PRE-ANNOUNCEMENT OF INSIDERS’ TRADES†

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We consider the implications of a regime change regarding the timing of reports of trades made by corporate insiders. Presently, insiders report their trades after the fact; however, recently there have been renewed calls for insiders to pre-announce their trades to curb insiders’ ability to profit from their information advantage. Pre-announcement by insiders removes noise trades as source of disguise, implying that insiders can no longer realize such profit. Of course, insiders also trade for other unobservable motives. This too is a source of disguise, but a dysfunctional one because it serves as an incentive to distort trades from those that would be optimal otherwise. As a consequence, insiders may be predisposed to favor accounting standards that expand public disclosures pertaining to firm value. A mitigating factor is the price risk caused by disclosures made in advance of trade. These phenomena are present even without pre-announcement and become more prominent as markets become thinner.

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1. Introduction

Recent corporate scandals have led to renewed interest in revising insider trading regulations so as to promote greater transparency of insider trades. In 2000, the Securities and Exchange Commission (SEC) adopted Regulation FD calling for wide public disclosure of new information and simultaneously afforded insiders an affirmative defense against alleged violations of insider trading rules in advance of such disclosure through pre-arranged trading commitments. In 2002, the SEC adopted amendments to implement a provision of the Sarbanes-Oxley Act shortening the time before insiders are required to report their trades from as long as six weeks to just two days in most cases. In 2003, a blue-ribbon commission on Public Trust and Private Enterprise, recommended that corporate executives be required to provide advance public notice of their intention to sell shares in their companies.\textsuperscript{1} These moves toward greater transparency echo much earlier proposals in the legal press, law reviews, and even in the United States Congress for a pre-transaction public notification requirement requiring insiders to disclose an “intention to trade” in a specific amount prior to trading, which we term pre-announcement.\textsuperscript{2} As well, some companies have required that insiders preannounce all their trades (e.g., Ameritrade Holding Company) while others have required all insider trades take place via pre-arranged trading commitments (e.g., Libbey, Inc.).

In this paper we consider the consequences of a shift from the current regime under which insiders report their trades after the fact (without pre-announcement) to one in which they report their trades before the fact (with pre-announcement). The novelty in our analysis lies in modeling other motives for insiders to trade besides exploitation of private information. Corporate officers, directors, and other insiders routinely trade to realize stock-based compensation, shed firm-specific risk, meet liquidity needs, manage taxes, acquire influence over firm affairs,\textsuperscript{3} and plan their estates (see Appendix A for

\textsuperscript{1} In U.S. v. O’Hagan, 117 S. Ct. 2199, the Supreme Court indicated that advance revelation of intent to trade could hypothetically have the ancillary effect of eliminating legal jeopardy.

\textsuperscript{2} These include proposals made in the legal press by Klein (1983), in testimony before the Senate Judiciary Committee (see Coffee, 2006), in the U.S. Congress by Senator John Chafee (see Committee on Federal Regulation of Securities, 1987), and in law reviews by Gilson and Kraakman (1984), Samuelson (1988), and Fried (1998, 2000).

\textsuperscript{3} See Stulz (1988) on benefits of control.
anecdotal illustrations). The presence of these other motives for trading along with the plausible assumption that market makers cannot fully disentangle such motives from attempts to profit from private information adds an important dimension to our understanding of how a regulation requiring pre-announcement is likely to affect insiders’ trading strategies and price formation. Of special interest to accountants is the likely impact of pre-announcement of trades on insiders’ tendencies to oppose public disclosure standards that might pre-empt their information advantage.4

Our key findings are that pre-annoucement of trades increases trading costs for insiders and reduces risk shedding by insiders, causing them a loss of expected utility. To avoid this loss, insiders may be willing to support accounting standards that expand pre-emptive public disclosures, but this willingness is mitigated by the ex ante price risk caused by the disclosures.

Though insiders trade for many non-information based motives not observable to market makers, for modeling purposes, we focus on one stylized motive, namely, to shed risk associated with a privately observed endowment shock. The endowment shock can be likened to the evolution over time of an insider’s exposure to the risk from firm stock price fluctuations. Under current rules governing reporting of insider trades and stockholdings, it is generally not possible to measure precisely either the level or

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4 Evidence of such opposition can be found in Dechow, Hutton, and Sloan (1996) regarding letters pertaining to stock options disclosures, Aboody and Lev (1998) regarding the Software Publishers’ Associations negative stance on capitalizing software, and Hughes, Kao, and Williams (2002) regarding the Treasury Management Associations efforts to discourage disclosure of forward contracts. Of course, there could be other reasons for lobbying against standards that advance disclosure unrelated to insiders trading on private account. Standards that mandate more timely disclosure also serve to pre-empt insiders’ information advantage. For instance, SEC Rule “Additional Form 8-K Disclosure Requirements and Acceleration of Filing Date” (Release Nos. 33-8400 and 34-49424 <http://www.sec.gov/rules/final/33-8400.htm> accessed April 20, 2009) requires companies to file Form 8-K for eight new items; move two disclosure items currently required to be included in companies’ annual and quarterly reports to Form 8-K; and shorten the filing deadline for Form 8-K to four business days after an event triggering the form’s disclosure requirements. The final rule is less stringent that rule proposed rule (Release No. 33-8106 <http://www.sec.gov/rules/proposed/33-8106.htm> accessed June 28, 2004) which would have required disclosure of eleven items and a two-day filing deadline. Anecdotal evidence of opposition to this rule for more timely disclosure includes the comment letter dated August 26, 2002 from Frank H. Brod Chair, Committee on Corporate Reporting and David H. Sidwell Chair, SEC Subcommittee of the Committee on Corporate Reporting Financial Executives International to Mr. Jonathan G. Katz, Secretary of the SEC.
change in this exposure over time from public filings. Even with pre-announcement, an insider’s incentives for trading are not likely to be known to the market maker since the market maker is not privy to the insider’s entire portfolio or changes in firm holdings from non-market transactions. A useful way to think about this structure is to view the model as a reduced form of a larger portfolio-rebalancing problem. Although not presented here, we have also modeled additional motives for trading including both a marginal private benefit per share to an insider’s ending position and implicit risk sharing and derived qualitatively similar results. The crucial aspect in terms of the underlying economic intuition is the presence of some imprecision in the inferences about insiders’ motives for trading that market makers are able to draw from the public record of changes in insiders’ holdings, public disclosures by their firms, order flow inclusive of noise trades, and where applicable pre-announcement of insiders’ trades. As long as there is some imprecision in market makers’ imputation of motives, then there will be a tension between the desires to shed risk on one hand and to exploit private information on the other.

Apart from the revelation of insiders’ trades, the key distinction between regimes with and without pre-announcement of insider trades is the presence of liquidity trading in the order flow observed by the market maker under the latter regime. Given that liquidity trades constitute a source of noise, they serve as disguise for insiders trades. It is well known that the lower the noise from liquidity trading, the lower the gains to insiders from trading on their private information. One might wonder whether pre-announcement would preclude all insider trades. For instance, if the insider places a sell order, does this not mean that the stock is overvalued? Does a “no trade” theorem

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5 Over time, the SEC has changed the section 16(a) reporting requirements to enlarge the set of reportable transactions and to increase the detail in the reports. Under current Rule 16a-3, insiders must report initial stock holdings on Form 3, changes in holdings on Form 4, and year-end holdings on Form 5. The Rule exempts, among other transactions, issuer contributions to tax-qualified pension plans. These omissions necessarily introduce error in estimates of exposure to price fluctuations. Further, a complete accounting of an insider’s exposure to risk would include anticipated future compensation, which obviously is difficult to measure and is not part of the reporting regime, and details on the other elements of the insider’s personal portfolio that covary with firm stock.

