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The Optimal Regulation of Insider Trading*

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This paper models inside trading regulation with a well-defined objective and introduces an explicit measure of regulatory strictness. The regulator's objective is to minimize the trading loss of liquidity traders. With market professionals whose information-based trading is not regulated, the objective of regulation can be achieved by promoting competition between these market professionals and the insider. When stricter regulation induces improvement in the precision of the market professionals' information, tolerating some insider trading can be the optimal regulatory policy. It is also shown that allowing more market professionals to enter the market and disclosing information to them are as effective in achieving the regulatory objective as the direct restriction of insider trading. *Journal of Economic Literature* Classification Numbers: D82, G10, L13.

1. INTRODUCTION

In the 1980s, insider trading attracted much public attention, owing to several high profile cases (Stewart, 1991). As a response to public criticism, the Securities and Exchange Commission (SEC) tightened enforcement and the U.S. Congress enacted the Insider Trading Sanction Act and the Insider Trading and Securities Fraud Enforcement Act in 1984 and 1988, respectively. These acts increased penalities against convicted insiders.

Although insider trading has evoked public resentment, legal scholars and economists have argued that insider trading has benefits as well as

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costs, due to effects on the informational efficiency of the financial market, managerial incentives, and the redistribution of wealth among investors. Most research on insider trading regulation has focused on the polar cases of ignoring or banning insider trading, whereas the optimal regulation of insider trading has been largely ignored. In this paper, I examine insider trading regulation using a well-defined regulatory objective function, and introduce an explicit measure of regulatory strictness. The limitation of confining the analysis to the polar cases is thereby demonstrated.

Most countries have rules against insider trading, but the temptation for insiders to violate the rules still remains.[1] Among the many issues regarding insider trading regulation, this paper analyzes its effect on the distribution of wealth among different types of traders, and conditions are developed under which it is optimal for a regulator to tolerate some insider trading.

Insiders include employees as well as legal counsel, auditors, and others who have a fiduciary duty to represent the interests of their firm's shareholders. Although insiders have costless access to material nonpublic information about the firm that may be valuable to the security market, they are not the sole possessors of such information.[2] Traders such as brokers and fund managers, for example, acquire costly information about firms and attempt to execute advantageous transactions before the information is widely disseminated. *Market professionals*, unlike insiders, owe no fiduciary duty to the firms they study, and their trading on the information about the firms is not subject to regulation.[3]

Liquidity traders trade for exogenous reasons such as portfolio readjustment or immediate consumption. Institutional investors such as pension funds and insurance companies belong to this group. Since their trading is prompted by stochastic flows of funds under management rather than by information, they are primarily concerned about the transaction costs of their trading.

The *regulator* is a public authority with a well-defined objective function that is optimized subject to constraints. The objective of the regulator is the minimization of the liquidity traders' expected trading loss. Due to the constraint that the regulator restricts insiders but not market professionals, the regulator has to consider the indirect effect on the market professionals' trading strategy and the amount of resources they devote to studying the firm.

[1] Empirical studies, including those of Elliot *et al.* (1984), Seyhun (1989), and Arshadi and Eyssell (1991), show that insider trading is still widespread, and insiders earn excess returns in spite of the SEC's strict regulation of insider trading.

[2] Information is material if its disclosure would substantially change the security's price, and nonpublic if it is unavailable to general investors. See Bergmans (1991) for detailed discussion.

[3] The term "market professional" is used in Fishman and Hagerty (1991) and Haddock and Macey (1987).

As will be shown in Section 5, the optimal regulatory policy depends on the shape of the marginal cost curve for improving the precision of the market professionals' information. When stricter regulation of insider trading substantially improves the precision of the market professionals' information, tolerating some insider trading is the optimal regulatory policy. This is not because costs of monitoring insider trading or banning it are excessive. Even if such costs are arbitrarily small, in some cases allowing some insider trading *levels the playing field* between the insider and the market professionals, and maximizes the competition between them. It is also shown that other means of promoting competition between the insider and the market professionals, such as allowing more market professionals to enter the market and disclosing more information publicly, help reduce the trading losses borne by the liquidity traders as well.

Dennert (1991) surveys definitions of insider trading and its implications for the capital markets. The legal aspects of insider trading are dealt with in Solinga (1986), Macey (1991), and Bergmans (1991). Haddock and Macey (1987), by adopting the private-interest paradigm, show that insider trading regulation is motivated by wealth redistribution considerations. Fishman and Hagerty (1991) provide an analysis similar to the one here in that they distinguish between insiders and market professionals. In their model, market professionals choose to trade in one of two markets. The authors determine the conditions under which banning insider trading improves security price efficiency, but normative issues related to optimal regulation are not addressed. Chowdhry and Nanda (1991) consider the possibility of the insider's profit being confiscated by the regulator, but the optimal regulatory policy they obtain in their model is either to choose unrestricted insider trading or to completely ban it.

The remainder of this paper is organized in six sections. In Section 2, the objective of insider trading regulation is discussed along with the current legal status of insider trading regulation. The basic model is presented in Section 3 and market equilibrium under a given regulatory policy is derived in Section 4. In Section 5, it is shown that the optimal regulatory policy depends on the market professionals' trading strategies and more importantly, on the equilibrium precision of their information. Alternative means of achieving the objective of insider trading regulation are explored in Section 6. The last section draws conclusions and discusses directions for further research. Proofs are collected in the Appendix.

2. INSIDER TRADING REGULATION AND ITS OBJECTIVE

The primary legal tool used to regulate insider trading in the United States has been Rule 10(b)-5, promulgated by the Securities and Exchange Commission in 1942 under Section 10(b) of the Securities Exchange Act of 1934 (1934 Act).[4] Section 10(b) and Rule 10(b)-5 are general antifraud provisions without specific clauses prohibiting insider trading. But case law development under Rule 10(b)-5 has come to embody the "disclose-or-refrain" rule—the rule that anyone who possesses material nonpublic information is required to disclose it to the general public or else to refrain from trading on it.[5]

The "disclose-or-refrain" rule based on Rule 10(b)-5 could be so broadly applied that it could prohibit almost any trading involving informational imbalance among trading parties. In 1980, the Supreme Court's ruling on *Chiarella v. US*, which was later reaffirmed by *Dirks v. the SEC*, provided a stringent interpretation of Rule 10(b)-5 and a strict definition of "insider." In these two cases, the Supreme Court ruled that the mere possession of material nonpublic information does not necessarily require its holder to follow the "disclose-or-refrain" rule (Macey, 1991; Bergmans, 1991). Only those who have a fiduciary duty to their shareholders are not allowed to trade on the information obtained through their position. Those classified as insiders based on this fiduciary duty criterion are not only traditional corporate insiders such as officers and directors of the firm, but also anyone who has access to corporate information through their positions, such as legal counsels and underwriters of the firm.

These two rulings have profound implications for financial markets. Trading by market professionals such as investment bankers and fund managers on the basis of information obtained through their research is not subject to insider trading regulation. Consequently, market professionals have now become strong proponents of strict enforcement of insider trading regulation (Macey, 1991; Haddock and Macey, 1987). This point is analyzed in more detail in the following sections.

Public outcry prompted Congress to pass the Insider Trading Sanction Act of 1984 (ITSA) and the Insider Trading and Securities Fraud Enforcement Act of 1988 (ITSFEA), which increase penalities imposed on convicted insiders (Macey, 1991).

The objective of insider trading regulation has never been clearly specified by the SEC. Its stated rationale for prohibiting insider trading is to protect the "integrity of the nation's capital market."[6] The courts' rulings related to Rule 10b-5 have reflected the view that insider trading should

[4] The only provision of the 1934 Act specifically regulating insider trading is Section 16(b), which prohibits corporate insiders from short selling and making short-swing trading profits within a 6-month period. Another legal measure against insider trading is Rule 14(e)-3, which prohibits trading based on information of impending tender offers. This paper deals with insider trading regulation based on Rule 10(b)-5 because it is the main legal ground prohibiting insider trading and it broadly encompasses Section 16(b) and Rule 14(e)-3.

