle (1985) and Grossman (1992). We define the trade order as the liquidity trader wishing to buy Q shares of the risky asset, which is to be determined endogenously. Before executing the order, the liquidity trader would utilize the service of a broker. The service of the broker is needed for two reasons: (1) The liquidity trader would like the broker to locate an optimal number of dealers to share the order of Q shares in order to minimize the size impact; and (2) to search for information regarding the true value of the security in the process.

3. TRADING SEQUENCE

Our analysis examines the trading sequence in a reverse order. First, we consider the dealers who would take the opposite side of the trade. Second, we examine the process of brokerage search--the cost of search, the information signal obtained from the search, and how the number of counter-party dealers is chosen. Then, we analyze the strategy of the large investor, the endogenously determined order size Q, and the transaction price in a rational expectation equilibrium. Finally, we examine the impact of public disclosure on the welfare of the liquidity trader.

3.1 COUNTER-PARTY DEALERS

The size of the purchase order initiated by the liquidity trader, *Q*, is chosen endogenously by considering the supply from counter party dealers who, as noted earlier, are risk averse with negative exponential utility functions. Their optimization problem is one of mean-variance utility maximization given the post trade wealth constraint. That is, the ith representative dealer attempts to

$$\underset{q_i}{Max} \qquad E[\tilde{W}_i] - \frac{\rho}{2} Var[\tilde{W}_i], \qquad (1)$$

where $E[\bullet]$ and $Var[\bullet]$ represent the mean and variance operator, $\tilde{W}_i$ is the random post trade wealth and ρ is the coefficient of absolute risk aversion. The post trade wealth is given by

$$\tilde{W}_i = (\tilde{v} - p)q_i + z_i \qquad (2)$$

where $\tilde{v}$ is the full-information value of the risky asset, *p* the transaction price, *q* the number of shares of the risky security supplied by the ith dealer, and z_i is the ith dealer's cash holding. We assume counter-party dealers know the total size of the order. This assumption is motivated by a reputation consideration on the part of the broker who wishes to maintain long-term relationships with potential customers and business associates. Substituting Equation (2) into Equation (1) and maximizing utility with respect to q_i, we can derive the supply function from the representative dealer q_i. This yields

$$q_i(p,Q) = \frac{E\left\langle \tilde{v} \middle| Q \right\rangle - p}{\rho Var\left\langle \tilde{v} \middle| Q \right\rangle} \qquad (3)$$

The supply function depends on the total size of the order because the dealer's belief about the true value of the risky security, as will be seen later, depends on a noisy signal inferred from *Q*, the total trade size.

3.2 THE BROKER'S SEARCH

We assume the broker is a competitive agent who does not hold inventory but facilitates the optimal and efficient execution of a large trade by searching for information as well as for counter-party dealers[4]. The broker is competitive in the sense that he would expect zero profit from the order execution and only charges a commission based on his search effort. This is reasonable given that large investors such as financial institutions have much greater market power and are valuable customers a broker would like to keep. Further, potential competition from other brokers will tend to let large investors capture all the rent. In the course of search, the broker faces a number of problems. From the point of view of minimizing the impact of a large trade order on transaction price and obtaining information, he would like to contact as many dealers as possible. On the other hand, the cost of search will increase as the number of dealers contacted increases. Search costs will include the physical cost of making contact with dealers, which will be relatively small. More significant search costs are information cost and reputation cost. The cost associated with revealing a larger impending trade to an increasingly large group of people as more dealers are contacted is one type of information cost. The cost to the broker from failing to arrange the trade in a timely manner is related to both information costs and reputation costs. Reputation cost, in particular, may arise even if counter-party dealers realize that the broker and his client, the large investor, are manifestly uninformed. Dealers to whom a trade subsequently results in losses may be reluctant to participate in future trades arranged by the broker. Thus it is reasonable to model search cost as an increasing function of the number of dealers contacted. The cost associated with the search process will depend on the level of information flow in the market. With an increasing level of public disclosure by the firm, for example, information is easier to come by and thus the information cost will be reduced. Furthermore, with public disclosure of more information, reputation cost to the broker is reduced because county-party dealers are less reluctant to participate, which will also reduce the cost of failing to arrange a trade in a timely manner. It is therefore reasonable to assume the search cost will be inversely related to the level of information flow in the market. For our model, we consider a cost function of the form $C(n) = \frac{\lambda n^2}{f}$, where *n* is the number of counter party dealers who would take the opposite side of the trade. The constant λ is inversely related to the probability of locating willing counter party dealers. The marginal cost is increasing implying diminishing returns to search. The parameter *f* is related to the level of public information on the value of the firm.