6 Modeling incentives for trade as random variables can be traced to Garman (1976) who also assumes that stock ownership conveys private benefits.
apply? While pre-announcement of trades eliminates liquidity traders as a source of disguise for the insider’s information-based trades, pre-announcement does not prevent trade because the insider’s other motives for trade provide an additional source of disguise. Analogous to the market maker’s inability to disentangle the informed trade from the liquidity trade in the standard model, the market maker cannot disentangle the component of the insider’s trade that is due to private information from the component driven by other motives. Thus, the insider’s mixed motives make trade with the market maker feasible. Moreover, the profits the insider receives from his private information are offset, on average, by the price adjustment imposed by the market maker on the insider’s trades, including those that are unrelated to private information, e.g., when the insider unwinds his endowment. Hence, the market maker breaks even in expectation and the insider’s information imposes trading costs on all his trades.

The regime with pre-announcement can be viewed as the limiting case of no liquidity trading. Holding constant the precision of public disclosures, we show that with pre-announcement of their trades, insiders cannot generate the expected profits from their information advantage that they obtain in the absence of mandatory pre-announcement. That is to say, insiders now bear the trading costs implied by price adjustments made by the market maker in anticipation that insiders may be trading on private information. Constructively, the incentive to distort their trades away from those that would be optimal in meeting other motives (shedding risk in our model) in the fruitless attempt to exploit their private information under pre-announcement is a deadweight loss to insiders, a loss that they would prefer to avoid, possibly to the point of removing that incentive by pre-commitment to greater public disclosure so as to reduce their information advantage.

The mitigating factor with respect to making pre-commitments to more informative public signals prior to receipt of private information under pre-announcement is the added risk of unfavorable price changes when prices adjust to the information conveyed by those signals before insiders trade, as opposed to the lesser information conveyed by
the order flow. Hirshleifer’s (1971) insight that public disclosure in advance of an opportunity to trade (insure) imposes a deadweight loss is clearly an element of this tradeoff. The tension between the added price risk of disclosure versus the risk of retaining an under-diversified position in a fruitless effort to exploit private information is both subtle and interesting. The tendency to distort trades in a manner that exposes insiders to risk in order to exploit private information is also present without pre-announcement, although in this case the insider’s expected profits from conditioning trades on private information may more than offset the deadweight loss from not satisfying other motives; e.g., loss of expected utility due to under-diversification. Among our results with pre-announcement, we depict the tradeoff between the greater price risk from pre-emptive public disclosure than from the order flow and risks from under-diversification implied by trade distortions by demonstrating how an insider’s ex ante expected utility changes as a function of the precision of a public signal.

Comparing regimes with and without pre-announcement, it is clear that, by providing insiders with an opportunity to profit from their private information at the expense of noise traders assumed to trade for liquidity reasons, insiders prefer the latter. More notably, we show that, ceteris paribus, insiders prefer accounting standards that go further in the direction of pre-empting their information advantage by mandating greater public disclosure under the former regime than under the latter. This raises the prospect that a new insider trading regulation requiring that insiders pre-announce their trades might mitigate the tendency corporate insiders have exhibited in the past to oppose accounting standards that would expand disclosure. While other reasons for such opposition grounded in sound economic arguments have been offered, it is still the case that, holding total information constant, pre-announcement removes the opportunity to profit on private information and, hence, is likely to work in the direction of less resistance. Interestingly, we also show that insiders may prefer an interior choice of public signal precision even without pre-announcement provided the amount of noise from liquidity

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7 For example, public disclosure may reveal proprietary information that would benefit rivals in oligopoly competition.
trading is sufficiently small. Of course, without pre-announcement and holding constant the disguise provided by liquidity traders, insiders would always prefer less precise disclosures.

A related paper by Glosten (1989) considers a setting in which market makers recognize that they are trading with insiders who may or may not be trading on private information. His interest is quite different from ours in that he seeks to compare the behavior of monopolist market makers (specialists), who provide liquidity by averaging profits over successive trades, with that of competitive market makers, who may more frequently shut down the market when adverse selection problems become too severe. Market shutdowns can occur in our model under pre-announcement of insider trades when there is too little uncertainty regarding the insider’s non-information based motive for trading, a case ruled out in our analysis by imposing a second-order condition. Bhattacharya and Speigel (1991) also characterize market shut downs in cases where the adverse selection problem is sufficient to overcome uninformed traders’ desire to shed risk. Risk sharing is likewise present in Speigel and Subrahmanyam (1992) as the incentive for uninformed traders to trade with privately informed traders, thereby allowing for trade even in the absence of liquidity trading as in our pre-announcement case. However, none of these papers consider the consequences of greater transparency of insiders’ trades on their trading behavior in meeting other motives for trading, level of price risks that insiders may face, and insiders’ preferences toward the precision of preemptive public signals.

The remainder of this paper is organized as follows: section 2 presents our model; section 3 characterizes equilibria with and without pre-announcement of insiders’ trades; section 4 provides comparative statics; section 5 presents sensitivity analysis on the insiders’ welfare including the impact of a regime change to require pre-announcement; and section 6 concludes.
2. Model

A single risk-averse and privately informed insider places demands for his company’s stock with a competitive market maker, who sets prices based on what can be inferred about future payoffs from publicly available information and the order flow. We consider two regimes. In the first regime, the insider must pre-announce his demand. This allows a competitive market maker to distinguish the insider’s demand from the demands of noise traders who trade simultaneously. In the second regime, the insider does not pre-announce his demands; however, he must report his trades after the fact. In the second regime with continuous trading over a finite interval, the insider is able to eliminate all risk associated with noise trades and exploit the disguise provided by noise trades. In this context, the pricing risk created by noise trades has no effect on the insider’s equilibrium trading strategy: a risk-averse insider behaves identically to a risk-neutral insider. Furthermore, we show that, as in Huddart, Hughes, and Levine (2001), the model is equivalent in all relevant aspects (total liquidity, total order flow, and expected insider profits), to the one-period Kyle (1985) model. In light of these results, we analyze a one-period model in which we suppress the risk associated with noise trades. This eases the analysis considerably. In Appendix B, we establish the equivalence of the one-period model and its continuous-time analog.

The company’s liquidation value, \( v \), is normally distributed with mean \( \bar{v} \) and variance \( \Sigma_\phi \). There is no loss in generality in further assuming that \( \bar{v} = 0 \). The insider exhibits constant absolute risk aversion with parameter \( \rho \). The insider knows his endowment, \( z \), but the market maker only knows that it is normally distributed with mean \( \bar{z} \) and variance \( \sigma^2_\xi \). The insider receives a private signal, \( \eta = v + \epsilon \), where \( \epsilon \) is normally distributed with mean 0 and variance \( \sigma^2_\epsilon \). The public signal, \( s \), is a garbling of the insider’s private signal; i.e., \( s = \eta + \phi = v + \epsilon + \phi \), where \( \phi \) is normally distributed with mean 0 and variance \( \sigma^2_\phi \). The extreme cases of no and full pre-emptive public disclosure correspond to \( \sigma^2_\phi = \infty \) and \( \sigma^2_\phi = 0 \), respectively. The insider submits an order to trade \( x \) shares. Noise traders submit net orders to trade \( y \) shares. These orders are assumed to be uninformed liquidity trades and normally distributed, with mean zero. Let the variance of \( y \)}
be $\sigma_y^2$. If the insider does not pre-announce his trades, then the market maker updates price based on the private signal $s$ and the combined order flow $x + y$. The random variables $v, y, z, \epsilon, \eta,$ and $\phi$ are independent.