[5] See Macey (1991) and Bergmans (1991) for details of case law.

[6] See the SEC's Proposed Insider Trading Bill (Nov. 18, 1987).

be prohibited to prevent uninformed investors from being treated "unfairly" by corporate insiders profiting from information not available to the general public.[7] Brudney (1979) and Haddock and Macey (1987) suggest that although insider trading regulation places some weight on the efficiency of the financial market, its principal goal appears to be to protect informationally disadvantaged investors.[8]

3. MODEL

This model considers a financial market with risk-neutral traders and a single risky security being traded. The *ex post* payoff of the security, denoted by $\tilde{v}$, is normally distributed with mean $\bar{v}$ and precision (inverse of variance) h_v.

Three different kinds of traders are engaged in trading: an insider, a market professional, and liquidity traders. The first two are information-based traders who trade to profit from their private information regarding $\tilde{v}$. An *insider* has costless access to the private observation of $\tilde{v}$ without any noise through his position in the firm.[9] Under the law, he is not entitled to benefit from trading on his private information. If an insider is found to have profited from trading on information regarding $\tilde{v}$, then his trading profit is confiscated and additional penalty is imposed. A *market professional* observes a noisy signal regarding $\tilde{v}$, denoted as $\tilde{v} + \tilde{\varepsilon}$, where $\tilde{\varepsilon}$ is independent of $\tilde{v}$, and normally distributed with mean 0 and precision h_ε. The precision of his observation can be improved by incurring a cost of $C(h_\varepsilon)$. It is assumed $C'(h_\varepsilon) > 0$. Unlike the insider, the market professional's trading on his information regarding $\tilde{v}$ is not subject to any regulatory restriction. Both the insider and the market professional place their orders to maximize their expected trading profits. Finally, *liquidity traders* trade for exogenous reasons,[10] and their net trading order, denoted by $\tilde{u}$, is independent of $\tilde{v}$ and $\tilde{\varepsilon}$, and normally distributed with mean 0 and precision h_u. Statistical properties of $\tilde{v}$, $\tilde{\varepsilon}$, and $\tilde{u}$, and the shape of $C(h_\varepsilon)$ are common knowledge.

After a price schedule is announced by a competitive market marker,

[7] This view is most clearly stated in the rulings of *Speed v. Transamerica Co.* and *the SEC v. Texas Gulf Sulphur Co.*, and in the dissenting opinion by Justice Blackmun in *Chiarella v. U.S.* For more details, see Macey (1991) and Jennings (1991).

[8] Brudney (1979) argues that antifraud provisions adopted to prohibit insider trading "serves principally a protective function—to prevent overreaching of public investors."

[9] I make this assumption for simplicity of analysis. Even if the insider's information contains noise, the same results are obtained.

[10] The reasons for liquidity trading may include idiosyncratic wealth shocks, the need for immediate consumption or tax planning.

traders submit their market orders to him. The market maker clears the market and sets the price such that he expects to earn zero profit conditional on the observed net trading order. The market maker is assumed to observe only the net trading order of all the traders combined, as in Kyle (1985). The price set by the market maker satisfies the following equation due to the zero expected profit condition:

$$P = \bar{v} + \lambda\tilde{y} = E[\tilde{v} \mid \tilde{y}]. \quad (1)$$

Here $\tilde{y}$ is the net trading orders of all the traders combined. In (1), the inverse of λ is the measure of market liquidity in that $1/\lambda$ represents the size of the net trading order necessary to induce the change of price by one unit.

Although the law prohibits the insider from profiting on privileged information, the law in itself does not ensure that the insider will comply. The policy of the *regulator* determines how strictly the law is enforced, and thereby determines the extent of the insider's trading activity. The regulatory policy is composed of two parts: the probability of convicting an insider and the penalty imposed on the convicted insider. It is assumed that both can be arbitrarily set by the regulator without cost. The assumed objective of regulatory policy is the minimization of the trading losses of the liquidity traders, which, as will be shown, can be achieved by maximizing the liquidity of the market. If the insider is convicted of insider trading, his trading profit is confiscated, and he must pay an additional fine.[11] It is assumed that trading profit and the fine collected from the convicted insider are kept by the regulator, not distributed back to traders or the market maker.[12] This implies that whether the insider is convicted or not, the ex post wealth of traders and the market maker does not change. Thus, the regulator tries to redistribute *ex ante* wealth among traders by restricting insider trading, not the *ex post* wealth by distributing the trading profit and the fines collected from the convicted insider.

The sequence of trading is given in Table I. Note that the regulator starts the investigation of insider trading after trading is completed, and the payoff of the security accrues to the holders of the security. Several points are worth mentioning. First, given a price schedule as opposed to an actual price, traders submit their market orders taking into account their effect

[11] ITSFEA authorizes federal courts to impose a maximum penalty of $1 million or 10 years in prison on individual violators.

[12] In practice, the conviction of insiders brings about a flurry of lawsuits filed by the investors. However, it is difficult to identify the victims of the insider trading and to assess the amount of their financial losses. This is because determining the "normal price" without insider trading at the time the insider trading occurs is practically impossible. See *Business Week*, Nov. 12, 1990, p. 50.

TABLE I
SEQUENCE OF TRADING

Pretrading period
• Regulator announces policy.
• Market professional decides the precision of his information.
Trading period
• Market maker announces the price schedule.
• Traders observe signals and submit market orders to the market maker.
• Price is determined based on the price schedule and aggregate net orders.
• Payoff of the security is realized and accrues to the security holders.
Regulation period
• Regulator starts the investigation of insider trading.
• If the insider is convicted, his profit is confiscated and he pays additional fine based on the penalty rule.

on the price; due to the random orders of liquidity traders, the price cannot reflect all the traders' private information. Second, since the regulatory policy impacts the aggressiveness with which the insider trades, it tacitly influences the extent to which two information-based traders compete against each other. The regulator thus determines the regulatory policy considering not only its direct effect on the insider but also its indirect effect on the market professional. Consequently, the market maker's price schedule varies with the changes in traders' strategies induced by different regulatory policies. The following section explores the market equilibrium based on the model presented in this section.

4. MARKET EQUILIBRIUM

This section analyzes the market equilibrium under a given regulatory policy and in the process introduces a measure of how strictly insider trading is restricted by the regulator. The first part of this section explores equilibrium price schedules and trading strategies of the insider and the market professional, which is followed by an analysis of the market professional's choice of the equilibrium precision of his information.

Suppose the regulatory policy R announced by the regulator is such that the probability of convicting the insider is q and, if convicted, the fine is α

times the square of his trading order.[13] As shown in the sequence of trading, given the regulatory policy R and the inferred precision of market professional's information h_ε, the competitive market maker announces the price schedule $P = \bar{v} + \lambda(h_\varepsilon, R)\tilde{y}$. Trading strategies of the insider and the market professional, denoted by $\mu(\tilde{v} - \bar{v})$ and $\rho(\tilde{v} + \tilde{\varepsilon} - \bar{v})$, respectively, are determined such that $\mu(\tilde{v} - \bar{v})$ and $\rho(\tilde{v} + \tilde{\varepsilon} - \bar{v})$ maximize the expected profit of each insider and market professional, respectively, taking the regulatory policy, the precision of the market professional's information, price schedule and the other trader's trading strategy as given.

