Ronald A. Dye*
University of Chicago

Inside Trading and Incentives

This paper analyzes shareholders' incentives to sanction inside trading. I show that if a manager of a firm is initially compensated with earnings-contingent contracts, then the welfare of that manager and all of the firm's shareholders can be improved by allowing the manager to trade on his private information. This result is established in the context of a multiple principal (the shareholders)/single agent (the manager) model, with the manager's trades observable ex post, and is robust with respect to the specification of investors' preferences and the definition of stock market equilibrium.

I

The traditional arguments against inside trading (insiders "take advantage of" other investors;[1] inside-trading profits overcompensate managers [see Ross 1979]; too much information is collected if inside trading is allowed [see Fama and Laffer 1971; Hirshleifer 1971]) emphasize the social costs of prohibiting such trading, without explaining the private incentives shareholders have to sanction this trading. The efficiency argument in favor of inside trading—inside trading improves the functioning of the stock market because information, as a public good, will be underproduced unless those who acquire it profit through inside trading (Demsetz 1969)—does not explain shareholders' support of inside trading, because the owners of a firm do not seek to improve the efficiency of the stock market by sacrificing trading profits to insiders.

Several alternative hypotheses for shareholders' failure to impose restrictions on inside trading have been advanced:

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1. For a list of such arguments, see references in Manne (1966, chap. 1).

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1. Shareholders have no incentive to impose prohibitions on inside trading, since the restrictions on inside trading outlined in the Securities and Exchange (SEC) Act of 1934 coincide with the restrictions on inside trading sought by shareholders;[2] that is, explicit corporate restrictions on inside trading are redundant, given the SEC Act. If this view is correct, then prior to 1934 we would expect to observe either corporate prohibitions or other statutory restrictions on inside trading that function as substitutes for the SEC-mandated restrictions. Other than common law prohibitions against fraud (which have always applied to transactions in securities), there were few regulations on inside trading then: the "majority rule" that, prior to 1934, governed transactions on organized exchanges in all but three states, allowed insiders to treat other investors at arm's length (i.e., insiders were under no obligation to disclose the information on which their trades were based).[3] Evidence of formal corporate regulations on inside trading prior to 1934 is nonexistent,[4] so it appears that SEC restrictions on inside trading are not surrogates for corporation-sponsored restrictions.

2. Corporations do not impose restrictions on inside trading, since such restrictions are unenforceable. This argument has several flaws: successful SEC prosecution of inside trading violations attests to the enforceability of inside-trading regulations, albeit at perhaps substantial cost.[5] Also, the ease of enforcing a regulation is hardly the appropriate criterion on which to judge whether the regulation should be promulgated. Further, even if it were possible with positive probability to violate a restriction on inside trading without being detected, this does not imply that such restrictions have no impact on the trading behavior of insiders: the decision to violate an inside-trading restriction depends on the anticipated trading profits, the probability of being detected (which increases with the amount of trading), and the associated corporation-specified penalties for trading (which may be substantial when the reputations of managers are important and all corporations perceive inside trading to be a heinous offense). Thus, it is not

2. The SEC Act of 1934 imposes the following restrictions on inside trading: insiders (i.e., officers, directors, major shareholders) must report all inside transactions to the SEC; they are prohibited from receiving short-swing profits via transactions in their shares (i.e., trading profits obtained through purchases or sales within a 6-month's period can be confiscated) or selling their firms short. Also, material information must be publicly announced prior to trading.

3. The "special facts" rule, which requires disclosure of material information never applied to transactions conducted through organized exchanges. See Manne (1966).

4. Implicit corporate restrictions on inside trading, though difficult to document, may exist nevertheless; e.g., if a manager took a major short position in his firm, this might be prima facie grounds for dismissal.

5. Easterbrook (1982) asserts that inside-trading restrictions may not be imposed because the enforcement costs outweigh the benefits.

clear that prohibitions against inside trading are unenforceable; even if enforcement is costly and imperfect, such bans could alter insiders' behavior if shareholders were sufficiently contemptuous of inside trading by managers.

