REGULATING INFORMATION DISCLOSURE AMONG STOCK EXCHANGE MARKET MAKERS

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Regulating Information Disclosure Among Stock Exchange Market Makers

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Abstract

The paper considers the effect of mandatory last trade reporting in a competitive dealership market in the presence of traders with superior information. It is shown that last trade reporting typically has two opposing effects on the quality of the market. Bid-ask spreads decrease because the information contained in recent trading history reaches all competitors. However, they widen because market makers are less willing to pay to capture the information. The former effect generally dominates.

Regulating Information Disclosure Among Stock Exchange Market Makers*

This paper addresses a set of regulatory concerns relating to the transparency and speed of disclosure of stock exchange trading information. Its first aim is to discuss whether it is in the interests of ordinary traders, wishing to trade at minimal transaction costs, to oblige dealers to report and publicize all information concerning recent transactions as fully and promptly as possible.

Whether such last-trade reporting (revealing the volume and pricing of recent transactions to all market participants within a matter of minutes) is desirable, has been the subject of heated debate among both regulators and practitioners. London market makers generally opposed the idea when first mooted, on the grounds that the release of such information would enable others to take advantage of market makers in vulnerable positions. Regulators are particularly concerned that last-trade reporting might then lead to a general widening of market makers' bid-offer spreads, thus worsening the terms on which investors can trade and harming the liquidity of the market. Also, trading may be induced to by-pass the main market in favour of foreign exchanges or off-exchange dealers who are not subject to such stringent disclosure requirements. This would render disclosure requirements ineffective unless they are universally applied.

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*This paper is a radically revised version of a paper presented to the Money Study Group in May 1986, entitled "The effect of last trade reporting in the securities markets". I would like to thank Charles Goodhart for encouraging an interest in this topic; Patricia Jackson, Bill Allen and Paul Temperton for their time and patience in explaining the workings of the securities markets; and Pete Kyle and my colleagues at the London School of Economics, David de Meza, John Sutton, David Webb and Hugh Wills, for many helpful discussions.

In London, the idea of a last-trade tape met with particularly strong opposition in the gilts market; and indeed the Stock Exchange currently has no plans to introduce last-trade reporting in that market. On the other hand, in the equities market, general opinion is much more in favour of last trade reporting. Such a tape is now in place for at least the largest and most heavily traded equities on the Stock Exchange: the current rulebook stipulates that during normal trading hours the price and size of transactions in the major "alpha" securities is to be reported and made public within 5 minutes through the SEAQ electronic quotations system. In its report on the choice of a new dealing system for equities, the Stock Exchange council (1984) finds that:

> In principle publication of trading information is desirable in order to maximise confidence in the market. But, as other markets have found, the time lag between transactions and publication needs careful study. An extremely short time lag, especially in the early stages of development, could threaten the ability of market makers to compete effectively and could thus damage the liquidity of the market. This would not be in the interests of either investors or companies. The question of immediate publication of last trade information will therefore be closely examined.

These views closely mirror historical experience in the U.S.A. There, last-trade information is not publicly disseminated in the Treasury bond market; and dealers are vehemently opposed to the idea. On the other hand, for equities the NASDAQ experience suggests that the provision of a last-trade tape has been a resounding success, despite some measure of initial opposition from market makers. To quote the 1983 annual report of the NASD (National Association of Securities Dealers):

> NASDAQ's National Market System, made up of NASDAQ companies meeting special financial and market standards, attracted record investor interest in its first full year of operation. Distinguished by last-sale reporting and running volume figures, NMS has added a new dimension to the trading of NASDAQ securities and hundreds of NASDAQ companies have voluntarily requested National Market System designation for their securities.