Considering the possibility of being convicted and paying a fine, and taking the price schedule, market professional's trading strategy and h_ε as given, the insider solves the following problem:

$$\max_x \,(1 - q)E[x(\tilde{v} - \bar{v} - \lambda(x + \rho(\tilde{v} + \tilde{\varepsilon} - \bar{v}) + \tilde{u}))\,|\,\tilde{v}] - q\alpha x^2. \quad (2)$$

The solution to the insider's problem is given by

$$\mu(\tilde{v} - \bar{v}) = \frac{(1 - \lambda\rho)}{2(\lambda + \beta)}(\tilde{v} - \bar{v})$$

where $\beta = \alpha q/(1 - q)$.

The first term in (2) represents the insider's expected *trading profit*, conditional on his not being convicted. If the insider is convicted, his trading profit is confiscated, and his net loss is αx^2.[14] This possible loss is represented by the second term. The insider tries to maximize the expected *net* profit taking into account this possibility of being convicted and having his trading profit confiscated with an additional fine.

Between unrestricted insider trading and the complete ban of it, there exists a range of regulatory policies. As either the chance of convicting the insider or the amount of the penalty imposed on the convicted insider increases, insider trading becomes more restricted. The parameter $\beta = \alpha q/(1 - q)$ is the unique measure of how strictly insider trading is regulated. A larger β, which can be obtained by raising α, q, or both, restricts insider

[13] This assumption regarding the penalty simplifies the analysis a great deal in that the relation between the insider's trading strategy and his signal is always linear, and as will be shown in the following analysis, his optimal *trading profit* is proportional to the square of the optimal trading order submitted by him.

[14] Equation (2) actually means that if the insider is convicted, his *ex post* trading profit or loss now belongs to the regulator. Regardless of the amount of his ex post trading profit or loss, the convicted insider's net loss is the fine paid to the regulator. It is possible that the insider also suffers an ex post trading loss. Since the insider's expected trading profit is always positive, however, the regulator expects to confiscate positive trading profits.

trading more strictly in the sense that, given a price schedule and $\tilde{v}$, the insider places a smaller trading order.

With $\beta = 0$, the insider trades on his information without risk of conviction or fine, and the insider's trading order and the market equilibrium are those obtained if insider trading were unrestricted.[15] With $\beta = \infty$, the insider cannot trade without being caught and punished by the regulator, or a harsh penalty is imposed on the convicted insider. The insider, then, does not place any order under any price schedule and $\tilde{v}$, and insider trading is eliminated altogether. The following lemma presents the equilibrium trading strategies of the insider and the market professional.

LEMMA 1. *Given the precision of the market professional's information h_ε, the regulatory policy $R = (q, \alpha)$, and price schedule $P = \bar{v} + \lambda\tilde{y}$, the insider and the market professional place the following market orders respectively*:

$$\mu(\tilde{v} - \bar{v}) = \frac{2h_v + h_\varepsilon}{\lambda(4h_v + 3h_\varepsilon) + 4\beta(h_v + h_\varepsilon)}(\tilde{v} - \bar{v}) \tag{3}$$

$$\rho(\tilde{v} + \tilde{\varepsilon} - \bar{v}) = \frac{(\lambda + 2\beta)h_\varepsilon}{\lambda[\lambda(4h_v + 3h_\varepsilon) + 4\beta(h_v + h_\varepsilon)]}(\tilde{v} + \tilde{\varepsilon} - \bar{v}). \tag{4}$$

Here $\beta = \alpha q/(1 - q)$.

Given the regulatory policy and the precision of the market professional's information, the equilibrium price schedule, $P = \bar{v} + \lambda^*(h_\varepsilon, \beta)\tilde{y}$ satisfies equation (1) due to the zero expected profit condition of the competitive market maker,

$$P = \bar{v} + \lambda^*\tilde{y} = E[\tilde{v} \,|\, \tilde{y} = \mu(\tilde{v} - \bar{v}) + \rho(\tilde{v} + \tilde{\varepsilon} - \bar{v}) + \tilde{u}],$$

where λ^* is the equilibrium value of λ.

Given a price schedule $P = \bar{v} + \lambda\tilde{y}$, the expected trading loss of liquidity traders is

$$E[\tilde{u}(\tilde{v} - \bar{v} - \lambda(\mu(\tilde{v} - \bar{v}) + \rho(\tilde{v} + \tilde{\varepsilon} - \bar{v}) + \tilde{\mu}))] = \frac{\lambda}{h_u}.$$

[15] If $\alpha = 0$ and $q > 0$, insider trading remains regulated because it is still possible that the insider will be convicted and his trading profit confiscated. Although the insider's expected net profit is reduced due to the chance of his being convicted, from (2) it is shown that the insider still places the same size of trading order, and the market equilibrium is exactly the same as with no restriction on insider trading.

As noted earlier, $1/\lambda^*$ is the measure of equilibrium market liquidity. As the market becomes more liquid, uninformed liquidity traders buy or sell their securities with less impact on the price, and therefore, their expected trading loss, λ^*/h_u, decreases. Thus, the objective of insider trading regulation can be achieved by minimizing λ^*.

Since there are two information-based traders, and the market maker's expected equilibrium profit is zero, the expected trading loss of liquidity traders is equal to the *combined expected trading profits* of the insider and the market professional. Thus, in equilibrium the following equation is obtained:

$$\Pi^{\mathrm{i}}(\lambda^*, \beta, h_\varepsilon) + \Pi^{\mathrm{f}}(\lambda^*, \beta, h_\varepsilon) = \frac{\lambda^*}{h_u}. \tag{5}$$

Here

$$\Pi^{\mathrm{i}}(\lambda^*, \beta, h_\varepsilon) = \frac{(\lambda^* + 2\beta)(h_\varepsilon + 2h_v)^2}{h_v[\lambda^*(4h_v + 3h_\varepsilon) + 4\beta(h_v + h_\varepsilon)]^2} \tag{6}$$

$$\Pi^{\mathrm{f}}(\lambda^*, \beta, h_\varepsilon) = \frac{(\lambda^* + 2\beta)^2(h_\varepsilon + h_v)h_\varepsilon}{h_v\lambda^*[\lambda^*(4h_v + 3h_\varepsilon) + 4\beta(h_v + h_\varepsilon)]^2}. \tag{7}$$

$\Pi^{\mathrm{i}}(\lambda^*, \beta, h_\varepsilon)$ and $\Pi^{\mathrm{f}}(\lambda^*, \beta, h_\varepsilon)$ represent the insider's and the market professional's expected trading profits, respectively.[16] From Eqs. (5), (6), and (7), two important implication are derived. First, although only the insider is subject to insider trading regulation, the profit earned by the market professional is also indirectly affected by it. Second, due to the presence of the market professional, liquidity traders still expect to lose money from their trading even if the insider is completely removed from the market. Thus, in order to minimize the expected trading losses of liquidity traders, the regulator needs to set regulatory policy to minimize the combined expected trading profits of both insider and market professional, not just the insider's expected trading profit. As will be shown in the next section, in certain cases, stricter regulation of insider trading increases the market professional's trading profit to the detriment of not only the insider but also the liquidity traders.

For each regulatory policy, the optimal precision of the market professional's information, h_ε^*, satisfies the following equation:

[16] From Lemma 1 and Eq. (6), the equilibrium trading profit earned by the insider is proportional to the square of his trading order. Therefore, the fine imposed on the convicted insider is proportional to his trading profit.

$$\frac{d\Pi^{\mathrm{f}}(\lambda^*(h_\varepsilon^*, \beta), \beta, h_\varepsilon^*)}{dh_\varepsilon} = \frac{dC(h_\varepsilon^*)}{dh_\varepsilon}. \tag{8}$$

It is clear from (8) that regulatory policy regarding insider trading affects the market professional's decision on the precision of his information, through which the both market professional's and the insider's trading profits are determined.