3. Shareholders desire managers to trade in their firm's shares. This view has been propounded most forcefully by Manne (1965, 1966). Essentially, he believes that inside trading has desirable incentive effects on both prospective and practicing managers. This view is also subject to criticism: (*a*) while endowing managers with some fraction of the firm's shares may align the manager's and shareholders' interests more closely, it is unclear that allowing the manager to trade in those shares is desirable from the owners' perspectives. (*b*) As was true in the famous case of Texas-Gulf Sulphur Company versus the SEC, inside information usually comes after the exertion of effort (in this case, after the results of geological surveys) so it is not clear that the ability to trade on inside information alters the efforts of the managers prior to the acquisition of the inside information in desirable ways.[6]

Thus, while the absence of corporate prohibitions on inside trading cannot be explained simply by an appeal to enforcement costs or the existence of SEC restrictions on this trading, the suggestion that shareholders seek to promote inside trading also seems susceptible to criticism. In this paper, I will attempt to identify when sanctions on inside trading may be valuable to a firm's shareholders. In Section II, I present an alternative theory of inside trading, by embedding a model of the principal-agent relationship in a stock market. I demonstrate that the desirability of inside trading depends on the distributional relationships among the inside information held by management, the manager's effort, and the output of the firm that employs him. Under certain distributional assumptions both the manager and the firm's owners may achieve strictly higher utility by allowing the manager some discretion in the selection of his compensation schedule than they would obtain if the manager were not given such discretion. This discretion in contract selection allows the manager to "communicate" his private information to the firm's owners. Inside trading is shown to be one means by which such discretion can be granted to managers. In Section III, two extensions are considered. The number of firms in the stock market is expanded, and the case where the insider's information eventually becomes public even in the absence of inside trading is analyzed. Section IV contains the conclusions.

6. Leftwich and Verrecchia (1981) develop a model in which, since insiders profit by trading whenever there is a deviation between the insider's and the market's forecasts of a firm's earnings, insiders have an incentive to undertake projects which have a high probability of producing such deviations in forecasts.

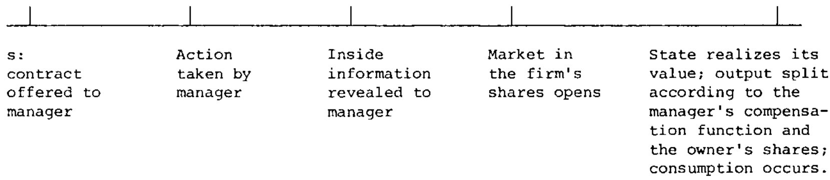

FIG. 1

II

I begin by providing a brief overview of the model and then introduce the details needed for the formal analysis. A manager works for several owners of a firm that is in business for one period.[7] These owners offer the manager a contract. Given the contract, the manager selects some unobservable variable, interpreted here as his effort level,[8] that maximizes his expected utility and that stochastically affects the firm's output. Subsequently, he receives a private signal correlated with the firm's output. A market for the firm's shares opens. After the close of the market, the realized value of output becomes known to all, contracts are honored, and consumption occurs. The time line in figure 1 summarizes the chronology of events. Since the trading strategy of the manager may be affected by the private signal he obtains, the manager's effective compensation may vary with his private information, if he is allowed to trade in the firm's shares. The question this paper addresses is: When is it mutually beneficial to the manager and the firm's owners to give the manager discretion in the selection of his compensation by allowing inside trading? To answer this requires an explicit model, such as the following one.