This paper attempts to provide a theoretical framework for discussing some of the issues relating to transparency, disclosure and last-trade reporting. The model follows the work of "Bagehot" (1971), Copeland and Galai (1983), Glosten and Milgrom (1985) and others, in modelling competing risk-neutral market makers who quote bid and offer prices at which they stand committed to trade with all comers. Its only novelty is that we consider a setting in which different market makers may have different information, derived from their recent trading experience. Any transaction is an investment in information. Market makers are willing to compete for lossmaking business in the short run if the trade yields profitable information for the future.[1]

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[1]In this they resemble the bookmaker quoted in the Financial Times (6/12/1986), who welcomes bets placed by a particularly successful punter: "He's my most valuable client. I always shorten the odds when he bets, and it saves me a fortune."

The paper is organised as follows. The model is presented in Section 1. Section 2 describes the market outcome under the two different regulatory regimes, with and without last trade reporting, and compares them. In this section, it is assumed that market makers cannot update prices instantaneously and therefore may be forced to trade at simultaneously set mixed-strategy equilibrium prices that are, ex post, suboptimal. Section 3 goes to the other extreme in assuming that market makers' prices reflect the information contained in their competitors' price quotes. In Section 4, the problem of off-exchange dealing is addressed. It is argued that trading may gravitate towards the markets where disclosure is least regulated. Conclusions are drawn in Section 5.

1. The model

We consider a very simple example. Market makers and most other traders, to be referred to as "liquidity" traders, know only that the security to be traded may be high (V_H) or low (V_L) in value, with prior probability 1/2 each. There are also "informed" traders who do know the "true" or best-information value V of the security.

There are two trading periods; at the end of the second one the security's value becomes publicly known to all market participants, eliminating the informational advantage of the "informed" traders. Within each period one trader exactly comes to the market: we abstract from any connection between informed trading and the volume of trade. He may be informed or uninformed with probabilities α and $(1-\alpha)$ respectively, independently of previous periods. If uninformed, he buys/sells a unit at the best price quoted with probability 1/2 each. If informed, he buys or sells a unit if the price $P_A \leq V$ or the bid price $P_B \geq V$ respectively. With bid and ask prices in the range $V_L \leq P_B \leq P_A \leq V_H$, this means that informed traders buy whenever $V = V_H$ and sell whenever $V = V_L$.

Each period, market makers competitively set expected profit maximizing prices in the light of all their information. For future reference updated expected values are collected in Table 1.

2. Market outcomes with and without trade reporting

a. The case of mandatory trade reporting

If any first-period trading event is disclosed to all market makers before the second period commences, then bid and ask prices in both periods will settle at a level where market makers make a zero expected profit, given the information conveyed by the trading history. Thus in equilibrium:

$$
\begin{aligned}
P_A^{\,I} &= V_B \\
P_B^{\,I} &= V_S \\
P_A^{\,II}(B) &= V_{BB} \\
P_A^{\,II}(S) &= V_{SB} \qquad (1) \\
P_B^{\,II}(B) &= V_{BS} \\
P_B^{\,II}(S) &= V_{SS}
\end{aligned}
$$

where superscripts denote the trading period in question, and arguments of second-period price quotes are the first-period trading event (B = customer buy; S = customer sale).

b. <u>The case of confidential trading histories</u>

We now assume that, at the beginning of period II, only the market maker who made a deal in the first period knows whether it was a buy or a sell transaction.

For the remainder of this section, imagine that market makers compete by simultaneously setting prices that must be maintained for the duration of the trading period. That is, prices cannot be revised in the light of others' quotes.

To justify this assumption one can think of the trading period as a very brief one - no longer than the time it takes to enter new price quotes on display. Alternatively, one can regard the model as one in which market makers cannot immediately observe one another's trading prices. While at first sight this may seem unrealistic in a modern exchange where prices are quoted electronically, in the case of the smaller London ("gamma securities") and NASDAQ stocks, market makers are not obliged to quote "firm" prices. That is, they are not obliged to trade with all comers at quoted prices. Thus market makers cannot fully monitor one another's true trading prices at every instant in time. Also, as will be discussed in Section 4, the model applies to a setting where a number of off-exchange market makers, who are not obliged to disclose trades or display continuous bid and ask price quotes, operate on the side.