5. OPTIMAL REGULATORY POLICY

With a stricter regulatory policy, the insider optimizes by adopting a less aggressive trading strategy. That is, the threat of conviction and a fine induces the insider to place a smaller order even though this means a lower expected profit. In response to more restricted trading on the part of his rival, the market professional trades more aggressively, and thereby expects to earn a higher profit. This effect of stricter regulation on the trading strategies and the profit of the insider and the market professional is called a *restriction effect.*

There is, however, another effect. As insider trading is restricted, the market professional increases the precision of his information due to the increased marginal profit from doing so. This enables him to trade more aggressively. The insider's informational advantage over the market professional is thus diluted, and this induces him to place an even smaller trading order, further reducing his trading profit. This effect is called an *information effect.* The following two propositions show that the optimal regulatory policy depends on the magnitude of the information effect, which is determined by the shape of $C'(h_\varepsilon)$, the marginal cost of improving the precision of the market professional's information.

If the shape of $C'(h_\varepsilon)$ is such that there is no information effect, then the optimal regulatory policy is one of two extremes: (i) completely eliminate insider trading or (ii) allow it without restriction. However, with an information effect, the regulator minimizes liquidity traders' losses by tolerating some insider trading, which enhances competition between the two information-based traders. The following subsection investigates the optimal regulatory policy when there is no information effect.

5.1. *Optimal Regulatory Policy without Information Effect*

Suppose the marginal cost curve, $C'(h_\varepsilon)$, is such that the precision of the market professional's information remains unchanged irrespective of the regulatory policy, and the only remaining effect is the restriction effect. This happens if the market professional can acquire the information of a

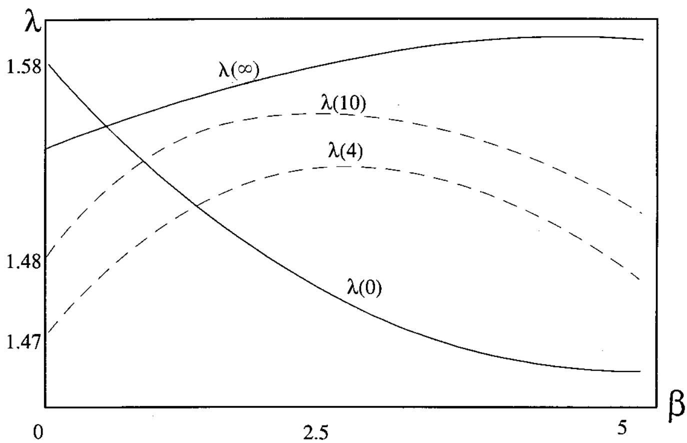

FIG. 1. Optimal regulatory policy without information effect. $\lambda(\infty) = \lambda^*(\infty, \beta)$, $\lambda(10) = \lambda^*(10, \beta)$, $\lambda(4) = \lambda^*(4, \beta)$, $\lambda(0) = \lambda^*(0, \beta)$.

certain level of precision by incurring a fixed cost, but the marginal cost of improving the precision of information beyond that level is extremely high. The "value-motivated trader" in Harris (1993) can be regarded as such a market professional. Value-motivated traders, such as mutual fund managers, establish research departments that "render the available stock of fundamental data into information by analysis" (Harris, 1993, p. 33). These data are publicly available, but investors at large do not have the knowledge and resources to interpret them. A fixed cost is incurred in establishing a research department and periodic payments are required as well. The precision of the information generated by the research department is usually the maximum precision that can be obtained based on the publicly available data.

PROPOSITION 1. *Suppose the precision of the market professional's information, h_ε, remains unchanged for any regulatory policy. Then, there exists $\overline{h}_\varepsilon$ such that with $h_\varepsilon < \overline{h}_\varepsilon$ the optimal regulatory policy is to completely ban insider trading. If $h_\varepsilon \geq \overline{h}_\varepsilon$, the optimal policy is to allow insider trading without restriction.*

Figure 1 shows how λ^* varies as insider trading regulation gets stricter for four different levels of precision of market professional's information, $h_\varepsilon = 0$, $h_\varepsilon = 4$, $h_\varepsilon = 10$, and $h_\varepsilon = \infty$, respectively, with no information effect and with $h_v = 1$ and $h_u = 10$. With the exception of $h_\varepsilon = 0$ and $h_\varepsilon = \infty$, as the regulatory policy gets stricter, λ^* increases at smaller values of β, but it starts to decrease at higher levels of β. It is due to the fact that the market professional's trading profit is increasing at a decreasing rate, but the insider's profit is decreasing at an increasing rate. Therefore, the regulator's decision on the optimal regulatory policy is reduced to the choice between two extremes, either completely eliminating insider trading or allowing it without restriction. As Proposition 1 implies, which extreme is chosen depends on the precision of the market professional's information.[17] As Fig. 1 shows, λ^* increases for a wider range of β's as the precision of the market professional's information improves. This is because the market professional with the information of greater precision is better able to exploit the restriction on the insider trading and increase his trading profit by more than the decrease of insider's trading profit for a wider range of β's.

As is shown in Fig. 1, if $h_\varepsilon = \infty$, the insider has no informational advantage over the market professional. When insider trading is allowed without restriction, the highest level of competition between these two identical information-based traders with perfect information is achieved, which keeps their combined trading profit at the lowest level. Any restriction on insider trading increases the liquidity traders' trading losses due to the reduced competition between two information-based traders. In this case, eliminating insider trading *maximizes* the trading losses of liquidity traders. For the same reason, allowing insider trading without restriction is still the optimal regulatory policy if the precision of the market professional's information is great enough to make the insider's informational advantage over the market professional marginal. Any restriction on insider's trading enables the market professional to increase his profit at the expense of liquidity traders as well as the insider, which conflicts with the regulatory objective, and the optimal regulatory policy in this case is not to restrict insider trading.

A complete ban on insider trading is an optimal regulatory policy if $h_\varepsilon = 0$. In this case, since there is no market professional who is able to increase his profit by exploiting reduced insider trading, the liquidity traders' losses keep decreasing as the regulatory policy gets stricter. When insider trading is completely eliminated, there is no information-based trader in the market at all and liquidity traders' trading losses reach zero. For the same reason, if the precision of the market professional's information is low enough to preclude him from increasing his trading profit by exploiting the restriction on insider trading, then complete elimination of insider trading is still the optimal regulatory policy. Although the liquidity traders' trading losses are not reduced to zero, the complete removal of the insider from the market allows the market professional to be the only information-

[17] The case of $h_\varepsilon = 0$ can be interpreted as without a market professional. From (5), $(\lambda^* + 2\beta)/(4(\lambda^* + \beta)h_v) = \lambda^*/h_u$ holds with $h_\varepsilon = 0$, and λ^* decreases as β increases, which makes a complete ban on insider trading the optimal regulatory policy. If $h_\varepsilon = \infty$, then $[\lambda^*(\lambda^* + 2\beta) + (\lambda^* + 2\beta)^2]/[(3\lambda^* + 4\beta)^2 h_v] = \lambda^{*2}/h_v$, and λ^* increases as β increases, and therefore allowing insider trading is the optimal regulatory policy.