There are n investors in the firm. Investor i's von Neumann–Morgenstern utility function is denoted $V^i(\cdot)$ and his endowment consists of initial wealth W^i and initial fractional ownership in this firm $\bar{\theta}^i$

7. The implications of adopting a multiprincipal, single-agent model, as opposed to a more realistic multiprincipal, multiagent model can be described briefly: a common worry when no prohibitions on inside trading exist is that the manager will sell the firm short and then proceed to ruin the firm. This hypothetical possibility is more unlikely in a multiagent model, since it would require collusion among all the managers. I wish to thank Dan Fishel for this observation. Also, principals of multiagent corporations must design contracts to compensate for free-riding behavior, as illustrated by Holmström (1979).

8. By interpreting a as a pair $a = (e, i)$, we can view the choice of an action alternatively as a decision regarding both effort (e) and project selection (i): $x(a, \phi) = x_i(e, \phi)$, where $x_i(\cdot, \cdot)$ denotes the production function corresponding to the ith project.

(W^0 and $\bar{\theta}^0$ denote corresponding quantities for the manager); to begin, I assume that there are no risky investment possibilities other than this firm's market shares (this assumption is dropped in Sec. III).

The production technology of the firm is summarized by $x(a,\phi)$, where x denotes output, a is the manager's effort, and ϕ is an unobservable random variable that occurs after a is chosen. For each ϕ, x increases in a. The manager's utility function is common knowledge to all and is denoted by $U(c) - g(a)$; $U(\cdot)$, the utility from consumption, is strictly concave and increasing (i.e., the manager is risk averse), and $g(\cdot)$, the disutility from effort, is strictly convex and increasing. The manager's alternative to working for this firm provides expected utility $\bar{U}$. (If the manager's utility under a contract exceeds $\bar{U}$, the contract is said to be admissible.) After taking action a, the manager observes a signal $y \in [s, t]$ whose distribution is characterized by the density $f(x, y, a)$. (This signal may influence the manager's trading strategy in the market for the firm's shares). The contract between the manager and the firm's owners can be based on all publicly observed variables. These include the price of the firm and the realized value of output. The manager's trades are also assumed to be observable after, but not before, the market in the firm's shares closes, consistent with insider reporting requirements specified in section 16(b) of the Securities and Exchange Act of 1934.

Whether inside trading is desirable depends on the definition of market equilibrium. I consider two alternative definitions below. In the first definition, investor i infers the manager's utility-maximizing action (because he knows the data of the manager's decision problem), even though he cannot directly observe that action. In equilibrium, the action the manager takes coincides with the action investors expect him to take. However, in this definition, I do not assume that the equilibrium fully reveals the manager's private information y. This is modeled by postulating that investors' equilibrium purchases of the firm's shares lie on their unconditional demand curves; that is, they do not infer the insiders' private information by observing the price of the firm. The manager acts as a price taker in selecting his position in the firm's shares, but he considers the information he has acquired and the effects his trading has on his compensation schedule before choosing his market position. In selecting his action a (prior to receiving any information), the manager anticipates the impact this choice has on the distributions of the firm's output, his private information, and his trading strategy. Since this action choice is influenced by the rule used to compensate the manager, the equilibrium is defined relative to the compensation rule. The formal definition of equilibrium follows.

Definition 1: An equilibrium relative to a contract $s(\cdot)$ consists of an action a^*, a random price P^*, random purchases θ^i for $i = 0, 1, \ldots, n$ such that

i) given $s(\cdot)$, y, a^* and a fixed value for P^*, the manager selects θ^0 to maximize

$$E_{y|a^*}\, U\{s(x, \theta^0, P^*) + \theta^0[x - s(x, \theta^0, P^*) - P^*] + W^0 + \bar{\theta}^0 P^*\} - g(a),$$

subject to $\theta^0 P^* \leq \bar{\theta}^0 P^* + W^0$, $0 \leq \theta^0 \leq 1$. Also, given $s(\cdot)$ and the distribution of the random variables y, θ^0, and P^*, a^* maximizes

$$E_a U\{s(x, \theta^0, P^*) + \theta^0[x - s(x, \theta^0, P^*) - P^*] + W^0 + \bar{\theta}^0 P^*\} - g(a).$$

ii) Given s, a^*, a fixed P^*, $\theta^i = \theta^i\,(P^*)$ maximizes[9]

$$E_a V^i\{W^i + \bar{\theta}^i P^* + \theta^i[x - s(x,\theta^0,P^*) - P^*]\}$$

$$\theta^i \leq \bar{\theta}^i + W^i/P^*, \qquad 0 \leq \theta^i \leq 1.$$

iii) $\Sigma_{i=0}^{n}\, \theta^{i*} = 1$ for all realizations of P^*.