Pre-announcement of insider trades implies that the market maker can distinguish the insider’s demand, $x$, from the net orders submitted by noise traders, $y$. In the analysis that follows, assuming that $x$ can be distinguished from $y$ when the insider preannounces is the same as assuming that $\sigma_y^2 = 0$. Thus, insider trades given pre-announcement are akin to insider trades without pre-announcement in very thinly-traded stocks. When the stock is so thinly traded that there are no noise trades, the market maker correctly conjectures that any order flow must have been generated by the insider. Hence, pre-announcement of insider trades is the same as no pre-announcement with vanishing noise trade.

Figure 1 provides a timeline for the model.

[Figure 1]

The market maker observes $s$ as well as $x$, or $x + y$, before setting price $p_1$, implying that the insider’s portfolio is worth $v(x + z) - xp_1$ after trade. Accordingly, the insider chooses $x$ to maximize the following certainty equivalent:

$$E \left[ v(x + z) - xp_1 \mid \eta, z, s \right] - \frac{\rho}{2} \text{Var} \left[ v(x + z) - xp_1 \mid \eta, z, s \right]$$

$$= E \left[ v(x + z) - xp_1 \mid \eta, \phi, z \right] - \frac{\rho}{2} \text{Var} \left[ v(x + z) - xp_1 \mid \eta, \phi, z \right]$$

$$= M\eta(x + z) - xp_1 - \frac{\rho}{2} (x + z)^2 V,$$

where $M = \Sigma_0 / (\Sigma_0 + \sigma_y^2)$ and $V = M\sigma_y^2$.

In a discreet time model, (1) should include an additional term, $-\frac{1}{2} \rho x^2 \lambda \sigma_y^2$, corresponding to the variance in profits caused by the random nature of the noise trade variable. This term renders the discreet-time model intractable. As discussed earlier
(and proven in the Appendix B), (1) is the reduced form of a continuous time model in which the insider’s trades are disclosed immediately after he completes them. In the continuous time model, the variance of insider profits is unaffected by the noise trade variance and so does not appear in the reduced form. Accordingly, \( x \) in the reduced form is interpreted as the accumulated trade by the insider during the (continuous time) trading interval.

Suppose that a linear equilibrium exists in which

\[
x = \alpha + \beta (M\eta - Ks) + \delta(z - \bar{z}), \quad \text{and}
\]

\[
p_1 = p_s + \lambda(x + y - \mu_s),
\]

where \( \mu_s = E[x \mid s] \), \( p_s = E[v \mid s] = Ks \), and \( K = \Sigma_0 / \left( \Sigma_0 + \sigma^2_x + \sigma^2_\phi \right) \). Further suppose that \( p_1 = E[v \mid x + y, s] \). Thus, the insider’s demand is a linear function of his information advantage and his endowment, and the market maker sets the price at which the insider trades equal to the expected value of the firm conditional on the order flow, \( x + y \), and the preceding disclosure, \( s \). In the next section, we characterize this equilibrium.

3. Equilibrium Analysis

3.1 Without Pre-announcement of Insider Trades

The first proposition describes the insider’s trading strategy and the stock price in terms of the exogenous parameters.

**Proposition 1:** Given partial pre-emptive public disclosure, an equilibrium can be characterized by the following endogenous parameters:

\[
\alpha = \left( \frac{\sigma^2_\phi K}{\rho^2 \sigma^2_x \sigma^2_z V + \sigma^2_y / M} - 1 \right) \bar{z}, \quad \text{and}
\]

\[
\beta = \frac{1}{\rho V} \left( \frac{\rho^2 \sigma^2_x \sigma^2_z V + \sigma^2_y / M - \sigma^2_\phi K}{\rho^2 \sigma^2_x \sigma^2_z V + \sigma^2_y / M + \sigma^2_\phi K} \right),
\]

\( \bar{z} \)
\[
\delta = \frac{2\sigma^2 K}{\rho^2 \sigma_y^2 \sigma_z^2 V + \sigma_y^2 /M + \sigma_{\phi}^2 K} - 1, \quad \text{and} \\
\lambda = \frac{\rho \sigma^2 K V}{\rho^2 \sigma_y^2 \sigma_z^2 V + \sigma_y^2 /M - \sigma_{\phi}^2 K},
\]

where

\[
\sigma_y^* = (2\lambda + \rho V)^2 \sigma_y^2,
\]

and provided the second-order condition

\[
\rho^2 \sigma_e^2 \sigma_y^2 V + \sigma_y^2 /M - \sigma_{\phi}^2 K > 0
\]

is satisfied.

The proof is in Appendix B. Note that \( \sigma_y^* \) is an endogenous but monotone function of \( \sigma_y^2 \). Its effects on the other endogenous parameters is only through \( \lambda \), the only endogenous parameter in (8). Clearly, 

\[
\frac{\partial \sigma_y^*}{\partial \sigma_y^2} > 0,
\]

so the comparative statics for \( \sigma_y^* \) are the same as for \( \sigma_y^2 \) by the Chain Rule. Below we consider extreme cases of public disclosure choices given pre-announcement of \( x \), or equivalently no noise trades.

The second-order condition is sufficient to ensure that the insider’s expected sales are less than his expected endowment and trading intensity is less negative than in the no pre-emptive public disclosure case as we would anticipate given the incentive to distort demands based on the insider’s private information. As well, the second-order condition implies that both the insider’s intensity of trading based on private information and the market maker’s marginal price adjustment based on pre-announced insider trades are both positive.\(^8\)

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\(^8\) The second order condition itself makes sense in that if the adverse selection problem is so great that the incentive to shed risk is overwhelmed by the incentive to distort trades based on private information such that it is no longer possible for the market maker to break-even, then the market shuts down and there is no trade.
3.2 With Pre-announcement of Insider Trades

It is evident from (10) that \( \sigma^2_y = 0 \) implies \( \sigma^*_y = 0 \). Hence we have:

**Corollary 1:** Given pre-announcement by insiders and partially informative pre-emptive public disclosure, an equilibrium can be characterized as follows:

\[
\alpha = \left( \frac{\sigma^2_K}{\rho^2 \sigma^2 \sigma^2_z V} - 1 \right) \bar{z},
\]

\[
\beta = \frac{1}{\rho \bar{V}} \left( \frac{\rho^2 \sigma^2 \sigma^2_z V - \sigma^2 \sigma^2_z K}{\rho^2 \sigma^2 \sigma^2_z V + \sigma^2 \sigma^2_z K} \right),
\]

\[
\delta = \frac{2\sigma^2 \sigma^2_z K}{\rho^2 \sigma^2 \sigma^2_z V + \sigma^2 \sigma^2_z K} - 1, \quad \text{and}
\]

\[
\lambda = \frac{\rho \sigma^2 \sigma^2 \sigma^2_z K \bar{V}}{\rho^2 \sigma^2 \sigma^2_z V - \sigma^2 \sigma^2_z K},
\]

provided the second-order condition

\[
\rho^2 \sigma^2 \sigma^2_z V - \sigma^2 \sigma^2_z K > 0
\]

is satisfied.

In order to gain some insight with respect to the above characterization of an equilibrium, we first examine the extreme cases of full pre-emptive public disclosure and no pre-emptive public disclosure. It is easy to check that an equilibrium for the limiting cases as \( \sigma^2 \phi \) goes to zero and infinity, respectively, are characterized by the following two corollaries.