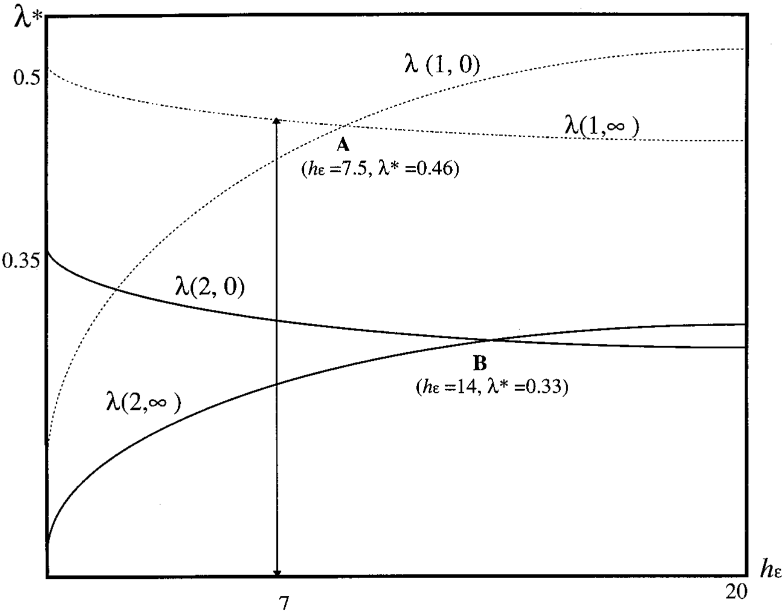

FIG. 2. Comparative statics. $\lambda(1, 0) = \lambda^*(h_\varepsilon, 0)$ and $\lambda(1, \infty) = \lambda^*(h_\varepsilon, \infty)$ with $h_v = 1$; $\lambda(2, 0) = \lambda^*(h_\varepsilon, 0)$ and $\lambda(2, \infty) = \lambda^*(h_\varepsilon, \infty)$ with $h_v = 2$.

based trader. With the low precision of his information, liquidity traders expect to lose less than when the insider is still trading.[18]

The critical level of precision of market professional's information, $\bar{h}_\varepsilon$, which determines the regulator's choice between allowing insider trading and completely banning it, depends on h_v.

COROLLARY 1. *Without information effect, λ^* decreases in h_v and h_u, and $\bar{h}_\varepsilon$ increases in h_v, but is independent of h_u.*

Figure 2 illustrates Corollary 1. The λ^*'s are derived under the two extreme regulatory policies and two different levels of h_v, 1 and 2. From (5), it is shown that for any regulatory policy and precision of market professional's information, λ^* decreases in h_v. The implication of Proposition 1 is that if the market professional has substantial informational disad-

[18] The same implication and intuition of Proposition 1 can be obtained in the following way. Suppose insider trading is allowed without restriction, but the insider's information is noisy. The precision of the insider's information is denoted by h_η, and $h_\eta = 0$ is equivalent to $\beta = \infty$: $h_\eta = \infty$ matches $\beta = 0$. Given h_ε, equilibrium $\hat{\lambda}(h_\eta)$ is derived for each h_η. For the same $\bar{h}_\varepsilon$ as in Proposition 1, the equilibrium $\hat{\lambda}$ is minimized by $h_\eta = 0$ if $h_\varepsilon < \bar{h}_\varepsilon$; otherwise, $h_\eta = \infty$ minimizes $\hat{\lambda}$, and the intuition is the same as in Proposition 1.

vantage vis-à-vis the insider, then the insider trading must be eliminated to minimize the liquidity traders' trading losses. Given h_ε, as the precision of prior information on $\tilde{v}$ is increased, the market professional's informational disadvantage increases in the sense that $\mathrm{Corr}(\tilde{v}, \tilde{v} + \tilde{\varepsilon}) = \sqrt{h_\varepsilon/(h_v + h_\varepsilon)}$ decreases. Therefore, the range of h_ε under which the optimal regulatory policy is the complete ban of insider trading expands.

From (5), it can be shown that for any h_ε, both $\lambda^*(h_\varepsilon, \infty)$ and $\lambda^*(h_\varepsilon, 0)$ are linear in $\sqrt{h_u}$. Since $\bar{h}_\varepsilon$ satisfies $\lambda^*(\bar{h}_\varepsilon, \infty) = \lambda^*(\bar{h}_\varepsilon, 0)$, we can see that $\bar{h}_\varepsilon$ and the regulatory decision do not depend on h_u.

5.2. *Optimal Regulatory Policy with Information Effect*

The result of the previous section that the regulator may choose to ban insider trading altogether and do this effectively does not appear consistent with the stylized facts. Seyhun (1992) shows that insider trading actually increased in the 1980s despite the SEC's stricter policy. Therefore, I now relax the assumption that stricter control of insider trading does not improve the precision of the market professional's information.

PROPOSITION 2. *Suppose a stricter regulatory policy induces an improvement in the precision of the market professional's information. Then, the optimal regulatory policy involves neither allowing unrestricted insider trading nor completely banning it, but tolerating it to a certain degree.*

Figure 3 shows three curves of marginal profit of improving the precision of the market professional's information under three different regulatory policies with $h_v = h_u = 1$. The curve MP(0) represents the marginal profit under $\beta = 0$. The curve MP(2) represents the one under the regulatory policy of $\beta = 2$, and MP(∞) under $\beta = \infty$. The marginal cost curve is such that the optimal values of precision of information chosen by the market professional are $h_\varepsilon^* = 0.4$, $h_\varepsilon^* = 0.5$, and $h_\varepsilon^* = 1.1$, respectively, for $\beta = 0$, $\beta = 2$, and $\beta = \infty$, respectively. Equation (5) derives λ^* under each regulatory policy. The equilibria are $\lambda^* = 0.48$ under $\beta = 0$, and $\lambda^* = 0.362$ under $\beta = \infty$, but regulatory policy $\beta = 2$ results in $\lambda^* = 0.35$, which is smaller than those derived under extreme regulatory policies.

If the marginal cost of improving the precision of the market professional's information is flat or decreasing, then substantial improvement in the precision of the market professional's information is expected as the regulatory policy gets stricter. In Harris (1993), this type of market professional is referred as an "informed trader" who speculates on "flow of new fundamental information" such as "events, announcements and private information," and the speed of processing this information along with the precision of information improves as he spends more for information processing.

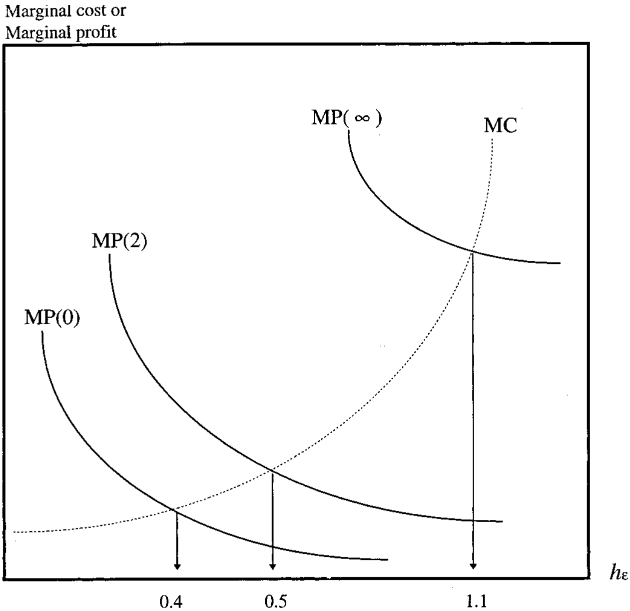

FIG. 3. Optimal regulatory policy with information effect. MC = $C'(h_\varepsilon)$ and MP(0) = $\dfrac{d\Pi^{f}(\lambda(h_\varepsilon, 0), 0, h_\varepsilon)}{dh_\varepsilon}$, MP(2) = $\dfrac{d\Pi^{f}(\lambda(h_\varepsilon, 2), 2, h_\varepsilon)}{dh_\varepsilon}$, MP($\infty$) = $\dfrac{d\Pi^{f}(\lambda(h_\varepsilon, \infty), \infty, h_\varepsilon)}{dh_\varepsilon}$.

If a substantial information effect is triggered by the restriction of insider trading, then the insider's trading is reduced not only by direct restriction of his trading but also by improvement in the precision of his rival's information. Unlike the case of no information effect, the combined trading profits earned by the insider and the market professional decrease at sufficiently low levels of restriction on insider trading. The reason is that insider trading restrictions level the playing field between the insider and the market professional, increasing competition between them, and thereby minimizing the trading losses of liquidity traders. However, banning insider trading altogether is not optimal because beyond a certain critical level, further restrictions on insider trading do not improve the precision of the market professional's information. Consequently tighter restrictions on insider trading diminish competition between the insider and the market professional and thus increase trading losses of liquidity traders.