By varying his purchases in the firm's shares, the manager in effect chooses from among a family of contracts

$$\{s(x, \theta^0, P) + \theta^0[x - s(x, \theta^0, P) - P]\,|0 \leq \theta^0 \leq 1\}. \qquad (1)$$

If the owners of the firm prefer the manager *not* to engage in inside trading, they can eliminate the gains from inside trading by writing a contract of the form

$$s(x, \theta^0, P) = \begin{cases} -\,K, \; \theta^0 = 1 \\ \dfrac{\hat{s}(x) + \theta^0(P - x)}{1 - \theta^0}, \qquad \theta^0 \in [0,\, 1). \end{cases} \qquad (2)$$

With a contract of this form, the manager's effective compensation is $\hat{s}(x) + \bar{\theta}^0 P + W^0$ independent of the value of his private information or his inside-trading activities for sufficiently large K. Such a contract is equivalent to an (enforceable) prohibition on inside trading and, in the sequel, when the owners offer contracts (not) of this form, inside trading will be said to be prohibited (allowed). For the owners of the firm to benefit from the manager's inside trades, a contract of the form (2) must be undesirable; that is, the owners of the firm profit by providing the manager with some discretion in contract selection (which requires that [1] not be a singleton).

9. At the time investor i calculates his demand for the firm's shares, he is *not* assumed to be aware of the actual purchases by the insider. Rather, he realizes that the insider's purchases are a random variable (described by condition i in the equilibrium's definition) which influences his (the investor's) residual claims on the firm's earnings (since the insider's market position influences his compensation). The investor's expectations are taken over the two random variables, $\tilde{x}$ and the insider's purchases $\tilde{\theta}^0$, at the time he calculates his (unconditional) demand for the firm's shares (in ii).

Notice that if $\theta^0(y, P)$ is the insider's utility-maximizing choice of shares given y and P, each element of the family of contracts in (1) can be written in terms of x, P, and the manager's *announced* value $\hat{y}$ of his private information y by writing

$$\hat{s}(x, P, \hat{y}) = s[x, \theta^0(\hat{y}, P), P] + \theta^0(\hat{y}, P)\{x - s[x, \theta^0(\hat{y}, P), P] - P\}.$$

With this formulation of the manager's contract, the manager announces, perhaps dishonestly, the value of his private information y after he observes the price P but before he observes the output x. He will have no incentive to lie, however (since if he gained by reporting a false value of y, this would imply that his original demand for the firm's shares was not utility maximizing, given his private information, contrary to the definition of $\theta^0(y, P)$).[10] This discussion motivates an analysis of the consequences of offering the manager a set of contracts of the form (3):

$$\{\hat{s}(x, \hat{y}) \mid \hat{y} \in (s, t)\} \tag{3}$$

In the theorem below I present sufficient conditions for the owners to profit by offering a family of such contracts when y is announced after the market closes. As a corollary, I show that the owners can benefit from allowing inside trading.