**Corollary 2:** Given fully informative pre-emptive public disclosure (i.e., \( \sigma^2 \phi = 0 \)), an equilibrium can be characterized as follows:

\[
\alpha = -\bar{z},
\]

\[
\beta = 1/ (\rho \sigma^2 \epsilon),
\]

\[
\delta = -1, \quad \text{and}
\]

\[
\lambda = 0.
\]
The above results are intuitive. The second-order condition in this case is always satisfied because there is no adverse selection in this case. With full disclosure, the market maker adjusts price to reflect the insider’s private information before trade, thereby eliminating an information based incentive to trade. The insider’s only remaining motive for trading is to shed risk which he accomplishes by selling his realized endowment. The insider’s expected demand is therefore to sell \( z \). Understanding that there is no information conveyed by the insider’s demands, the market maker sets marginal trading costs equal to zero. It is notable that with full disclosure, the second order condition is always satisfied and the market can never breakdown because breakdowns only occur when asymmetric information overwhelms other incentives to trade.

**Corollary 3:** Given uninformative pre-emptive public disclosure (i.e., \( \sigma_\phi^2 = \infty \)), an equilibrium can be characterized as follows:

\[
\alpha = \left( \frac{\Sigma_0}{\rho^2 \sigma^2_x \sigma^2_z V + \sigma^*_y / M} - 1 \right) \bar{z},
\]

\[
\beta = \frac{1}{\rho V} \left( \frac{\rho^2 \sigma^2_x \sigma^2_z V + \sigma^*_y / M - \Sigma_0}{\rho^2 \sigma^2_x \sigma^2_z V + \sigma^*_y / M + \Sigma_0} \right),
\]

\[
\delta = \frac{2 \Sigma_0}{\rho^2 \sigma^2_x \sigma^2_z V + \sigma^*_y / M + \Sigma_0} - 1, \quad \text{and}
\]

\[
\lambda = \frac{\rho \Sigma_0 V}{\rho^2 \sigma^2_x \sigma^2_z V + \sigma^*_y / M - \Sigma_0},
\]

provided the second-order condition

\[
\rho^2 \sigma^2_x \sigma^2_z V + \sigma^*_y / M - \Sigma_0 > 0,
\]

is satisfied.

The endogenous parameters are not qualitatively different from those in Proposition 1. The term \( \sigma^2_\phi K \) converges to \( \Sigma_0 \) in the limit. Of course, there is no price adjustment prior to trade in the absence of a public disclosure. A point to keep in mind for when we consider the insider’s expected utility in advance of that disclosure is that price
changes made by the market maker in response to the pre-emptive public disclosure impose greater risk on the insider than price changes made only in response to the order flow.

4. Comparative statics

Now we return to the general case where the market maker cannot distinguish the insider’s demands from those of noise traders and consider how the insider’s trading strategy and the market makers pricing strategy change as we vary the amount of noise trading. Recall that pre-announcement of insider trades is equivalent to a reduction in noise trading, so the following comparative statics illustrate the effect of such a policy.

4.1 Sensitivity to Noise Trading

Proposition 2: A small change in the amount of noise trading affects the insider’s trading strategy and market depth as follows:

\[
\frac{\partial \alpha}{\partial \sigma_y^2} < 0 \quad \text{provided } \bar{z} > 0, \\
\frac{\partial \beta}{\partial \sigma_y^2} > 0, \\
\frac{\partial \delta}{\partial \sigma_y^2} < 0, \quad \text{and} \\
\frac{\partial \lambda}{\partial \sigma_y^2} < 0.
\]

Proof: The result follows from differentiation of (3), (4), (6), and (7) with respect to \(\sigma_y^2\) and the observation that \(\sigma_y^2\) is monotone in \(\sigma_y^2\).

A decrease in noise trading induces less trading intensity by the insider and larger price adjustments by the market maker consistent with the insider’s loss of disguise. As well, the sensitivity of the insider’s trades to deviations in his realized endowment from the prior expectation becomes greater as the prospect of profiting from private information diminishes. Although we have yet to determine how such a change in noise trading might affect the insider’s expected utility, it can be shown that the insider is made worse off the weaker the prospects are from exploiting his private information.
4.2 Sensitivity to Informativeness of Public Disclosure

We now suppress the presence of noise trading by assuming pre-announcement of the insider’s trades and consider the sensitivity of the insider’s trading strategy and the market maker’s pricing strategy with respect to the precision of the public signal.

**Proposition 3:** A small change in the informativeness (precision) of pre-emptive public disclosure affects the insider’s trading strategy and market depth as follows:

\[
\frac{\partial \alpha}{\partial \sigma^2_\phi} > 0 \quad \text{provided } \bar{z} > 0, \tag{24}
\]

\[
\frac{\partial \beta}{\partial \sigma^2_\phi} < 0, \tag{25}
\]

\[
\frac{\partial \delta}{\partial \sigma^2_\phi} > 0, \quad \text{and} \quad \tag{26}
\]

\[
\frac{\partial \lambda}{\partial \sigma^2_\phi} > 0. \tag{27}
\]

**Proof:** The result follows from differentiation of (3), (4), (6), and (7) with respect to \( \sigma^2_\phi \).  

As the precision of the public signal decreases, the insider can be expected to sell less of his expected endowment (increase expected demand) with less negative intensity due to the greater incentive to distort his demands based on his non-pre-empted private information. Although as previously mentioned the insider cannot profit in expectation from his private information, the less public revelation of that information the more private information remains to create that incentive. Recognizing that the insider has greater private information following the public signal, the market maker increases the marginal trading cost. Concomitantly, the insider reduces his intensity of trading on his private information anticipating these higher trading costs.
5. Insider’s Welfare

5.1 Sensitivity analysis given pre-announcement

We now step back and consider the insider’s welfare as we vary the precision of the public signal, endowment risk, and prior uncertainty, given pre-announcement of the insider’s trades. Our analysis concludes by analyzing the effect of the amount of noise trading on the insider’s preferred public disclosure policy. The insider’s ex ante expected utility can be expressed as follows:

\[ E[U(v(x + z) - xp_1)], \]

where \( x = \alpha + \beta (M\eta - Ks) + \delta(z - \bar{z}), p_1 = p_s + \lambda(x - \mu_s), p_s = E[v \mid s], \) and \( \mu_s = E[x \mid s]. \) The endogenous parameters \( \lambda, \alpha, \beta, \) and \( \delta \) assume the values given in Proposition 1. They are non-zero for \( \phi \in (0, \infty). \) Since the function \( U \) is exponential and all random variables in the analysis are normally distributed, we use the following fact from Christensen and Feltham (2003, 106–108) to derive closed-form solutions for the ex ante expected utility of the insider.

Fact: Given (i) scalars \( r, \) and \( f; \) (ii) an \( n \times 1 \) vector \( \nu; \) and, (iii) symmetric matrix \( Q, \) all constants. Let \( d \sim N(\mu, \Sigma) \) be an \( n \times 1 \) vector of normally distributed random variables with mean \( \mu \) and variance-covariance matrix \( \Sigma. \) Then

\[
E \left[ \exp \left( -r \left( f + \nu' d + \frac{1}{2}d'Qd \right) \right) \right] = \sqrt{\frac{|H|}{rQ + H}} \exp \left[ - \left( rf + \frac{1}{2} \mu' H \mu - \frac{1}{2} \left( rv - H \mu \right)' (rQ + H)^{-1} (rv - H \mu) \right) \right],
\]

where \( H = \Sigma^{-1}, \) provided \( rQ + H \) is positive definite.