Focusing on the period II ask side of the market, let F(.) denote the cumulative distribution function of the lowest price quoted in the second period by the market makers who did not trade in the first period. The expected profit[2] of the market maker who is "informed" because he did trade in the first period is given by:

$$E\ [\pi_m|B] = (1-F(p))\ (p-V_{BB}) \times \text{Prob}(\text{Buyer}|B) = (1-F(p))(p-V_{BB})\ \tfrac{1}{2}(1+\alpha^2) \qquad (2)$$

$$E\ [\pi_m|S] = (1-F(p))\ (p-V_{BS}) \times \text{Prob}(\text{Buyer}|S) = (1-F(p))(p-V_{BS})\ \tfrac{1}{2}(1-\alpha^2) \qquad (3)$$

where p is his ask price.

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[2]In these expressions the possibility of a tied price is ignored - in the equilibrium derived, this is indeed not a problem.

In contrast, an uninformed market maker's expected profit when setting ask price p is:

$$E[\pi_u] = \text{Prob}(p \leq \text{lowest price set by other uninformed market makers})$$

$$\times \left(\frac{1}{4}(1+\alpha^2)(1-G_B(p))(p-V_{BB}) + \frac{1}{4}(1-\alpha^2)(1-G_S(p))(p-V_{BS})\right) \quad (4)$$

where G_B is the probability distribution of the price set by the informed market maker when the first period transaction is a buy; G_S, when it is a sell.

Solving for the unique mixed-strategy equilibrium (that involves prices no higher than V_{BB}) on the ask side of the market:

Distribution of uninformed market makers' lowest price:

$$F(p) = \begin{cases} 0 & \text{for } p \leq V_B \\ \dfrac{p-V_B}{p-V_{BS}} & \text{for } p \in (V_B, V_{BB}) \\ 1 & p \geq V_{BB} \end{cases} \quad (5)$$

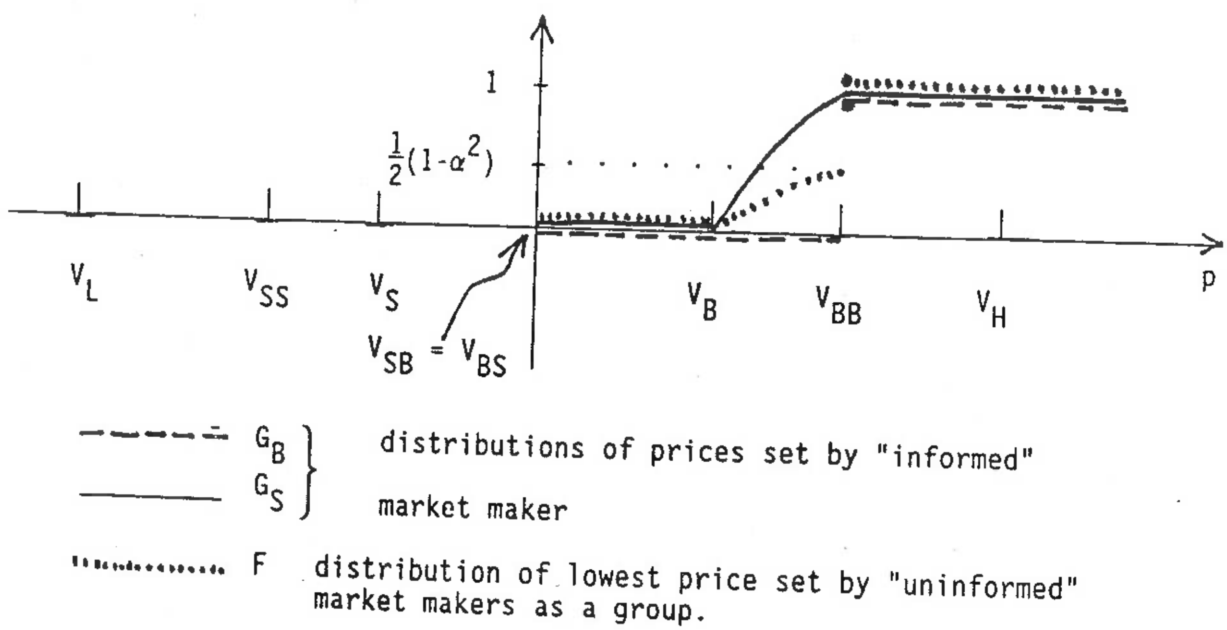
Distribution of price set by 'informed' market maker conditional on his previous transaction:

$$G_B(p) = \begin{cases} 0 & p < V_{BB} \\ 1 & p \geq V_{BB} \end{cases} \quad (6)$$

$$G_S(p) = \begin{cases} 0 & p \leq V_B \\ 1 - \left(\frac{V_{BB}-p}{p-V_{BS}}\right)\left(\frac{1+\alpha^2}{1-\alpha^2}\right) & p\epsilon[V_B, V_{BB}] \\ 1 & p \geq V_{BB} \end{cases} \tag{7}$$

The bid side of the market is completely analogous. Observe that in equilibrium the uninformed market makers' expected profit is zero. Their individual strategies are not uniquely determined in this equilibrium - only the joint c.d.f. of the lowest price that they quote.

Figure 1. Equilibrium ask price distribution in period II



Observe that the informed market maker's expected profit π_m from the ask side of the market is given by:

$$E[\pi_m | B] = 0 \tag{8}$$

$$E\,[\pi_m|S] \;=\; (V_B - V_{BS}) \times \frac{1}{2}\,(1-\alpha^2)$$
$$= \frac{1}{4}\,\alpha(1-\alpha^2)\;(V_H - V_L) \qquad (9)$$

Since the bid side of the market is identical, the total expected period II profit of a market maker who has captured the first-period trade is:

$$E[\pi_m] = \frac{1}{4}\alpha(1-\alpha^2)(V_H - V_L). \qquad (10)$$

Now in the first period, market makers realize that if they undercut all other traders, thus capturing that period's trade, they can use the confidential information on that trade to make a profit later on. This means that bid-ask spreads in the first period will be narrower than they would be if all trades were mandatorily disclosed. Under Bertrand competition, market makers will be driven to prices at which they make an expected loss on the first period trade equal to the expected subsequent profit on the second one:

$$P_A - V_B + E[\pi_m] \;=\; 0$$

i.e. $$P_A = V_B - \frac{1}{4}\,\alpha(1-\alpha^2)\;(V_H - V_L)$$

$$P_A = \frac{1}{2}\,(1 - \frac{1}{2}\,\alpha - \frac{1}{2}\,\alpha^3)\;V_L + \frac{1}{2}\,(1 + \frac{1}{2}\,\alpha + \frac{1}{2}\,\alpha^3)\;V_H \qquad (11)$$

Thus bid-ask spreads in the initial period are <u>narrower</u> in the absence of last-trade reporting, as market makers are willing to pay for the information contained in trades.

c. Comparison of regimes

Consider now the welfare of the different parties involved under the two regimes considered. We will establish the qualitative features summarized in Table 2. Concerning uninformed trades, it will be shown (I) that $\pi_u < 0$: on average they are harmed in the second period if there is no last trade reporting. Also (II), $(1-\alpha)\pi_m + \pi_u < 0$: they are harmed overall, taking both periods together. Lastly (III), the informed traders gain overall what the uninformed traders lose. But within the second period taken by itself, they lose on average: $\pi_i < 0$.

I. π_u<0: In Period II uninformed traders gain from last trade reporting

In the no-disclosure case, an uninformed buyer faces a period II price randomized on the interval $[V_B, V_{BB}]$. In contrast, under trade reporting he faces V_{BS} and V_{BB}, with probability one half each.