Propositions 1 and 2 show that except in the case in which the precision of the market professional's information is so low that restricting insider trading is ineffective in promoting competition between the two information-based traders, banning insider trading altogether is not optimal for the reasons discussed earlier. As the next proposition shows, the market professional is always the beneficiary of stricter regulatory policy.

PROPOSITION 3. *The market professional's optimal net profit*, $\Pi^f(\lambda^*(h_\varepsilon^*, \beta), \beta, h_\varepsilon^*) - C(h_\varepsilon^*)$ *always increases in the strictness of regulatory policy.*

Proposition 3 shows that market professionals such as investment banks and fund managers are the main beneficiaries of insider trading regulation and explains why they are strong proponents of strict enforcement of insider trading regulation.

5.3. *Price Efficiency and Insider Trading Regulation*

The regulator must sometimes consider insider trading regulation from a vantage point other than that of the liquidity traders. It is widely believed that another important aspect of the financial market is the price efficiency measured by the correlation between the price and the ex post payoff of the security. As the next corollary shows, price efficiency may be sacrificed if insider trading is restricted.

COROLLARY 2. *Without information effect of insider trading regulation, the price of the security is most efficient if insider trading is unrestricted.*

Corollary 2 along with Proposition 1 implies that price efficiency and the market liquidity are simultaneously achieved by permitting unfettered insider trading only when restriction on insider trading does not improve the precision of market professionals' information which happens to be high. If the restriction on insider trading has no information effect, and the precision of the market professional's information is sufficiently low, then a ban on insider trading minimizes liquidity traders' trading losses, but reduces price efficiency. However, when insider trading regulation induces an information effect, it is possible that restricting insider trading will reduce the trading losses of liquidity traders while at the same time improve price efficiency. However, it would only be coincidental that the regulatory policy that minimizes the liquidity traders' losses also maximizes price efficiency.

6. ALTERNATIVE MEANS OF REGULATING INSIDER TRADING

Insider trading regulation forces the insider to adopt a less aggressive trading strategy because of the possibility of paying a fine proportional to the number of shares he trades, which is in equilibrium proportional to his trading profit. An insider's trading can be directly restricted without making it a subject of criminal prosecution if a tax is imposed on the number of shares he trades.[19]

It has been thus far assumed that insider trading regulation can be implemented without cost. The analysis changes little if the cost of implementing regulatory policy is included in the regulator's decision on the optimal regulatory policy.[20]

If any cost is involved in implementing the insider trading regulation or if the regulator is concerned about price efficiency, then different ways of improving the market liquidity other than directly restricting insider trading must be considered. For instance, as in Corollary 1 and Fig. 2, without an information effect, banning insider trading is the optimal regulatory policy of $h_\varepsilon = 7$, $h_u = 1$, and $h_v = 1$. Instead of banning insider trading, the regulator is able to improve market liquidity by increasing h_v to 2 while allowing insider trading. And h_v can be improved by forcing the insider to disclose more information to the general public, especially to the market maker.

Thus far it has been assumed that there is only one market professional. As the next corollary shows, as the number of market professionals increases, more intense competition between the insider and market professionals helps improve market liquidity.

COROLLARY 3. *For a given regulatory policy, an increase in the number of market professionals with information of identical precision improves the market liquidity.*

The following two corollaries demonstrate that the optimal regulatory policies are qualitatively the same as those in a simpler model, even with more than one market professional, and they hint at another means of minimizing liquidity traders' losses.

COROLLARY 4. *Suppose n market professionals have identical precision of information, h_ε, and this remains unchanged for any regulatory policy.*

[19] With a tax on the number of shares traded, the insider's problem changes to

$$\max_x E[x(\tilde{v} - \bar{v} - \lambda(x + \rho(\tilde{v} + \tilde{\varepsilon} - \bar{v}) + \tilde{u})) \mid \tilde{v}] - t\alpha x^2.$$

As is shown in (2), in equilibrium, the amount of tax paid by the insider is proportional to his trading profit. I thank Richard Green and an anonymous referee for this suggestion.

[20] Since $\beta = \alpha q/(1 - q)$, for each level of restriction of insider trading, the regulator can find the least costly combination of the probability of convicting the insider and the penalty imposed on the convicted insider, which is denoted $T(\beta)$. Then, if the regulator is supposed to achieve the goal of insider trading regulation within the budget amount of $\overline{T}$, then his problem is $\min_\beta \lambda^*(\beta)$ subject to $T(\beta) < \overline{T}$. If the benefit of decreasing the liquidity traders' losses is denoted by $U(\lambda^*(\beta))$ where $U' < 0$, and the regulator is required to maximize the net benefit of the regulation, then his problem is $\max_\beta U(\lambda^*(\beta)) - T(\beta)$.

Then, for each n, there exists a unique $\overline{h}_\varepsilon(n)$ *which decreases in n such that with* $h_\varepsilon < \overline{h}_\varepsilon(n)$ *the optimal regulatory policy is to completely ban insider trading. Otherwise, allowing insider trading without restriction is the optimal policy.*

The competition between two types of information-based traders is enhanced as either the number of market professionals increases or the precision of their information improves. Therefore, as the number of market professionals increases, $\overline{h}_\varepsilon(n)$, the critical level of the precision of their information which determines the optimal regulatory policy decreases.

COROLLARY 5. *Suppose a stricter regulatory policy induces a substantial improvement in the precision of the n market professional's information. Then, the optimal regulatory policy involves neither allowing unrestricted insider trading nor completely banning it, but tolerating some insider trading, and the optimal level of restriction,* $\beta^*(n)$, *decreases in n.*

Since multiple market professionals collectively improve the precision of their information, the regulator is able to obtain the optimal level of competition with a lower level of restriction of insider trading as more market professionals trade in the market.

Corollaries 3, 4, and 5 suggest alternative ways of achieving the assumed goal of insider trading regulation. For instance, if there is more than one potential market professional who can acquire information at a fixed cost, the regulator can minimize liquidity traders' losses by lowering this cost while permitting unrestricted insider trading, which promotes competition among information-based traders and thereby reduces liquidity traders' trading losses.

7. CONCLUSION

The common justification of insider trading regulation is restoration of the fairness of the market, and protection of liquidity traders from insiders with privileged access to nonpublic information. Although insider trading is illegal, the degree of insider trading in the market depends on how strictly the law against insider trading is enforced, which is determined by regulatory policy. The constraint in achieving the objective of the regulatory policy, however, is that the insider is not the only trader who trades on information about the firm.

Market professionals spend resources to acquire superior information about the firm, but their information-based trading is not subject to regulatory restriction. Both insider and market professionals trade on the information about the firm, but the regulator is allowed to restrict only insider trading. In determining the optimal regulatory policy, however, the regulator is supposed to consider the market professionals' trading strategy and the equilibrium precision of their information for each regulatory policy.

In the presence of market professionals, it is not always optimal to allow insider trading without restriction or to completely ban it. Sometimes a stricter regulatory policy results in increased profit for the market professionals at the expense of liquidity traders as well as the insider. If the market professionals are induced to improve the precision of their information by stricter regulatory policy, then tolerating some insider trading minimizes the trading losses of liquidity traders. This is not because it is prohibitively costly to monitor insider trading. Even if there is no cost involved in enforcing an insider trading ban, there are conditions under which permitting some insider trading levels the playing field, maximizing competition between traders and therefore minimizing the trading losses of liquidity traders.