The resulting expression is not amenable to a characterization of the insider’s preferences toward the precision of pre-emptive public disclosure analytically. Accordingly, we resort to numerical examples to depict the insider’s expected utility as a function of \( \sigma^2_\delta. \)

[Figure 2]
Figure 2 illustrates how the ex ante expected utility of the insider varies with the precision of the public disclosure given a parameterization such that the insider prefers an interior choice of precision. As shown by the figure, the insider’s expected utility is initially increasing in the variance of the public signal. In this region, as the public signal becomes less precise, the insider faces less risk of price changes before he has an opportunity to trade, and this effect more than offsets the loss in expected utility from distortion of demands due to the insider’s fruitless attempt to exploit his private information. Further loss of precision in the public signal yields less marginal reduction of price risk relative to the dysfunctional consequences of the information based component of the insider’s demands.

[Figure 3]

We can gain more insight as to the forces at work from Figure 3 wherein we consider the effects of varying the risk associated with the insider’s endowment on the insider’s expected utility under the extreme cases of full and no pre-emptive public disclosure. The idea here is to show how different parametrizations could lead to different orderings of full and no public disclosure and, hence, further an appreciation of why insiders might prefer an interior choice of pre-emptive public disclosure precision. Under full disclosure, the insider’s expected utility is decreasing because the insider’s endowment is increasingly uncertain implying risk with respect to the proceeds from selling the realization. His expected utility is increasing under no public disclosure because the greater the variance of his endowment then the more likely he would be trading to shed risk rather than exploit his private information, thereby reducing the marginal trading costs set by the market maker. This increase in expected utility dampens out as the variance of the endowment continues to increase.

[Figure 4]

Next, in Figure 4 we vary the prior variance of firm value as a measure of the insider’s private information. Not surprisingly, the insider’s expected utility is decreasing

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9 The insider’s expected utility is also decreasing in his expected endowment under either full or no public disclosure because of uncertainty with respect to price.
in his private information irrespective of pre-emptive public disclosure. Under full disclosure, more private information is revealed by pre-emptive public disclosure causing the insider to face greater price risk. Under no public information, more private information implies greater distortion of demands to exploit that information and greater price risk though not as much as with full disclosure. The incremental price risk of full disclosure becomes higher as the prior variance becomes large relative to the noise in the private signal to the point where expected utility is lower in that case.

5.2 Comparing regimes with and without pre-announcement

Finally, we compare the insider’s ex ante expected utility with and without pre-announcement depending on the thinness of the market.

[Figure 5]

In Figure 5 we allow for the presence of noise trading and examine how a change in the amount of noise trading impacts on the insider’s expected utility as a function of the precision of the public signal. We can see that decreasing the amount of noise trading enhances the benefits of pre-emptive public disclosure. The family of functions depicting the insider’s expected utility moves from a preference for the least informative public disclosure policy when noise trading is highest to an interior policy as noise trading diminishes. This observation suggests that a regime change to pre-announcement of insider trades could induce insiders to become less resistant to proposed accounting standards that increase the informativeness of public disclosures.

6. Conclusion

Recent corporate scandals have drawn the public’s attention to the trading behavior of corporate insiders. With this attention have come proposals for changes in the regulation of insider trading that, in general, call for greater transparency than presently exist under SEC requirements. In response to allegations of trading on private information, a common mea culpa of insiders for their trades is that their trades were based on
motives other than the exploitation of an information advantage. This paper considers how pre-announcement of insider trades would impact on insider demands, prices set by market makers in response to those demands, and insiders’ ex ante preferences regarding pre-emption of their information advantage through accounting standards that mandate greater public disclosure.

The principal tensions explored in our analysis are, first, the ex post tension between an insider’s incentives to distort demands in order to take advantage of private information and to shed risk associated with an under-diversified position in shares obtained through stock compensation awards and other non-market transactions; and, second, the ex ante tension between the dysfunctional consequences of expected distortions in demands under less pre-emptive public disclosure and greater price risk under more pre-emptive public disclosure. Concomitantly, we consider the consequences of a change from the current regime of insiders’ reporting their trades ex post to a regime with pre-announcement.

We derive comparative statics for the introduction of pre-announcement of insider trades. Prices become more sensitive to insider trades since they are not garbled in the order flow by uninformed trades. This increased price sensitivity leads to less extensive (and costlier) trading by the insider resulting in greater risk exposure. Combined, these effects result in reduced expected utility for the insider under such a pre-announcement regime. Of course, this loss of utility could be offset in general equilibrium by higher compensation in the executive labor market, so shareholders ultimately bear the costs.

We also derive comparative statics that depict changes in insider trading strategies and market pricing that follow from changes in the precision of pre-emptive public disclosure of firm value. The tendency of the insider to trade in order to shed risk is diminished by less precise public disclosure due to the insider’s incentive to distort trades in an effort to exploit his greater information advantage. This effort is ineluctable and fruitless. Consistent with the prospect of private information driving insider demands, the market maker imposes larger price adjustments when public disclosure is less complete and, accordingly, the insider trades less intensely on his information.\textsuperscript{10}

\textsuperscript{10} These last two results are intuitive and analogous to comparative statics in other Kyle (1985)-based models of insider trading.
Our principal results when we step back to consider the insider’s welfare characterize his preferred precision of pre-emptive public disclosure and how his preferences vary with pre-announcement of trades (and more generally with the amount of uninformed trades offering disguise to the insider). Mandatory pre-announcement of insider trades would lead to an increase in insiders’ preferred level of public disclosure, which could change political pressures, resulting in an expansion of public disclosure mandated by accounting standards. Nonetheless, it is interesting to point out that the price risk associated with price changes before insiders have an opportunity to trade can limit insiders’ willingness to support accounting standards that would mandate public disclosures that fully pre-empt their information advantage.

For simplicity and ease of exposition, we chose to report only those results for the modeling choice of limiting the insider’s non-private information based motives for trading to a desire to shed risk. Qualitatively similar results obtain when we assume that the insider has more varied motives. The comparative statics are somewhat more complicated when we allow for a richer portrayal of motives. However, ex ante, it is still a competition between the incentive to distort trades to exploit private information and the price risk associated with pre-emptive public disclosure that shapes the insider’s preferences regarding that disclosure.

Policy makers seeking to discourage insiders from exploiting their access to private information for personal gain have a number of instruments available for that purpose, not limited to requiring pre-announcement of insider trades. They can seek to impose more severe penalties than currently prescribed on insiders who can be shown to have conditioned their trades on private information.\footnote{\textcite{Beneish} points out that neither the prospect of loss of employment or SEC imposed penalties are sufficient to deter insider trading on private information.} However, monitoring insider trades and attempting to infer whether those trades were based on private information after the fact is not a simple matter. Not only are there costs associated with monitoring and the legal machinery of sanctions, but, as Spiegel and Subrahmanyam (2000) suggest, there may be strategic effects such that prosecution based on price changes as a measure of
insider trading could actually be misdirected toward insiders with less precise private information. Moreover, the notion that insiders must trade to enjoy stock-based compensation suggests that policies designed to punish insiders for trades that might be construed as improper from circumstantial evidence makes such compensation unattractive, even though stock-based may be efficient in resolving agency conflicts.

Another policy instrument is to directly mandate accounting standards that would result in public disclosure that pre-empts private information based trades. One difficulty here as previously mentioned is that accounting standards that expand disclosure have often encountered strong and effective resistance from corporate executives in a context without pre-announcement of insider trades. A consequence of policies that require or otherwise induce pre-announcement of insider trades is that pre-announcement tends to better align the preferences of corporate insiders and accounting standard setters who seek to expand public disclosure.