Now

$$V_B > \frac{1}{2} (V_{BS} + V_{BB}). \tag{12}$$

Hence the price he faces is, on average, more advantageous if there is disclosure.

Note that this argument is fairly robust - it was unnecessary to calculate precisely the average price paid under the mixed strategy regime. A knowledge of the supports of the distributions G_B, G_S and F is enough to establish the result.

II. $(1-\alpha)\ \pi_m + \pi_u < 0$: Last trade reporting benefits uninformed traders overall

Comparing the no-disclosure case to that with full disclosure, informed and uninformed traders taken together lose, on average, π_m to the market makers in period II. The price distribution facing them is:

$$\begin{cases} \text{more advantageous on a continuation (buy following buy, sell following sell)} \\ \text{less advantageous on a reversal (buy following sell, sell following buy)} \end{cases}$$

Suppose, then, that $M > 0$ is the ex ante expected extra cost if the previous transaction was in the opposite direction; let $N < 0$ be the expected extra cost, if it was similar.

With probability $(1-\alpha)$, an uninformed trader enters the second period. His expected extra loss in the no-disclosure case is:

$$-\pi_u = (1-\alpha)\left(\frac{1}{2} M + \frac{1}{2} N\right) \tag{13}$$

With probability α, an informed trader enters the second period. He is somewhat more likely to match a previous transaction:

$$-\pi_i = \alpha\left(\frac{1}{2}(1-\alpha^2)M + \frac{1}{2}(1+\alpha^2)N\right) \tag{14}$$

Lastly, market makers taken together make a positive expected profit $\pi_m \geq 0$, where:

$$\pi_i + \pi_u + \pi_m = 0 \tag{15}$$

Substituting out for π_i,

$$\pi_u = -\pi_m + \alpha(\frac{1}{2}(M+N) - \frac{\alpha^2}{2}(M-N))$$

$$= -\pi_m - \frac{\alpha}{1-\alpha}\pi_u - \frac{\alpha^3}{2}(M-N)$$

$$= (1-\alpha)[-\pi_m - \frac{\alpha^3}{2}(M-N)] \quad (16)$$

$$\Rightarrow \pi_u < -(1-\alpha)\pi_m \text{ since } M - N > 0. \quad (17)$$

Note, again, that this argument is fairly general and not confined to the details of this example.[3] Al that is required is that market makers make expected profits in the second period equal to their losses in the first period. While informed and uninformed traders are equally able to take advantage of the better deal in the first period, in the second period the cost of nondisclosure is borne by those traders who do <u>not</u> match the direction of previous transactions. Disproportionately, this tends to be the uninformed.

Observe that second-period losses of liquidity traders might not outweigh first-period gains if it were generally the case that the proportion $(1-\alpha)$ of liquidity trades tends to be appreciably lower in Period II-type situations compared to Period I-type situations. In that case, liquidity traders might actually benefit, on average, from nondisclosure over the two periods taken together.

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[3]To establish the result it was unnecessary to compute an explicit value for π_u for comparison with $(1-\alpha)\pi_m$.

Perhaps this explains why last trade reporting is not as vociferously advocated for the gilts and Treasury bond markets. These are markets where relatively more professionals trade; these are more likely to recognize phases of unsettled pricing when trading information is trickling onto the market, and to redirect their transactions towards more stable Period I-type situations. In contrast, private punters on the equity markets might not be able to interpret the state of the market well enough to pursue such a transaction cost minimizing strategy. Our model ignores these considerations by presuming that liquidity trading is inelastic: the volume of trade is independent of the bid-ask spread.

III. Informed traders lose from last trading reporting

Clearly, if market makers' overall expected profit is unchanged at zero while uninformed traders lose money from nondisclosure, an equal overall gain goes to informed traders. Thus informed traders gain over the two periods taken together.