Suppose *n* counter party dealers are contacted to take the opposite side of the trade, the equilibrium price that clears the market can be obtained by solving the following equation:

$$Q + \sum_{i=1}^{n} q_i(p, Q) = 0 \qquad (4)$$

Substituting equation (3) into equation (4), we can express the equilibrium transaction price as a function of the total trade size, *Q* and the number of counter party dealers, *n*:

$$p(Q,n) = E\left\langle \tilde{\nu} \middle| Q \right\rangle + \rho Var\left\langle \tilde{\nu} \middle| Q \right\rangle \frac{Q}{n} = E\left\langle \tilde{\nu} \middle| Q \right\rangle + \frac{\phi Q}{n} \qquad (5)$$

where $\phi = \rho Var\langle \nu \mid Q \rangle$ and is the variance conditional on *Q*. This term is related to the risk to a representative dealer from selling *Q/n* shares of the risky security. To execute a purchase order, a competitive broker conducts his search in a way that minimizes trading cost and search cost.

3.3 THE LARGE INVESTOR

In our model, the large investor comes to the market to trade for liquidity, portfolio hedging or other non-information reasons. To create a portfolio hedging motive for trade, we assume the liquidity trader is endowed with initial and unobservable holdings of h risky assets, where h is distributed normally with a normalized mean of zero and a variance of σ_h^2. In light of the strategies adopted by counter party dealers, the liquidity trader's order size *Q* must take into account the information obtained during the brokerage search process and its expected impact on the transaction price. In our model an information signal about the true value of the risky security can be obtained from the brokerage search process. To formalize this, we assume the liquidity trader, through the service of the broker, observes a private signal regarding the value of the risky asset[5] at the end of the search process but before the actual transaction. Let S_L denote the realization of this signal. S_L is drawn from a normal distribution with mean equal to the realized liquidation value *v* and variance $\frac{\sigma_v^2}{f}$, where *f* is related to the level of information in the market. For the sake of tractability and to focus on the effect of public disclosure, we assume *f* is only related to the accounting standard that governs the firm's financial disclosure. With more public information about the firm in the market, *f* is greater and the signal obtained from the search process is more accurate. The signal observed by the liquidity trader is drawn from a distribution of increasing precision. With an increasing flow of information, the signal to noise ratio increases with information flow. From the properties of the normal distribution [see for example, DeGroot (1970), p.167], the expected value of the security is a weighted average of the prior mean and the signal S_L,

$$E\left\langle \tilde{v} \middle| S_L \right\rangle = v_L = (1-\omega_0)0 + \omega_0 S_L \qquad (6)$$

where zero is the normalized prior mean and $\omega_0 = \frac{\sigma_v^2}{\sigma_v^2 + \frac{\sigma_v^2}{f}} = \frac{f}{f+1}$. The liquidity trader is also risk averse and has a utility function of the form given by equation (1). The post trade wealth of the investor is

$$\tilde{W}_L = \tilde{v}(Q+h) + Z_L - pQ - C \qquad (7)$$

where Z_L is the cash endowment of the liquidity trader and C the total search cost. Substituting equation (7) into equation (1), the liquidity trader's maximization problem is

$$\underset{Q}{Max}\, v_L = (Q+h) + Z_L - pQ - C - (\frac{\rho}{2})\sigma_L^2 (Q+h)^2 \qquad (8)$$

where σ_L^2 denotes the conditional variance of the asset's value and is equal to $\sigma_L^2 = \frac{\sigma_v^2 \sigma_v^2 / f}{\sigma_v^2 + \sigma_v^2 / f} = \frac{\sigma_v^2}{f+1}$ (DeGroot, 1970). We note the risk that the liquidity trader associates with buying Q decreases with the level of information flow. The optimal order size can be found by differentiating equation (8) with respect to *Q*, which yields,

$$v_L - Q\frac{\partial p}{\partial Q} - p - \frac{\partial C}{\partial Q} - \rho\sigma_L^2(Q+h) = 0 \qquad (9)$$