Yet another instrument is the affirmative defense against prosecution of insiders for trading on private information afforded through pre-commitment by Rule 105b-1. However, the effect of pre-commitment in deterring information-based trading is questionable. Ke, Huddart, and Petroni (2003) find that insiders know and trade upon foreknowledge of earnings as long as two years before the earnings announcement, which suggests that insiders may pre-commit well in advance of trading (anonymously) and still succeed in exploiting their information advantage. Jagolinzer (2009), who finds that pre-committed trades undertaken through the Rule 10b5-1 yield abnormal profits to insiders, offers direct evidence that insiders succeed in exploiting their information advantage notwithstanding pre-commitment.

To parse out the consequences of pre-announcement of trades by insiders, we have implicitly assumed away the presence of other factors that may influence preferences of corporate executives regarding accounting standards. One such factor may be the possibility that greater information asymmetry may imply a higher cost of capital (Baiman and Verrecchia, 1996). Hence, firms may seek to resolve such an asymmetry
through adoption of accounting policies that expand disclosure. Another factor could be heightened political fallout from being seen to oppose accounting standards calling for an expansion of public disclosure. A further limitation of our analysis is that we suppress issues pertaining to the potential role of public disclosure in restricting the scope for insiders to manipulate accounting numbers. Whether these omitted factors significantly detract from a reliance on pre-announcement of insider trades to curb abuses is an empirical question.

12 Recent empirical research by Easley, Hvidkjaer, and O’Hara (2002), Francis, LaFond, Olsson, and Schipper (2003), Botosan and Plumlee (2004), and Aboody, Hughes, and Liu (2004) suggests an association between asymmetric information and cost of capital that might be driven by uninformed traders requiring a premium as compensation for trading against insiders.
Appendix A: Motives for Insider Trades

Here are several excerpts from the financial press containing reasons offered for insider trades:

1. “The latest insider selling, most of which was options-related, reflected a desire by the officers and directors to diversify . . .” Antec The Atlanta Journal and Constitution March 28, 1999.

2. “In one of the biggest executive votes of confidence in a long time, Microsoft Vice President Steven Ballmer spent $46.2 million late last month to buy shares in the software maker.” Microsoft USA Today April 17, 1989.

3. “The fact of the matter is that up until a few months ago, insiders in Nona were paid in stock rather than cash for their services . . . insiders like Doug have to sell positions in their stock in order to feed their families . . .” Nona Morellis II PR Newswire April 16, 1996.

4. “According to the company, the sale of stock in the open market was to repay personal debt and for tax reasons.” Supercuts Business Wire December 30, 1992.

5. “The sale was to fund the construction of a summer camp in Wyoming for disadvantaged and at-risk youth . . . It’s his own individual initiative.” Coca-Cola Enterprises The Atlanta Journal and Constitution May 24, 1999.

6. “This arrangement clearly delineates the intentions of our key insiders . . . They have flexibility in diversifying their portfolios, but maintain a substantial commitment to their investment in U. S. Robotics.” U. S. Robotics PR Newswire August 10, 1993.

7. “Tuesday, Campbell Soup announced a plan to require CEO David Johnson and 69 other top executives to hold stock worth one-half to three times their salaries.” Campbell Soup USA Today, May 5, 1993.

8. “We are pleased that these principals [referring to corporate insiders] have the confidence in our business to further enhance their stock positions in VTC.” Virtual Technology Corporation Business Wire, September 7, 1999.

9. “. . . today announced recent purchases of common stock by each of its executive officers. . . . All of these transactions were related to the exercise of non-qualified stock options with the intent to hold the stock.” American Healthcorp Business Wire, May 4, 1999.

10. “On the surface, that $7.5 million worth of buying could have been viewed as evidence that Mr. Goings is confident about the future of Tupperware’s stock price . . . . But a closer look indicates that . . . the purchase was financed by an $8 million interest-free loan from the company itself.” Tupperware Wall Street Journal, January 13, 1999.
Appendix B: Proofs

Equivalence of One-Period Model to Discrete Horizon Continuous-Time Model

Huddart, Hughes, and Levine (2001), hereafter HHL, provide a solution to a discrete time analog of Kyle’s (1985) rational expectations trading model in which an insider, endowed with long-lived private information, must disclose the quantity he trades at the close of each round of trading. The ex post public reporting of the insider’s trades changes the equilibrium strategy of the insider given that the market maker can infer information from the insider’s previous trade before the next round of trading. By playing a mixed strategy in every round except the last one, the insider garbles the information conveyed by his trade. HHL term the random component of trade in round \( n \) the dis-simulation component of the insider’s trade. HHL show that, in the limit, as the number of trading rounds and incidents of disclosure per unit time becomes large, the insider’s expected profits are halved relative to the case of multi-period Kyle without disclosure. Price discovery corresponds to Kyle’s result in the limit as the number of trading rounds per unit time becomes large.

For our purposes, the noteworthy aspect of HHL’s analysis is that the insider’s trading cost does not depend on the number of rounds and in fact exactly equals the trading cost in a one-period Kyle (1985) model. Likewise, the expected total profit is constant at the same level as one-period Kyle and total order flow of the insider is the same as in a one-period Kyle.

Below, we present two lemmas that extend HHL’s analysis leading to the claim that, in the case of continuous trading, a fixed variance of noise trades over the finite interval of time during which trade takes place, and disclosure of the insiders’ trade after each round, then (i) the insider’s aggregate profits equal the insider’s profits in a one-period Kyle (1985) model and (ii) the market maker’s price adjustment and the total order flow are the same as the price adjustment and the order flow in a one-period Kyle
(1985) model. Consequently, the variance of noise trades does not impose costly risk on the insider and does not reduce his certainty equivalent.

**Lemma 1:** Given $N$ trading rounds, a fixed variance of noise trades over the finite interval of time during which trade takes place, and disclosure of the insiders’ trade after each round, then (i) the insider’s expected aggregate profits equal the insider’s expected profits in a one-period Kyle (1985) model and (ii) the market maker’s price adjustment and the total order flow over the $N$ periods are the same as the price adjustment and the order flow in a one-period Kyle (1985) model.

**Proof of Lemma 1:** In HHL, $u_n$ is the liquidity trader’s order flow at time $n$. In our analysis, fixed variance of noise trades over $N$ periods implies that the variance of $u_n$ is $\sigma^2_u = \sigma^2_y/N$ for all $n$. The greater the number of trading rounds, then the smaller the variance of noise trades in a given round. This is consistent with Kyle (1985) where more trading periods means shorting intervals between trading rounds within a fixed epoch of total trading time. In this case, continuous trading is the limit as $N \rightarrow \infty$.

Let $x_n$ the quantity traded by the insider at time $n$. Let $p_n$ be the price set by the market maker based on the order flow at time $n$ and let $p^*_n$ be the price following the disclosure $x_n$. Proposition 4 of HHL characterizes equilibrium with a risk-neutral insider. In this case,

$$p_n = p^*_{n-1} + \lambda (x_n + u_n),$$

$$p^*_n = p^*_{n-1} + 2\lambda x_n,$$

$$\lambda = \frac{\Sigma_0^{1/2}}{2\sigma_u},$$

and

$$E(\pi) = \frac{\Sigma_0^{1/2} \sigma_u}{2},$$

irrespective of $N$. Moreover,

$$v = p^*_N = p^*_0 + 2\lambda \sum_{n=1}^N x_n$$

and

$$\sum_{n=1}^N x_n = \frac{v - p^*_0}{2\lambda}.$$
Thus, HHL show that immediate post-trade disclosure is equivalent to one round of trading in Kyle’s (1985) model, irrespective of the number of rounds (and clearly this holds in the limit of continuous trading).

HHL do not consider the variance of profits since they assume that the insider is risk-neutral. There are three sources of uncertainty: the inside information about value, \( v \), the noise trade sequence, \( u \), and the dissimulation trades, \( z \), required by the equilibrium mixed strategy.