Informed traders obviously gain from narrower first-period spreads. But what about the second period? Interestingly enough, in our example they are worse off on average in the second period taken by itself. To see this, take an informed trader who knows $V = V_H$ and thus wishes to buy a unit in the second period. On average a proportion $\frac{1}{2}$ $(1+\alpha)$ of the preceding trades will have been a buy; $\frac{1}{2}$ $(1-\alpha)$, a sell. On average the expected second-period price, in the absence of last trade reporting will exceed:

$$\frac{1}{2}(1-\alpha)\ V_B + \frac{1}{2}(1+\alpha)\left(\frac{1}{2}(1-\alpha^2)\ V_B + \frac{1}{2}(1+\alpha^2)\ V_{BB}\right) \qquad (18)$$

since the ask price is a random variable on $[V_B, V_{BB}]$, and in the case of a preceding buy transaction $p = V_{BB}$ with probability $\frac{1}{2}(1+\alpha^2)$ in equilibrium.

In contrast, under last-trade reporting, the average price is

$$\frac{1}{2}(1-\alpha) V_{BS} + \frac{1}{2}(1+\alpha) V_{BB}. \tag{19}$$

The previous expression is the greater of the two. Thus the informed trader's average second-period ask (bid) price paid is higher (lower) in the absence of last-trade reporting! Even though he engages in relatively more continuation than reversal transactions, the losses on reversals outweigh the gains on continuations. It is not clear that this result will generalize beyond our particular example.

Note again that the informed trader's profit is higher over the two periods taken together in the absence of last trade disclosure. The discount offered in the first period by market makers wishing to profit from the information revealed by his trading pattern more than offsets the second-period loss.

3. Rational expectations equilibrium

The analysis so far has implicitly assumed that market makers cannot instantaneously re-adjust their price quotes in the light of the prices set by their competitors. In practice, they can do so fairly readily. With the new electronic quotation systems such as London's SEAQ or the U.S. NASDAQ market, it is possible to observe competitors' prices at all times and to update quoted prices within a minute or two. On markets where market makers have no obligation to deal at quoted prices, the latter may not be all that informative. For the larger alpha and beta London stocks, however, market makers are obliged to trade up to a deal size specified by the Stock Exchange authorities (the "marketable quantity"), or, if they quote a larger deal size, up to that quantity, at quoted prices. Since recently a similar obligation applies to small orders placed with NASDAQ market makers.[4] In that case, both bid and ask prices carry valuable information. It therefore seems reasonable to model market makers' price setting as a tatonnement process in which quotes are rapidly adjusted until they attain equilibrium values that reflect market makers' rational responses to all the information they have, including the quotes of their competitors. The adjustments are presumed to take place so quickly that, in the meantime, no traders arrive to take advantage of out-of-equilibrium quotes.

In any such rational expectations equilibrium, if market makers observe one another's price quotes and respond optimally, given those quotes, it is necessarily the case that all market makers make at most a zero expected profit on each transaction provided that liquidity traders' demand is sufficiently inelastic to ensure that any decrease/increase in the ask/bid price strictly reduces expected profit for the market maker quoting the sharpest price).

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[4]This has generated a small industry of opportunistic traders who repeatedly hit any market maker who is slow to adjust his quotes to new information. NASDAQ authorities are considering policies to thwart such abuse by market professionals.

Any market maker setting a strictly "inside" price by himself would have the incentive to widen it a little, gleaning extra profit. And any group of market makers who jointly set the inside price must each believe it yields zero profits. If not, they each have an incentive to undercut slightly and capture the entire market.[5] Differences in information among market makers are irrelevant to this argument.