In contrast to the examination of the optimal regulation of insider trading in a single market, Chowdhry and Nanda (1991) explore insider trading regulation with many market professionals and two markets. When market professionals can move freely between two markets, regulation in one market affects the equilibrium in the other. This effect includes not only the precision of the single-market professional's information, but also the precision of the collective information of multiple-market professionals. This suggests potentially interesting issues related to numerous market professionals with multiple-market trading and the coordination of regulation among different exchanges that await further research.

APPENDIX

Proof of Lemma 1. Suppose the insider and the market professional have linear trading strategies, $\mu(\tilde{v} - \bar{v})$ and $\rho(\tilde{v} + \tilde{\varepsilon} - \bar{v})$, respectively. The insider's problem and its solution are already derived in Section 4; similarly the market professional's problem is

$$\max_z E[z(\tilde{v} - \bar{v} - \lambda(z + \mu(\tilde{v}) + \tilde{u})) \,|\, \tilde{v} + \tilde{\varepsilon}]$$

and its solution is

$$z^* = \frac{1 - \lambda\mu}{2\lambda}\frac{h_\varepsilon}{h_v + h_\varepsilon} = \rho(\tilde{v} - \bar{v}).$$

Second-order conditions can be easily checked, and unique solutions of μ and ρ are given in (3) and (4). *Ex ante* trading profits earned by the insider and the market professional given in (6) and (7) are derived from the following equations with the solutions of μ and ρ:

$$\Pi^{\mathrm{i}}(\lambda, \beta, h_\varepsilon) = E[\mu(\tilde{v} - \bar{v})(\tilde{v} - \bar{v} - \lambda(\mu(\tilde{v} - \bar{v}) + \rho(\tilde{v} + \tilde{\varepsilon} - \bar{v}) + \tilde{u}))]$$

$$\Pi^{\mathrm{f}}(\lambda, \beta, h_\varepsilon) = E[\rho(\tilde{v} + \tilde{\varepsilon} - \bar{v})(\tilde{v} - \bar{v} - \lambda(\mu(\tilde{v} - \bar{v}) + \rho(\tilde{v} + \tilde{\varepsilon} - \bar{v}) + \tilde{u}))]. \quad \blacksquare$$

Proofs of Propositions 1 *and* 2. Given a regulatory policy and a precision of the market professional's information, equilibrium λ is determined in (5). Π denotes the combined expected trading profit of the insider and the market professional. Since the precision of market professional's information is determined by the regulatory policy, the equilibrium λ depends on both regulatory policy and the precision of the market professional's information. Equation (5) is rewritten as

$$\Pi[\lambda^*(h_\varepsilon^*(\beta), \beta), \beta, h_\varepsilon^*(\beta)] = \lambda^*(h_\varepsilon^*(\beta), \beta). \tag{9}$$

By differentiating both sides of (9) and rearranging terms,

$$\frac{\partial \Pi}{\partial \beta} + \frac{\partial \Pi}{\partial h_\varepsilon}\frac{dh_\varepsilon^*}{d\beta} = \frac{d\lambda^*}{d\beta}\left(1 - \frac{\partial \Pi}{\partial \lambda}\right), \tag{10}$$

where

$$\frac{d\lambda^*}{d\beta} = \frac{\partial \lambda^*}{\partial h_\varepsilon}\frac{dh_\varepsilon^*}{d\beta} + \frac{\partial \lambda^*}{\partial \beta}.$$

Since the combined expected trading profits of the insider and the market professional always decrease in λ, the sign of $d\lambda^*/d\beta$ depends on the sign of the LHS of (10). The first term represents the restriction effect of insider trading regulation, and the information effect is reflected in the second term. The LHS of (10) is given in the equation

$$\frac{1}{\lambda A^3}[2\lambda(h_\varepsilon + 2h_v)(\lambda h_\varepsilon^2 - 8\beta(h_\varepsilon + h_v))]$$
$$+ \frac{1}{\lambda A^3}[(\lambda + 2\beta)^2(\lambda(h_\varepsilon - 4h_v) + 4\beta(h_v + h_\varepsilon))]\frac{\partial h_\varepsilon^*}{\partial \beta}, \quad (11)$$

where $A = \lambda(4h_v + 3h_\varepsilon) + 4\beta(h_v + h_\varepsilon)$.

If there is no information effect, then the second term of (11) is always zero. From (11), it can be shown that as regulation gets stricter, λ^* increases, reaches the maximum, and then starts to decrease, which implies that minimum λ^* can be obtained at either $\beta = 0$ or $\beta = \infty$. $\lambda^*(h_\varepsilon, 0)$ and $\lambda^*(h_\varepsilon, \infty)$ derived from (5) are given in the following equations:

$$\lambda^*(h_\varepsilon, 0) = \sqrt{\frac{h_u}{h_v}}\frac{\sqrt{(h_\varepsilon + 2h_v)^2 + h_\varepsilon(h_\varepsilon + h_v)}}{4h_v + 3h_\varepsilon} \quad (12)$$

$$\lambda^*(h_\varepsilon, \infty) = \sqrt{\frac{h_u}{h_v}}\sqrt{\frac{h_\varepsilon}{4(h_v + h_\varepsilon)}}. \quad (13)$$

For each h_v and h_u, there exists unique $\bar{h}_\varepsilon$ which satisfies $\lambda^*(\bar{h}_\varepsilon, 0) = \lambda^*(\bar{h}_\varepsilon, \infty)$, and it can be shown that $\lambda^*(h_\varepsilon, 0) > \lambda^*(h_\varepsilon, \infty)$ for $h_\varepsilon < \bar{h}_\varepsilon$, otherwise $\lambda^*(h_\varepsilon, 0) \leq \lambda^*(h_\varepsilon, \infty)$ holds. Therefore, the optimal regulatory policy is either banning insider trading or allowing it without restriction.

Suppose $h_\varepsilon^*(0)$ is sufficiently small, but $\partial h_\varepsilon^*/\partial\beta$ is sufficiently large for β to approach zero. Then, (11) is decreasing for small β, reaches a minimum, and then starts to increase so that the minimum λ^* is obtained at neither $\beta = 0$ nor $\beta = \infty$. Hence, in this case tolerating some insider trading is the optimal regulatory policy as it minimizes the equilibrium λ. ■

Proof of Corollary 1. From (12) and (13), $\bar{h}_\varepsilon$ is derived as a solution of the following equation:

$$\sqrt{\frac{h_u}{h_v}}\frac{\sqrt{(\bar{h}_\varepsilon + 2h_v)^2 + \bar{h}_\varepsilon(\bar{h}_\varepsilon + h_v)}}{4h_v + 3\bar{h}_\varepsilon} = \sqrt{\frac{h_u}{h_v}}\sqrt{\frac{\bar{h}_\varepsilon}{4(h_v + \bar{h}_\varepsilon)}}. \quad (14)$$

Given h_u, $\bar{h}_\varepsilon$ is a function of h_v, and by taking a derivative of both sides of (14) with respect to h_v and h_ε, it can be shown that $\bar{h}_\varepsilon$ is an increasing function of h_v. However, from (14), it is clear that $\bar{h}_\varepsilon$ does not depend on h_u. ■

Proof of Proposition 3. Using the envelope theorem, the following equation can be obtained:

$$\frac{d(\Pi^{\mathrm{f}} - C(h_\varepsilon^*))}{d\beta} = \frac{\partial \Pi^{\mathrm{f}}}{\partial \beta} + \frac{\partial \Pi^{\mathrm{f}}}{\partial \lambda}\frac{\partial \lambda^*}{\partial \beta}. \tag{15}$$