**Lemma 2:** Given continuous trading over a finite interval, noise trades do not affect the variance of the insider’s profits.

**Proof of Lemma 2:** First, consider the profit of the insider conditional on the realization of \( v \) and the choice of dissimulation path \( W = \{w_n\}_{n=1}^N \). Note that in this case, all the \( x_n \) are predetermined and do not depend on the noise trades. Each period, the profit is

\[
\pi_n = (v - p_n)x_n \\
= (v - p_{n-1}^n - \lambda x_n - \lambda u_n)x_n,
\]

while the variance of the insider’s expected profit in period \( n \) is

\[
\text{Var}(\pi_n \mid v, W) = \lambda^2 w_n^2 \text{Var}(u_n) \\
= \lambda^2 w_n^2 \sigma_u^2 \\
= \frac{\Sigma_{0}^{1/2} \sigma_u}{N} x_n^2.
\]

Over all periods,

\[
\text{Var}(\pi \mid v, W) = \sum_{n=1}^{N} \text{Var}(\pi_n \mid v, w) - \sum_{m=1}^{N} \sum_{n=1}^{N} \text{Cov}(\pi_m \pi_n \mid v, w) \\
= \frac{\Sigma_{0}^{1/2} \sigma_u}{N} \sum_{n=1}^{N} x_n^2.
\]

This follows from the fact that the noise trades are independent across time, so the covariance terms are all zero. The last thing to note is that, as Kyle discusses, each
period’s insider trade is of order $1/N$. This fact is the key to the great simplification of the continuous case in Kyle’s model. This observation is clear from the equation derived above that $\sum_{n=1}^{N} x_n = (v - p_0^*)/(2\lambda)$. That implies that $x_n^2$ is of order $1/N^2$. In turn, $\sum_{n=1}^{N} x_n^2$ is of order $1/N$, so $\text{Var}(\pi | v, W)$ is of order $1/N^2$. From this fact, we can conclude that $\lim_{N \to \infty} \text{Var}(\pi | v, W) = 0$.  

Claim:  In the limit as $N \to \infty$, a fixed variance of noise trades over the finite interval of time during which trade takes place, and disclosure of the insiders’ trade after each round, then (i) the insider’s aggregate profits equal the insider’s profits in a one-period Kyle (1985) model and (ii) the market maker’s price adjustment and the total order flow are the same as the price adjustment and the order flow in a one-period Kyle (1985) model.

Proof of Claim:  Lemma 1 implies that dissimulation trades offset each other entirely over time, implying that the total insider order flow is unaffected by dissimulation. Indeed,

$$\frac{d}{dw_n} \sum_{i=1}^{N} x_i = 0 \quad \text{for all } n.$$  

In other words, total trades over time by the insider are unaffected by the dissimulation. This is clear from $\sum_{n=1}^{N} x_n = (v - p_0^*)/(2\lambda)$.

In essence, dissimulation works by making a random trade in one period offset by an opposite random trade in a later period (actually a lot of random offsetting trade pairs). Since trading costs are constant over time, ignoring noise trades, the dissimulation trades will have no effect on total profits since they only affect the timing, not the total, of insider trades. Of course, the random nature of noise trades will affect total profit based on the noise trade price effect in the period the insider makes the first trade versus the price effect in the period the insider makes the offsetting trade. But as noted earlier, in the limit these noise trade price effects are infinitesimal, so the variance in profits due to dissimulation is also zero in the continuous trading limit.
From Lemma 2, the only source of variance in trading profits in the limit is due to \( v \). Given the above analysis, for the continuous case,

\[
\pi = \frac{(v - p_0^*)^2}{4\lambda},
\]

\[
E(\pi) = \frac{\Sigma_0}{4\lambda}, \quad \text{and}
\]

\[
\text{Var}(\pi) = \frac{\Sigma_0^2}{4\lambda}.
\]

Since the only source of uncertainty is the information about value, which is revealed prior to trading, there is no risk in profit by the time trading starts. Therefore, it is clear that the HHL trading strategy, which maximizes expected total profits conditional on \( v \), also maximizes \( E(\pi \mid v) - \frac{1}{2} \rho \text{Var}(\pi \mid v) = E(\pi \mid v) - \frac{1}{2} \rho \cdot 0 \). Thus, even if the insider is risk averse, with continuous time trading, that risk-aversion has no effect on the optimal strategy. The last thing to note is that in HHL, the model is in all relevant respects equivalent to one-period Kyle regardless of the number of periods (in terms of liquidity, overall trades, and trading profits).

The overall conclusion is that continuous time trading with immediate ex post disclosures of trades and a risk-averse insider is isomorphic to one-shot trade with a risk-neutral insider. The only risk that the insider bears is the uncertainty in his information. He bears no risk from the noise trades themselves. Moreover, characteristics of an equilibrium in this setting including total order flow and expected insider profits are the same from those in Kyle’s one-period model.

**Proof of Proposition 1:** The first-order condition on (1) with respect to \( x \) for an arbitrary realization of the public signal \( s \), the insider’s endowment, \( z \), and private signal, \( \eta \), is

\[
M \eta - p_s - 2\lambda x + \mu_s \lambda - \rho(x + z)V = 0.
\]

Equation (B.1) implies

\[
x = \frac{M \eta - p_s - \rho z V + \mu_s \lambda}{2\lambda + \rho V} = \frac{M \eta - K s - \rho z V + \mu_s \lambda}{2\lambda + \rho V}.
\]
Since \( \mu_s = E[x \mid s] \), (B.2) implies

\[
\mu_s(2\lambda + \rho V) = (M - K)E[\eta \mid s] - KE[\phi \mid s] - \rho E[z \mid s]V + \mu_s\lambda.
\]

\[
= \rho \bar{z}V + \mu_s\lambda. \tag{B.3}
\]

Expression (B.3) follows because:

\[
(M - K)E[\eta \mid s] - KE[\phi \mid s] = 0, \quad \text{and}
\]

\[
E[z \mid s] = \bar{z}, \tag{B.4}
\]

Equation (B.4) follows from the definitions of \( M \) and \( K \) given the conditional probabilities:

\[
E[\eta \mid s] = \frac{\Sigma_0 + \sigma^2_\epsilon}{\Sigma_0 + \sigma^2_\epsilon + \sigma^2_\phi}s, \quad \text{and}
\]

\[
E[\phi \mid s] = \frac{\sigma^2_\phi}{\Sigma_0 + \sigma^2_\epsilon + \sigma^2_\phi}s,
\]

In equilibrium, (B.2) and (B.3) imply

\[
\mu_s = \alpha = -\frac{\rho V\bar{z}}{\lambda + \rho V}, \tag{B.5}
\]

\[
\beta = \frac{1}{2\lambda + \rho V}, \tag{B.6}
\]

\[
\delta = -\frac{\rho V}{2\lambda + \rho V}. \tag{B.7}
\]

The vector of random variables

\[
\begin{pmatrix}
v \\
\epsilon \\
\phi \\
y \\
z
\end{pmatrix}
\]

is jointly normally distributed with mean

\[
\begin{pmatrix}
0 \\
0 \\
0 \\
0 \\
\bar{z}
\end{pmatrix},
\]
and variance-covariance matrix

\[
Q = \begin{pmatrix}
\Sigma_0 & 0 & 0 & 0 & 0 \\
0 & \sigma^2_v & 0 & 0 & 0 \\
0 & 0 & \sigma^2_\epsilon & 0 & 0 \\
0 & 0 & 0 & \sigma^2_y & 0 \\
0 & 0 & 0 & 0 & \sigma^2_z
\end{pmatrix}.
\]