THEOREM:[11] If in equilibrium each investor $i = 1, \ldots, n$ owns a nonnegative fraction θ^i of the firm when the manager's total compensation is $s(x)$, and if

i) $f(x, y, a) = f(x|y)g(y|a)$
   for all $x \in X \subset \mathbf{R}$, $y \in (s, t)$, $t > s$, $a > 0$
   $= 0$, otherwise
ii) $E[x|y]$ is continuously increasing in y and has range $[p, q]$;
iii) the support X of the random variable x, conditioned on y, is independent of y for all $y \in (s, t)$;
iv) $a > 0$ is the manager's optimal action, given $s(x)$;
v) all investors are weakly risk averse, the manager is strictly risk averse, and all utility functions have bounded second derivatives;
vi) $V^{i\prime}\{W^i + \bar{\theta}^i P + \theta^i[x - s(x) - P]\}/U'[s(x)]$ is strictly increasing in x, for each i,

then there exists an equilibrium relative to a family of contracts $\{s(x, y)|y \in (s, t)\}$ which is unanimously preferred by all investors and the manager to the contract $s(x)$.

10. This observation is a simple application of the revelation principle (Myerson 1979).
11. A one-principal version of this theorem has been presented in Dye (1983), to which readers may wish to refer in order to supplement the very terse proof of the one-principal case in App. A.

Distributional assumption i implies that the realized value of output contains no information about the manager's actions not also contained in the manager's private signal y. If the signal y is multidimensional, this condition is sure to hold in practice (because of the private information the manager accumulates about his effort while on the job). The assumption is restrictive only because y is assumed to be single-dimensional.[12] It is a stronger condition than Holmström's (1979) informativeness criterion for including additional variables in contracts, since y is observed only by the manager here. In condition ii, y's are ranked so that high y's indicate more favorable news (Milgrom 1981) about x than low y's. If condition iii did not hold, forcing contracts (Mirrlees 1976) could be used to induce the manager to reveal y truthfully, in which case y would be essentially public information; iii eliminates such trivial cases. Condition iv is required to insure that the manager's actions can be characterized by first-order conditions; v is obvious. Condition vi holds, for example, if all investors are risk neutral and $s(x)$ is increasing. It can be interpreted as a multiprincipal extension of a condition that prevails in single principal/single agent contexts when high output indicates favorable news about effort (Milgrom 1981).

The proof (sketched in App. A) is established by constructing the following simple family of contracts:

$$s(x, y) = \begin{cases} s(x) + \dfrac{cx + d}{U'[s(x)]}, & \text{if } y \geq \underline{y} \\[2ex] s(x) + \dfrac{hx + l}{U'[s(x)]}, & \text{if } y < \underline{y}, \end{cases}$$

for some $\underline{y} \in (s, t)$ and some constants c, d, h, l with $c > h$. Because high y's are harbingers of high x's, the manager will prefer being compensated with $s(x) + \{cx + d/U'[s(x)]\}$ (to $s(x) + \{hx + l/U'[s(x)]\}$) when y is sufficiently large, since $c > h$. Then c, d, h, and l can be constructed so that the manager announces that y is greater than $\underline{y}$ only when that is the truth. This enhances risk sharing between the manager and the firm's owners and so improves on the original contract $s(x)$. If the manager can postpone the announcement of y until x occurs, improvements in risk sharing are impossible to obtain, and there is no benefit, in that case, to offering a family of contracts to the manager. Further, no benefits to offering a menu of contracts to the manager exist if the manager's private information y is independent of x; in particular, if the manager has no private information (i.e., y is degenerate), such menus are superfluous. These results continue to hold when,

12. A proof when y is multidimensional is available from the author on request.

instead of overtly announcing the value of his private information, the manager signals his private information through his inside-trading activities, as is demonstrated in the following corollary.

COROLLARY 1: If conditions i–vi of the theorem hold, then corresponding to any equilibrium relative to an admissible contract $s'(x)$ for which inside trading is prohibited, there exists another equilibrium relative to an admissible contract $s(x, \theta^0, P)$ for which inside trading is allowed that is unanimously preferred to the equilibrium relative to $s'(x)$. (The proof is sketched in App. B.)