Counter party dealers observe *Q*, which reflects both an information-based motive resulting from search and a portfolio-hedging motive stemming from initial holdings for trade, but not *h* and S_L. Since dealers know the distribution of the value of the asset, the distribution of the private signal of the liquidity trader (but not the signal itself), and the investor's decision rule, i.e. equations (6) and (9), they can infer a noisy signal of the following form,

$$S_d = \frac{Q\frac{\partial p}{\partial Q} + p + \frac{\partial C}{\partial Q} + \rho\sigma_L^2 Q}{\omega_0} \qquad (10)$$

This is in fact a noisy signal of v_L and has the form $S_d = v_L + \eta h$, where $\eta = \frac{-\rho\sigma_L^2}{\omega_0}$ is a constant. Thus, for a dealer who cannot observe the liquidity trader's initial holdings of the risky security, h, S_d represents the unbiased estimate of the true value of the risky asset with variance of $\frac{\sigma_v^2}{f} + \eta^2\sigma_h^2$, given the order size Q. The trade price of the risky security is a weighted average of prior mean and the noisy signal S_d,

$$p_{post} = E\left\langle \tilde{v} \middle| Q \right\rangle = E\left\langle \tilde{v} \middle| S_d \right\rangle = (1-\omega_d)0 + \omega_d S_d \qquad (11)$$

where $\omega_d = \frac{\sigma_v^2}{\sigma_v^2 + \eta^2\sigma_h^2 + \sigma_v^2 / f}$ and zero is the normalized prior mean of the risky asset. Noted that $E\left\langle \tilde{v} \middle| Q \right\rangle$ in equation (11) first appeared in equation (3) and describes the process by which counter-party dealers arrive at the transaction price given the total trade size Q. From the properties of the normal distribution and the relations $\eta = \frac{-\rho\sigma_L^2}{\omega_0}$, $\omega_0 = \frac{\sigma_v^2}{\sigma_v^2 + \frac{\sigma_v^2}{f}} = \frac{f}{f+1}$, and $\sigma_L^2 = \frac{\sigma_v^2\sigma_v^2 / f}{\sigma_v^2 + \sigma_v^2 / f} = \frac{\sigma_v^2}{f+1}$,

we have

$$\phi = \rho Var\langle \nu \mid Q \rangle = \frac{\rho^2\sigma_v^2\sigma_h^2 + f}{\rho^2\sigma_v^2\sigma_h^2 + f^2 + f} \qquad (12)$$

which also appeared first in equation (3) and is related to the risk a representative dealer associates with supplying *Q/n* shares of the risky asset. From the expression of ω_d, we can see that the weight the counter-party dealer attaches to the noisy signal increases as *f*, the level of information flow in the market, increases. This is due to the fact that counter-party dealers realize the broker may be engaging in information gathering and that with public disclosure making more information available, it is more likely that the trade arranged by the broker is partly information motivated. However from equation (12), we observe that the risk a representative dealer associates with supplying *Q/n* shares of the risky asset decreases with an increasing information flow. Substituting equation (11) into equation (5), we have the following differential equation,

$$p = \omega_d S_d + \frac{\phi Q}{n} = A(Q\frac{\partial p}{\partial Q} + p + \frac{\partial C}{\partial Q} + \rho\sigma_L^2 Q) + \frac{\phi Q}{n}. \qquad (13)$$

where $A = \frac{\omega_d}{\omega_0} = \frac{f^2 + f}{f^2 + f + \rho^2\sigma_v^2\sigma_h^2}$ is the ratio of the weights the investor and a representative counter-party dealer attach to their respective signals and $\phi = \frac{\rho^2\sigma_v^2\sigma_h^2 + f}{\rho^2\sigma_v^2\sigma_h^2 + f^2 + f}$. The solution to equation (13) will yield the transaction price *p* for a large trade of size *Q* in a rational expectation equilibrium. We show in the next section that such an equilibrium exists if the information flow to the market is modest relative to the perceived motive for portfolio hedging.