Returning to the disclosure issue, what conclusions emerge from the REE model? In our particular example, competitors' price quotes fully reveal their trading history, so the equilibrium is identical to that obtained with last trade reporting. No market maker benefits from superior information. So in REE there is no reason to offer a narrower bid-ask spread in the initial trading period of our example. In general, the equilibrium may be different to the extent that the price discovery process fails to reveal fully the entire amount of information that would have emerged from trade reporting - for example, different market makers' information may not be aggregated accurately. This possibility is well documented in the literature on common knowledge. Thus mandatory trade reporting may still improve the quality of the market (in the sense of low bid-ask spreads), to

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[5]Does this argument fail if, in practice, prices can only be chosen from a discrete set of rounded-off values? Suppose that the best estimate of the security's value exactly equals any one of those numbers with probability zero. In that case, in equilibrium, <u>all</u> market makers will quote the same prices and make some small positive expected profit on transactions. Any other outcome is incompatible with Aumann's (1976) theorem. It is common knowledge that all market makers who set an inside price expect to make a positive expected profit on transactions at the price. Those who withdraw from the market by setting a wider price do so because they expect the inside price to be loss-making. Provided all market makers have common priors, they cannot agree to disagree.

the extent that it depends inversely on the informational advantage that informed traders have over market makers as a group.

4. Off-exchange dealing

We have shown how mandatory disclosure of recent trades is likely to reduce transaction costs for ordinary liquidity traders. Here we will argue that such regulations are ineffective if they are not applied across the board.

Suppose, for example, that market makers compete against one or more off-exchange or foreign dealers who are not obliged to report recent trades or post continuous trading prices. Our example in Section 2b[6] can be interpreted as a description of how such dealers can always undercut the prices quoted by exchange dealers in the first trading period. For they can subsequently use the confidential information imparted by the initial trade by withdrawing from the lossmaking side of the market. Exchange dealers are unable to do this as they must disclose their trading history. Hence off-exchange dealing or trading on less heavily regulated foreign exchanges would tend to drive the exchange's market makers out of business. The regulatory regime thus sinks to the lowest common denominator.

A similar conclusion is reached by Kyle (1987) in a closely related example. In Kyle's example, the arrival process of traders and the high-low distribution of the security's value are identical to those of our example. The

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[6] If there are two or more off-exchange dealers, the equilibrium of Section 2b applies directly. If there is a single monopolistic off-exchange dealer, the situation is even worse because Period I bid-ask spreads are not narrowed competitively as described in Section 2b. Instead, they remain at $P_A = V_B$, $P_B = V_S$.

off-exchange dealer differs from the on-exchange dealers in two respects. Firstly, he is not obliged to report his first-period trade. Secondly, he is able to "intercept" the order flow in the sense that he can set his prices after observing the quotes set (simultaneously) by the exchange market makers. This widens the second-period bid-ask spread beyond that obtained in our example, because all trade reversals are siphoned off by the off-exchange dealer. Kyle's equilibrium is:

$$
\begin{aligned}
P_A{}^{I} &= V_B \\
P_B{}^{I} &= V_S \\
P_A{}^{II}(B) = P_A{}^{II}(S) &= V_{BB} \qquad (20) \\
P_B{}^{II}(B) = P_B{}^{II}(S) &= V_{SS}
\end{aligned}
$$

When Kyle's example is extended to a setting with two or more competing off-exchange deals (who simultaneously choose prices), the equilibrium is essentially that of Section 2b. The off-exchange dealers randomize their prices as described; and the exchange dealers quote bid and ask prices V_{SS} and V_{BB}, respectively. The off-exchange dealers ultimately liquidate their holdings at those prices.

Thus the quality of the market deteriorates if off-exchange dealers can escape last-trade reporting. The problem can be remedied by imposing penalties and restrictions on off-exchange dealing, and giving privileges to exchange market makers (limiting access to electronic price quotes to exchange members, stock borrowing privileges, favourable tax treatment, etc.). In addition, inter-exchange and international co-operation in setting disclosure standards seems called for. However, the usual prisoners' dilemma situation arises; individual jurisdictions or exchanges may be unwilling to impose stringent standards for fear of losing business to other arenas.