The conclusion of this corollary should be contrasted to the claims of other researchers regarding the value of contracting on unproductive private information. Fama and Laffer (1971) and Hirshleifer (1971) fail to acknowledge the possibility of improvements in risk sharing generated by the dissemination of information. Although Marshall (1974) considers risk sharing, his results do not apply in this context because he assumes that the distribution of output is exogenously specified, in which case the sole function of contracts is risk sharing. But, as is well known, optimal risk-sharing contracts do not have desirable incentive properties. The theorem demonstrates that contracts with both risk-sharing and incentive effects may be improved on by including announced values of privately observed variables in the contracts, even though including these other variables cannot improve on the risk-sharing properties of (output-contingent) contracts whose sole purpose is to share risk.

I now consider whether inside trading continues to be desirable when the equilibrium in the market for the firm's shares fully reveals the insider's private information. In general, no definitive conclusion can be reached in this case since, although risk sharing between the manager and investors may be improved by allowing inside trading (because of improvements in the manager's contract, as was demonstrated previously), risk sharing among investors may worsen when the equilibrium is fully revealing because investors cannot insure themselves against the value of the information revealed by the insider's trades. When investors are risk neutral, the latter undesirable side effect of fully revealing equilibria disappears, and the benefits of inside trading prevail. This is demonstrated formally in corollary 2. (The rational expectations' equilibrium referred to in corollary 2 is the same as in definition 1, except that investors condition their demands for shares on the information revealed about y through the market price.)

COROLLARY 2: If investors are risk neutral and conditions i–vi of the theorem hold, corresponding to any equilibrium relative to an admissible contract $s'(x)$ for which inside trading is prohibited, there exists a rational expectations equilibrium relative to an admissible contract $s(x, \theta^0, P)$ for which inside trading is allowed that is unanimously preferred to the equilibrium relative to $s'(x)$.

PROOF: By the theorem, given contract $s(x)$, there exists a contract $\hat{s}(x, y)$ of the form

$$\hat{s}(x, y) = \begin{cases} s(x) + n_1(x), & y \in Y \subset [s, t] \\ s(x) + n_2(x), & y \notin Y, \end{cases} \tag{4}$$

such that

$$EU[\hat{s}(x, y)] - g(a) > EU[s(x)] - g(a) \tag{5}$$

$$W^i + \bar{\theta}^i E[x - \hat{s}(x,y)] > W^i + \bar{\theta}^i E[x - s(x)], \qquad i = 1, \ldots, n, \tag{6}$$

(since risk-neutral investors are, at equilibrium prices, indifferent to trading away from their initial endowments, regardless of what contract is offered). Construct the following contract:

$$s(x, \theta^0, P) + \theta^0[x - s(x, \theta^0, P) - P] \equiv s(x) + n_2(x), \qquad \text{if } \theta^0 > 0$$

$$s(x, 0, P) \equiv s(x) + n_1(x). \tag{7}$$

Evidently, the insider will purchase a positive fraction of the firm if and only if $y \notin Y$ when he is compensated with $s(x, \theta^0, P)$. If the equilibrium is revealing, that is, investors can deduce whether $y \in Y$ by observing P, the equilibrium price takes on one of two values, P_1 or P_2, where $P_1 = E[x - s(x) - n_1(x)| Y]$ and P_2 is the solution to $P_2 = E[x - s(x, \theta^0, P_2)| Y^c]$. A quick calculation shows $P_2 = E[x - s(x) - n_2(x)| Y]$, so $E[x - s(x, \bar{\theta}^0, P)] = E[x - \hat{s}(x, y)]$, where

$$\bar{\theta}^0 = \begin{cases} 0, & y \in Y \\ \theta^0 > 0, & y \notin Y. \end{cases}$$

Thus, if the manager is compensated with $s(x, \theta^0, P)$, the inequalities (5) and (6) remain valid with $s(x, \theta^0, P)$ replacing $\hat{s}$; that is, a fully revealing rational expectations equilibrium with inside trading strictly dominates an equilibrium from which inside trading is forbidden.