4. EQUILIBRIUM

To determine the optimal number of counter party dealers, the broker conducts his search to minimize trading and search costs given the transaction price. His optimization problem is

$$\underset{n}{Min}\{Qp(Q,n) + \frac{\lambda n^2}{f}\} \qquad (14)$$

Differentiating equation (13) with respect to *n*, and setting it equal to zero, we have

$$\frac{\phi Q^2}{n^2} = \frac{2\lambda n}{f} \qquad (15)$$

The optimal number of dealers contacted can be expressed as a function of trade size Q,

$$n(Q) = (\frac{\phi f Q^2}{2\lambda})^{1/3} = 2^{(-1/3)}\alpha Q^{2/3} \qquad (16)$$

where $\alpha = (\frac{\phi}{\lambda} f)^{1/3}$ and is independent of *Q*. The total search cost is therefore

$$C = \lambda(\frac{\phi f Q^2}{2\lambda})^{2/3} = 2^{(-2/3)}\beta Q^{4/3} \qquad (17)$$

where $\beta = (\lambda^{1/2}\phi f)^{2/3}$ and is independent of *Q*. The marginal search cost per additional share is

$$\frac{\partial C}{\partial Q} = (\frac{4}{3})2^{(-2/3)}\beta Q^{1/3} = kQ^{1/3} \qquad (18)$$

where $k = (\frac{4}{3})2^{(-2/3)}\beta$ and is independent of *Q*. Substituting equation (16) and equation (18) into equation (13) and rearranging, we have

$$p = A[(k + \frac{l}{A})Q^{1/3} + Q\frac{\partial p}{\partial Q} + p + BQ] \qquad (19)$$

where $l = \frac{\phi}{2^{-1/3}\alpha}$ and $B = \rho\sigma_L^2 = \rho\frac{\sigma_v^2}{f+1}$ are both independent of Q. Solving equation (18) yields the equilibrium transaction price.

Proposition 1. There exists a rational expectation equilibrium in which the transaction price is given by

$$p = \frac{AB}{1-2A}Q + \frac{3A(k + l/A)}{3-4A}Q^{1/3}, \qquad (20)$$

if and only if $\frac{f(f+1)}{\sigma_v^2} < \rho\sigma_h^2$. That is, if firm-specific information is modest relative to the perceived need for portfolio hedging. The proof is shown in the appendix.

Proposition 1 indicates that with brokerage search, the price dependence on trade size, *Q*, is not linear. During the course of search, the broker will add more counter-party dealers if the reduction in price caused by reduced size exceeds the marginal cost. The brokerage search process mitigates the size impact on price by intensifying the search for counter-party dealers to take the other side of the trade as trade size increases. The requirement for the existence of equilibrium is a familiar requirement in trading models (see e. g. Glosten 1989) dealing with information signal to noise ratio. In our model, the broker and the liquidity trader update their prior distribution of the value of the risky asset according to new firm-specific information resulting from disclosure and search. In the limit as $f \to \infty$, the updated distribution will be normally distributed with mean v and zero variance in which case the investor will be buying as long as price is less than v without regard to any portfolio hedging motives. The market breaks down in our model if $\frac{f(f+1)}{\sigma_v^2}$, which could be interpreted as signal to noise ratio, exceeds the motive for portfolio hedging, $\rho\sigma_h^2$ and the liquidity trader *becomes* an informed trader during the search process and is perceived to trade for mostly informational motives. In order for a rational expectation equilibrium to exist, the signal obtained from search must be such that the signal to noise ratio, or the quality of firm-specific information has to be modest relative to the perceived need for non-information trading.