Lastly, note that dual-capacity traders - that is, firms which are both brokers and market makers - have a considerable competitive advantage over their rivals. London's "best execution" rule (obliging brokers to obtain at least as good a price from their in-house market maker as is available elsewhere) prevents flagrant abuse. Still, a more accurate knowledge of the identity of a recent customer (is he likely to be well-informed?) is enough to impart a competitive advantage in market making. Similarly, it is useful to know if the broking arm of the business is expecting a large order or batch of orders. Should analysts notify the in-house market maker of their research findings in advance so that he can pick up stock in anticipation, thus enabling him to satisfy orders promptly and efficiently? Or does this drive the price up unfairly against the brokerage customers? The issue is a hotly debated one. In a number of highly publicized cases, top analysts left dual-capacity firms in London in 1987 on the grounds that firm policy requiring them to pass their insights to the firm's market making arm was in conflict with the interests of their brokerage customers. The line between "front running" and acceptable use of information is indeed a very fine one.

5. Conclusions

Those who oppose last trade reporting believe that it may widen bid-ask spreads because market makers are less willing to take on large trades if they cannot cover themselves before news of the trade becomes known to their competitors. Our model illustrates this possibility; better terms are offered on initial potentially informative trades in the absence of last-trade reporting because market makers compete to invest in information. To the extent that most of the time, markets are in a Period I-type situation where information is yet to come onto the market, bid-ask spreads may on average over time seem lower without mandatory disclosure.

Our model does show, however, that on average (over their transactions) liquidity traders benefit from mandatory trade reporting. That is, without last trade reporting they would lose more at times when there is unreported trading information in the market than they would gain at other times.

It is not clear why market makers as a group initially opposed last-trade reporting. Perhaps they feared a loss of business to off-exchange dealers? In any case, experience with last-trade reporting has been very favourable. For example, the introduction of last trade reporting on NMS stocks is generally held to be a major contributor to the growth of NASDAQ trading volume. With liquidity trading elastic and inversely related to average transaction costs, the reduction in average transaction costs resulting from last-trade disclosure should increase the volume of trade.

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Table 1. Best estimate of security's value as a function of trading history

History of customer trades: Period I	Period II	Ex ante probability	Expected value of security, given trading history
Buy	--	$\frac{1}{2}$	$V_B \equiv \frac{1}{2}(1-\alpha) V_L + \frac{1}{2}(1+\alpha) V_H$
Sell	--	$\frac{1}{2}$	$V_S \equiv \frac{1}{2}(1+\alpha) V_L + \frac{1}{2}(1-\alpha) V_H$
Buy	Buy	$\frac{1}{4}(1+\alpha^2)$	$V_{BB} \equiv \frac{1}{2}\frac{(1-\alpha)^2}{1+\alpha^2} V_L + \frac{1}{2}\frac{(1+\alpha)^2}{1+\alpha^2} V_H$
Buy	Sell	$\frac{1}{4}(1-\alpha^2)$	$V_{BS} \equiv \frac{1}{2} V_L + \frac{1}{2} V_H$
Sell	Buy	$\frac{1}{4}(1-\alpha^2)$	$V_{SB} \equiv \frac{1}{2} V_L + \frac{1}{2} V_H$
Sell	Sell	$\frac{1}{4}(1+\alpha^2)$	$V_{SS} \equiv \frac{1}{2}\frac{(1+\alpha)^2}{1+\alpha^2} V_L + \frac{1}{2}\frac{(1-\alpha)^2}{1+\alpha^2} V_H$

Table 2. Net change in expected profit as a result of eliminating mandatory last trade reporting

	Period I	Period II	Total
Bid-ask spread	Narrower	Wider on average for all trades	--
Market makers' profit	$-\pi_m < 0$	$+\pi_m > 0$	0
Informed traders' gain	$\alpha\pi_m > 0$	$\pi_i < 0$	$\alpha\pi_m + \pi_i > 0$
Uninformed traders' gain	$(1-\alpha)\pi_m > 0$	$\pi_u < 0$	$(1-\alpha)\pi_m + \pi_u < 0$