Another way the adverse risk-sharing effects of rational expectations equilibria can be mitigated, which preserves the desirability of inside trading, consists of opening a market prior to the insider's receipt of information. Then, investors can take positions on that market that partially insure them against the information revealed by the insider's subsequent trading.[13] Corollary 3 exhibits one set of conditions sufficient to guarantee the desirability of inside trading in such a case, even when the equilibrium on the (chronologically) last market fully reveals the insider's information.

The time line corresponding to corollary 3 is shown in figure 2. In the equilibrium referred to in corollary 3, investors have rational expectations in two respects: in taking a position on market 1, they antici-

13. As Hart (1975) has shown, however, opening additional markets does not always produce Pareto improvements in allocations.

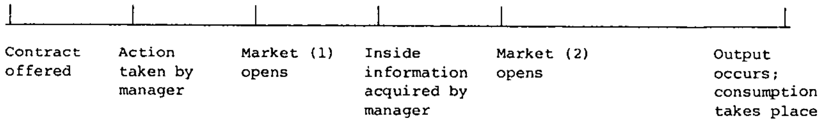

FIG. 2

pate the effect this has on their trading strategy in market 2. Also, in market 2, investors infer the value of the insider's information by observing the market-clearing price of shares.

COROLLARY 3: If all investors' utility functions have common constant absolute risk aversion, markets for the firm's shares open before and after the manager receives his private information, investors have rational expectations, and conditions i–vi of the theorem hold, then any equilibrium corresponding to an admissible contract $s(x)$ for which inside trading is prohibited is strictly dominated by an equilibrium corresponding to another admissible contract $s(x, \theta^0, P)$ for which inside trading is allowed. (The proof is sketched in App. C.)

Under the hypotheses of corollary 3, if the number of investors is sufficiently large, it can also be shown[14] that all investors strictly prefer

14. I show here that if the number (n) of investors (all of whom have identical utility functions with constant absolute risk aversion r) is sufficiently large, and each investor's wealth is large enough so that his utility-maximizing portfolio does not consist entirely of equity in the firm, then all investors will prefer having markets open both before and after the manager's announcement of y over having markets open only after y is announced. Let $P_n(y)$ be the equilibrium price on the market after y is announced and let $z = x - s(x, y)$. $E\{-e^{-r[W+(\bar{\theta}-\theta)P_n(y)+\theta z]}|y\}$ denotes an investor's expected utility, with initial endowment $\bar{\theta}$, wealth W and share purchases θ. From corollary 3, we know that $P_n(y)$ must adjust so that his equilibrium ownership in the firm is $1/n$. From the investor's first-order conditions for share purchases, conclude

$$P_n(y) = \frac{E[ze^{-(r/n)z}|y]}{E[e^{-(r/n)z}|y]}. \tag{F1}$$

With $\bar{P}_n$ denoting the equilibrium price of the firm on the market before y is announced, it can be shown similarly that

$$\bar{P}_n = \frac{E[ze^{-(r/n)z}]}{E[\bar{e}^{(r/n)z}]}. \tag{F2}$$

As was also noted in corollary 3's proof, the market after y is announced is inactive if a prior market exists. In this case, the investor's expected utility is $E\{-e^{-r[W+(\bar{\theta}-1/n)\bar{P}_n+(1/n)z]}\}$. As $n \to \infty$, the investor's expected utility from trading on this prior market (using [F2]) converges to

$$-e^{-r[W + \bar{\theta}E(z)]}. \tag{F3}$$

the scenario corresponding to corollary 3 over the situation in which no market exists prior to the insider's acquisition of information, so the opening of this additional market makes improvements in investors' welfare beyond those provided by inside trading alone.

III

A. *Multiple Firms*

In this section I extend Section II's results to a model with multiple firms. The purpose of this extension is to demonstrate that as long as the inside information obtained by the manager is idiosyncratic to the firm which employs him (i.e., the outputs of other firms are independent of the information he obtains), inside trading continues to be desirable from both the manager's and the owners' perspectives. Since most of the well-known cases of inside trading concern the receipt of such idiosyncratic information,[15] this additional hypothesis can be justified empirically.