5. THE IMPACT OF PUBLIC DISCLOSURE AND EMPIRICAL IMPLICATIONS

We now examine the impact of information flow due to public disclosure. Combining equation (12) and equation (13), we have

$$p = \omega_d [\frac{1}{\omega_0}(Q\frac{\partial p}{\partial Q} + p + \frac{\partial C}{\partial Q} + \rho\sigma_L^2 Q)] + \frac{\rho^2\sigma_v^2\sigma_h^2 + f}{\rho^2\sigma_v^2\sigma_h^2 + f^2 + f}\frac{Q}{n}, \qquad (21)$$

or

$$p = \omega_d S_d + \frac{\phi^{2/3}Q^{1/3}}{f\lambda^{1/3}}. \qquad (22)$$

The first term represents counter-party dealers' information about the expected value of the risky asset and is a positive function of *f*. We note that S_d denote the noisy signal dealers infer from the total trade size *Q*. This is a noisy signal of v_L, the signal the investor obtains through brokerage search process, which is turn is a noisy signal of v, the true post trade value of the risky asset. Given a buy order of size Q, the realization of the signal would be higher than the prior expected value of the risky asset (which is normalized to zero). In equation (22), ω_d shows the weight counter-party dealers attach to the signal in their process of updating their information about their expected value of the risky asset. With public disclosure and, consequently, a higher level of information flow about the risky asset, the investor's signal becomes more accurate which in turn increases the accuracy of the noisy signal to the counter-party dealers. Being more confident, dealers attach more weight to their noisy signal in their updating process. Hence, public disclosure tends to increase the transaction price because information resulting from such disclosure improves their updating process. The second term in equation (22) represents the risk county party dealers associate with supplying the risky asset and is a negative function of *f*. With public disclosure and a greater information flow, the compensation a representative dealer demands for the risk of supplying *Q/n* shares of the risky asset decreases as long as the liquidity trader is perceived to be trading substantially for non-information motives, i.e. $\frac{f(f+1)}{\sigma_v^2} < \rho\sigma_h^2$. Based on the analysis of the endogenously determined price schedule of our model, we can decompose the impact of trade disclosure on the equilibrium transaction price into two components: information precision impact and risk impact. Precision impact refers to the impact of public disclosure on the precision of a counter-party dealer's signal. Disclosure tends to improve the precision of signals of all market participants, which results in higher transaction price. The risk impact refers to the risk a representative dealer associates with supplying *Q/n* shares of the risky asset. This risk decreases with disclosure and as a result dealers demand less compensation for bearing such risk, which results in lower price. In summary, our result suggests that public disclosure affects the equilibrium price in two ways: (1) Public disclosure increases the precision of all market participants' signals regarding the value of the risky asset and increases the equilibrium price; (2) Public disclosure reduces the adverse-selection risk counter-party traders associate with a trade of large size and reduces the equilibrium price. The net, overall effect of trade disclosure depends on the interaction of these two effects.

What is immediately obvious from equation (22) is the relationship between transaction prices and trade size. The first term is linear in *Q*, while the second term is nonlinear. As explained, the actual dependence of transaction prices on *Q* depends on which of the two opposing effects of disclosure dominates. A simple regression model such as

$$p = aQ + bQ^{\frac{1}{3}}$$

could be utilized to test the implication of equation (22). The economic and statistical significance of the two coefficients—*a* and *b*—should provide important insights to the relationship between *p* and *Q*. Furthermore, the regression analysis can be complemented by an event study before and after the enactment of the Sarbane-Oxley Act of 2002, which should shed light on the impact of disclosure on the *p*-*Q* relationship. We are in the process of actively pursuing transaction data of "upstairs market", which are not readily available. We intend to carry out the empirical analysis outlined here once relevant data become available.

6. CONCLUDING REMARKS

In this paper, we focus on the search process of a competitive broker in the service of a large investor and examine the impact of public disclosure on the process. We develop a rational expectation model where total trade size, the number of counter-party traders and price are determined endogenously. To execute a large trade, the investor searches for information regarding the value of a risky asset and contacts an optimal number of counter-party traders through the services of a broker. The precision of the investor's signal depends on the availability of specific information about the risky security in the market, which is connected to the public disclosure requirement. Our result suggests that disclosure influences the equilibrium price in two ways: (1) disclosure increases the precision of all market participants' signals regarding the value of the risky asset and increases the equilibrium price; (2) disclosure reduces the adverse-selection risk counter-party traders associate with a trade of large size and reduces the equilibrium price. The net, overall effect of disclosure depends on the interaction of these two effects. Further, we show that in order for rational expectation equilibrium to exist, the quality of firm-specific information resulting from disclosure has to be modest relative to the perceived need for non-information trading.