Thus, the vector of random variables

\[
\begin{pmatrix}
v \\
x + y \\
s
\end{pmatrix}
\]

is also jointly normally distributed with mean

\[
\begin{pmatrix}
0 \\
-\rho V \bar{z} \\
0
\end{pmatrix}
\]

and variance-covariance matrix

\[
HQH' = \begin{pmatrix}
\Sigma_0 & \beta (M - K) \Sigma_0 & \beta^2 \left( \frac{(M-K)^2}{M} \Sigma_0 + K^2 \sigma^2_\phi \right) + \sigma^2_y + \delta^2 \sigma^2_\varepsilon \\
\Sigma_0 & \beta \left( \frac{M-K}{M} \Sigma_0 - K^2 \sigma^2_\phi \right) & \beta \left( \frac{M-K}{M} \Sigma_0 - (K^2 \sigma^2_\phi) \right)
\end{pmatrix},
\]

since

\[
\begin{pmatrix}
v \\
x + y \\
s
\end{pmatrix} = \begin{pmatrix}
0 \\
-\rho V \bar{z} \\
0
\end{pmatrix} + H \begin{pmatrix}
v \\
\epsilon \\
\phi \\
y \\
z
\end{pmatrix}
\]

for

\[
H = \begin{pmatrix}
1 & 0 & 0 & 0 & 0 \\
\beta (M - K) & \beta (M - K) & -\beta \kappa & 1 & \delta \\
1 & 1 & 1 & 0 & 0
\end{pmatrix}.
\]

Following DeGroot (1970, 55), the variance-covariance matrix for \((v x + y)'\) conditional
on $s$ is given by

\[
\begin{pmatrix}
\Sigma_0 \\
(\beta (M - K) \Sigma_0)
\end{pmatrix} \begin{pmatrix}
\beta (M - K) \Sigma_0 \\
\beta^2 \left( \frac{(M-K)^2}{M} \Sigma_0 + K^2 \sigma_\phi^2 \right) + \sigma_y^2 + \delta^2 \sigma_z^2 \\
\end{pmatrix}
\]

\[
\frac{- \left( \beta \left( \frac{M-K}{M} \Sigma_0 - K^2 \sigma_\phi^2 \right) \right) \left( \Sigma_0 \theta \beta \left( \frac{M-K}{M} \Sigma_0 - K^2 \sigma_\phi^2 \right) \right)}{\Sigma_0 + \sigma_\epsilon^2 + \sigma_\phi^2}.
\]

Thus,

\[
\text{Cov}(v, x + y \mid s) = \frac{\beta M \Sigma_0 \sigma_\phi^2}{\Sigma_0 + \sigma_\epsilon^2 + \sigma_\phi^2} = \frac{KM \sigma_\phi^2}{2\lambda + \rho V}
\]

and

\[
\text{Var}(x + y \mid s) = \sigma_y^2 + \delta^2 \sigma_z^2 + \frac{\beta^2 M^2 \sigma_\phi^2 (\Sigma_0 + \sigma_\epsilon^2)}{\Sigma_0 + \sigma_\epsilon^2 + \sigma_\phi^2} = \sigma_y^2 + \delta^2 \sigma_z^2 + \frac{KM \sigma_\phi^2}{(2\lambda + \rho V)^2}
\]

Furthermore, from the market maker’s breakeven condition,

\[
p_1 = E(v \mid x + y, s) = p_s + \frac{\text{Cov}(v, x + y \mid s)}{\text{Var}(x + y \mid s)}(x + y - \mu_s),
\]

we have

\[
\lambda = \frac{\text{Cov}(v, x + y \mid s)}{\text{Var}(x + y \mid s)} = \frac{(2\lambda + \rho V) KM \sigma_\phi^2}{(2\lambda + \rho V)^2 \sigma_y^2 + (2\lambda + \rho V)^2 \delta^2 \sigma_z^2 + KM \sigma_\phi^2} = \frac{(2\lambda + \rho V) KM \sigma_\phi^2}{\sigma_y^2 + \rho^2 V^2 \sigma_z^2 + KM \sigma_\phi^2},
\]

where $\sigma_y^* \equiv (2\lambda + \rho V)^2 \sigma_y^2$. Solving this last equality for $\lambda$ gives:

\[
\lambda = \frac{\rho KM V \sigma_\phi^2}{\sigma_y^2 + \rho^2 V^2 \sigma_z^2 - KM \sigma_\phi^2}
\]

30
which reduces to (7). Substituting (7) into (B.4) – (B.7) gives (3), (4), and (6), respectively. The second-order condition is

$$-2\lambda - \rho V \leq 0.$$  \hspace{1cm} (B.8)

By substitution and rearrangement, (B.8) reduces to (9).
References


Botosan, C. and M. Plumlee, 2004, Assessing the construct validity of alternative proxies for expected cost of equity capital, Working paper, University of Utah


The insider learns her endowment, $z$, and private information, $\eta$.

Public disclosure, $s$, is made.

Either (i) the insider publicly announces his trade, $x$, or (ii) the net order flow, $x+y$, is submitted to the market maker.

The market maker sets the stock price, $p_1$, at which the insider trades.

Liquidation values are realized.

Figure 1. Timeline.
Effect of varying $\sigma^2_\phi$ in the neighborhood of

$$\bar{z} = 1.00, \sigma^2_z = 0.10, \Sigma_0 = 1.00, \sigma^2_\varepsilon = 10.00, \sigma^2_y = 0.00, \rho = 2.00$$

Figure 2. Expected utility as a function of $\sigma^2_\phi$. 
Effect of varying $\sigma^2_z$ in the neighborhood of 
$\bar{z} = 1.00, \Sigma_0 = 1.00, \sigma^2_\epsilon = 10.00, \sigma^2_y = 0.00, \rho = 2.00$

$\Sigma z^2 / \text{Minus} 1.45 / \text{Minus} 1.4 / \text{Minus} 1.35 / \text{Minus} 1.3 / \text{Minus} 1.25 / \text{Minus} 1.2 / \text{Minus} 1.05$ / $\log (1 - U)$

Figure 3. Expected utility as a function of $\sigma^2_z$. The solid black line corresponds to no disclosure, i.e., $\sigma^2_\phi = \infty$. The dashed gray line corresponds to full disclosure, i.e., $\sigma^2_\phi = 0$. 
Effect of varying $\Sigma_0$ in the neighborhood of

$\bar{z} = 1.00, \sigma^2_z = 0.10, \sigma^2_\epsilon = 10.00, \sigma^2_y = 0.00, \rho = 2.00$

Figure 4. Expected utility as a function of $\Sigma_0$. The solid black line corresponds to no disclosure, i.e., $\sigma^2_\phi = \infty$. The dashed gray line corresponds to full disclosure, i.e., $\sigma^2_\phi = 0$. 
Effect of varying $\sigma^2_\phi$ in the neighborhood of 
$\bar{z} = 1.00, \sigma^2_z = 0.10, \Sigma_0 = 1.00, \sigma^2_\epsilon = 10.00, \rho = 2.00$

From bottom to top, the lines correspond to increasing variability of liquidity trades, $\sigma^2_y = 0.00, 0.02, 0.04 0.06, 0.08, \text{ and } 0.10$, respectively.

*Figure 5.* Expected utility as a function of $\sigma^2_\phi$ for a variety of values of $\sigma^2_y$. From bottom to top, the lines correspond to increasing variability of liquidity trades, $\sigma^2_y = 0.00, 0.02, 0.04 0.06, 0.08, \text{ and } 0.10$, respectively.