From $\partial\Pi^{\mathrm{f}}/\partial\beta > 0$ and $\partial\Pi^{\mathrm{f}}/\partial\lambda < 0$, $d(\Pi^{\mathrm{f}} - C(h_\varepsilon^*))/d\beta \geq 0$ is obtained if $\partial\lambda^*/\partial\beta < 0$ holds. Now let us show $d(\Pi^{\mathrm{f}} - C(h_\varepsilon^*))/d\beta \geq 0$ is still true even when $\partial\lambda^*/\partial\beta \geq 0$ holds. From (5), for a given h_ε, we have

$$\frac{\partial \Pi^{\mathrm{f}}}{\partial \beta} + \frac{\partial \Pi^{\mathrm{f}}}{\partial \lambda}\frac{\partial \lambda^*}{\partial \beta} + \frac{\lambda \Pi^{\mathrm{i}}}{\partial \beta} + \frac{\partial \Pi^{\mathrm{i}}}{\partial \lambda}\frac{\partial \lambda^*}{\partial \beta} = \frac{\partial \lambda^*}{\partial \beta}.$$

Since $\partial\Pi i/\partial\beta < 0$ and $\partial\Pi^{\mathrm{i}}/\partial\lambda < 0$ holds for any β, λ and h_ε, if $\partial\lambda^*/\partial\beta \geq 0$, then $\partial\Pi^{\mathrm{i}}/\partial\beta + (\partial\Pi^{\mathrm{i}}/\partial\lambda)(\partial\lambda^*/\partial\beta) < 0$ and the result follows. ■

Proof of Corollary 2. The correlation between the price and $\tilde{v}$ is given in the following equation:

$$\mathrm{Corr}(P, \tilde{v}) = \frac{\mathrm{Cov}(\bar{v} + \lambda(\mu(\tilde{v} - \bar{v}) + \rho(\tilde{v} + \tilde{\varepsilon} - \bar{v}) + \tilde{u}, \tilde{v})}{\sqrt{\mathrm{Var}(\tilde{v})\mathrm{Var}(P)}}. \tag{16}$$

From Lemma 1, $\mathrm{Cov}(P, \tilde{v}) = \lambda((\mu + \rho)/h_v)$ is obtained, and from (3), (4), and (5), variance of the price is

$$\begin{aligned} \mathrm{Var}(P) &= \lambda^2\left(\frac{(\mu + \rho)^2}{h_v} + \frac{\rho^2}{h_\varepsilon} + \frac{1}{h_u}\right) \\ &= \lambda\frac{\mu + \rho}{h_v} \end{aligned} \tag{17}$$

From (16) and (17),

$$\mathrm{Corr}(P, \tilde{v}) = \sqrt{\frac{2(h_v + h_\varepsilon)}{4h_v + 3h_\varepsilon}} \quad \text{and} \quad \mathrm{Corr}(P, \tilde{v}) = \sqrt{\frac{h_\varepsilon}{2(h_v + h_\varepsilon)}}$$

are obtained for $\beta = 0$ and $\beta = \infty$, respectively. Since

$$\sqrt{\frac{2(h_v + h_\varepsilon)}{4h_v + 3h_\varepsilon}} > \sqrt{\frac{h_\varepsilon}{2(h_v + h_\varepsilon)}}$$

holds for all h_ε, price is more efficient if insider trading is allowed without restriction. ■

Proof of Corollary 3. Suppose there are n market professionals with identical precision of information h_ε. Given a price schedule $P = \bar{v} + \lambda\tilde{y}$, the insider and market professionals submit the following trading orders respectively:

$$\phi(\tilde{v} - \bar{v}) = \frac{2h_v + h_\varepsilon}{\lambda(4h_v + (n+2)h_\varepsilon) + 2\beta(2h_v + (n+1)h_\varepsilon)}(\tilde{v} - \bar{v})$$

$$\delta(\tilde{v} + \tilde{\varepsilon} - \bar{v}) = \frac{(\lambda + 2\beta)h_\varepsilon}{\lambda(4h_v + (n+2)h_\varepsilon) + 2\beta(2h_v + (n+1)h_\varepsilon)}(\tilde{v} + \tilde{\varepsilon} - \bar{v}).$$

Equilibrium $\lambda^*(n)$ is determined in the equation

$$\Pi^{\mathrm{i}}(\lambda^*, \beta, h_\varepsilon, n) + \Pi^{\mathrm{f}}(\lambda^*, \beta, h_\varepsilon, n) = \frac{\lambda^*}{h_u},$$

where

$$\Pi^{\mathrm{i}}(\lambda^*, \beta, h_\varepsilon, n) = \frac{(\lambda + 2\beta)(2h_v + h_\varepsilon)^2}{h_v[\lambda(4h_v + (n+2)h_\varepsilon) + 2\beta(2h_v + (n+1)h_\varepsilon)]^2}$$

$$\Pi^{\mathrm{f}}(\lambda^*, \beta, h_\varepsilon, n) = \frac{(\lambda + 2\beta)^2(h_v + h_\varepsilon)h_\varepsilon}{h_v\lambda[\lambda(4h_v + (n+2)h_\varepsilon) + 2\beta(2h_v + (n+1)h_\varepsilon)]^2}.$$

Both $\Pi^{\mathrm{i}}(\lambda^*, \beta, h_\varepsilon, n)$ and $\Pi^{\mathrm{f}}(\lambda^*, \beta, h_\varepsilon, n)$ decrease in n, and therefore λ^* is a decreasing function of n. ■

Proofs of Corollaries 4 *and* 5. They are similar to those of Proposition 1 and 2 and are omitted here. ■

REFERENCES

Admati, A., and Pfleiderer, P. (1988). A theory of intraday patterns: Volume and price variability, *Rev. Finan. Stud.* **1,** 3–40.

Arshadi, N., and Eyssell, T. H. (1991). Regulatory deterrence and registered insider trading: The case of tender offer, *Finan. Manage.* **20,** 30–39.

Bergmans, B. (1991). "Inside Information and Securities Trading," Graham and Trotman, London.

Brudney, V. (1979). Insiders, outsiders and informational advantages under the federal securities laws, *Harvard Law Rev.* **93,** 322–376.

Chowdhry, B., and Nanda, V. (1991). Multi-market trading and market liquidity, *Rev. Finan. Stud.* **4,** 483–511.

Dennert, J. (1991). Insider trading, *Kyklos* **44,** 181–202.

ELLIOT, J., MORSE, D., AND RICHARDSON, G. (1984). The association between insider trading information announcement, *Rand J. Econ.* **16,** 521–536.

FISHMAN, M., AND HAGERTY, K. M. (1991). Insider trading and the efficiency of stock prices, *Rand. J. Econ.* **23,** 106–122.

GLOSTEN, L., AND MILGROM, P. (1985). Bid, ask and transaction prices in a specialist market with heterogeneously informed traders, *J. Finan. Econ.* **14,** 71–100.

HADDOCK, D. D., AND MACEY, J. (1987). Regulation on demand: A private interest model with an application to insider trading regulation, *J. Law Econ.* **30,** 311–339.

HARRIS, L. (1993). "The Winners and Losers of Zero-Sum Game: The Origins of Trading Profits, Price Efficiency and Market Liquidity," working paper, Univ. of Southern California.

JENNINGS, M. M. (1991). "Business and Legal Environment," PWS–Kent, Boston.

KYLE, A. S. (1985). Continuous auctions and insider trading, *Econometrica* **53,** 1315–1335.

MACEY, J. R. (1991). "Insider Trading: Economics, Politics and Policy," AEI Press, Washington, DC.

SEYHUN, N. H. (1988). The informational content of aggregate insider trading, *J. Business* **61,** 1–24.

SEYHUN, N. H. (1989). Insider's profit, costs of trading and market efficiency, *J. Finan. Econ.* **16,** 189–212.

SEYHUN, N. H. (1992). The effectiveness of the insider trading sanctions, *J. Law Econ.* **35,** 149–181.

SOLINGA, S. (1986). A proposed new regime of insider trading regulation, *Secur. Reg. Law J.* **14,** 99–121.

STEWART, J. B. (1991). "Den of Thieves," Simon and Schuster, New York.