APPENDIX: PROOF OF PROPOSITION 1.

To show that $p = \frac{AB}{1-2A}Q + \frac{3A(k + l/A)}{3-4A}Q^{1/3}$ A(1)

is the solution to the differential equation

$$p = A[(k + \frac{l}{A})Q^{1/3} + Q\frac{\partial p}{\partial Q} + p + BQ], \qquad \text{A(2)}$$

we take derivative of equation A (1) with respect to Q, which yields

$$\frac{\partial p}{\partial Q} = \frac{AB}{1-2A} + \frac{A(k+l/A)}{3-4A} Q^{-2/3} \qquad \text{A(3)}$$

Multiplying equation A(3) by Q, we have

$$Q\frac{\partial p}{\partial Q} = \frac{AB}{1-2A} Q + \frac{A(k+l/A)}{3-4A} Q^{1/3} \qquad \text{A(4)}$$

We now substitute equations (A1) and (A4) into equation A(2), then
Both the RHS and LHS of equation A(2) are

$$A(\frac{AB}{1-2A} Q + \frac{3A(k+l/A)}{3-4A} Q^{1/3})$$

Further, the solution, equation A(1) satisfies the initial condition that

$$p(Q=0)=0$$

which implies that without trade, the expected price of the risky asset is same as the expected value of the prior distribution, which is a normal distribution with a normalized mean of zero and a variance of σ_v^2.

To show the condition for equilibrium, we note that, for a buy order, the coefficients of both term in equation A(1) must be positive, which implies $A < \frac{1}{2}$. This is a necessary and sufficient condition under which both coefficients will be positive. From the text,

$$A = \frac{\omega_d}{\omega_0} = \frac{f^2 + f}{f^2 + f + \rho^2 \sigma_v^2 \sigma_h^2}.$$

Simple algebraic manipulation yields

$$\frac{f(f+1)}{\sigma_v^2} < \rho \sigma_h^2.$$

Q.E.D.

ENDNOTES

1. The inadequacy of Enron's disclosures of its liabilities, risk exposure, and related party transactions is a good example.
2. A block trade is defined as a trade of 10,000 or more shares. Block trades represented over 50% of NYSE trading volume in 1993; the corresponding figure in 1965 is about 3%.
3. The mean of the distribution can assume any value. The value of zero is chosen, without loss of generality, for the sake of tractability.
4. We do not consider the case of dual capacity trading in which the broker may act as a broker-dealer and take position as one of the counter parties. We also abstract from the issue of agency problems between the investor and the broker in our analysis.
5. The broker in our model shares the signal obtained from the search process as part of her service

REFERENCES

Burdett, K and M. O'Hara, 1987. "Building Blocks: An Introduction to Block Trading." *Journal of Banking and Finance*, 11, 193-212.

DeGroot, M. H., 1970. *Optimal Statistical Decision*. McCraw-Hill, New York.

Glostern, L., 1989. "Inside trading, liquidity, and the role of the monopolist specialist." *Journal of Business*, 62, 211-235.

Grossman, S. J., 1992. "The Information Role of Upstairs and Downstairs Trading." *Journal of Business*, 65, 509-528.

Keim, D. and A. Madhavan, 1996. "The Upstairs Markets for Large-Block Transactions: Analysis and Measurement of Price Effects." *Review of Financial Studies,* 9, 1-36.

Kyle, A. S., 1985. "Continuous Auctions and Insider Trading." *Econometrica,* 53, 1315-1335.

Wu. C. and W. Zhang, 2002. "Trade Disclosure m Information Learning and Securities Market Performance." *Review of Quantitative Finance and Accounting,* 18, 21-38.

Zhang, W., J. Li, and C. Wu, 2004. "To Trade not to Trade: The Effect of Broker Search and Discretionary Trading on Securities Market Performance." *Financial Review,* 39, 271-292.

Zhang, W., 2004. "Risk aversion, public disclosure, and long-lived information." *Economics Letters,* forthcoming.