To state the claim formally, let $\bar{\theta}_j^i$, $\theta_j^i(P^1, \ldots, P^m)$ denote, respectively, investor i's endowment of and (unconditional) demand for j's shares, the latter being contingent on all m firms' prices $P^1, \ldots, P^m$. The manager under our attention is employed at firm 1; the index $i = 0$ is reserved for his holdings of shares; z_j denotes a random variable characterizing (the sum of) investors' residual claims on firm j, $j = 1, \ldots, m$. If "our" manager is given the contract $s(x)$, $z_1 = x - s(x)$. As in Section II, the manager takes an action and then observes a variable y that is statistically related to x. Here y is assumed to be independent of $z_2, \ldots, z_m$. The contract the manager receives can be contingent on the realized value of output of firm 1, the price of firm 1, and his inside trading in firm 1. If the contract could also be contingent on the manager's entire asset portfolio, then the conditions under which inside trading is desirable coincide with the conditions listed in corollary 1, since the owners of firm 1 could undo any market position taken by the manager and in particular could confine the manager's entire portfolio to investments in firm 1. However, since such portfolio-contingent contracts are exceptional, I shall consider them infeasible.[16] The equilibrium I consider is the obvious multifirm extension of definition 1.

If a market opens only after y is announced, the investor's expected utility (prior to entering that market) converges, as $n \to \infty$, (using [F1]), to

$$E\{-e^{-r[W + 1\bar{\theta}E(z|y)]}\}. \tag{F4}$$

Since the investor's utility function is strictly concave ($r > 0$), (F3) strictly exceeds (F4), completing the claim.

15. This ignores second-order general equilibrium effects.

16. There may be some value, nevertheless, to implementing contracts contingent on $P^2, \ldots, P^m$ (but not explicitly on the manager's positions in these firms) if relative performance considerations are important.

COROLLARY 4: If all investors are risk neutral, conditions i–vi of the theorem hold, and y is independent of $z_2, \ldots, z_m$, then any equilibrium relative to an admissible contract $s(x)$, for which inside trading is forbidden is dominated by an equilibrium relative to some admissible contract $s(x, \theta^0, P^1)$ for which inside trading is allowed.

This corollary is simple to prove: as the manager's receipt of inside information does not provide him with information useful in forecasting other firms' earnings, the risk-averse manager holds no shares in firms other than his own, since they are priced (in equilibrium) at their expected output values. Thus, the manager acts as if no other firm's shares were available, and so the hypotheses of the theorem and its corollary apply to produce the result. (App. D provides the formal proof.)

B. Delayed Release of Insider's Information

If the information the insider receives eventually becomes public regardless of whatever market positions or announcements he makes, then the firm's shareholders are as well off prohibiting inside trading as allowing it, although the efficiency of the stock market may suffer by this delayed release. This result is clear, since the shareholders can use the eventually publicized information for contracting purposes without relying on the communication of this information through inside trades. In fact, the early release of the information through inside trading may be detrimental to shareholders, unless they take positions prior to the release to insure themselves against the information disclosed.

IV

The debate over inside trading has focused on what constitutes the appropriate public policy regarding this trading. The issue cannot be settled easily, since inside trading generates both positive and negative externalities, and so the magnitudes of these externalities must be known before reaching a conclusion. In this paper, I do not attempt to evaluate the social consequences of inside trading; instead, I analyze the private incentives of the owners of a firm to encourage its management to engage in inside trading. I show that, if a manager's inside trades are observable ex post, there may be strict gains to both the managers and owners of a firm in allowing inside trading over offering contracts contingent only on the firm's earnings. Such a demonstration does not establish the unique superiority of managerial compensation schemes that have, as one component of compensation, profits from inside trading. Rather, it establishes that inside trading is one mechanism that may be used by owners to improve on earnings-contingent contracts. Moreover, the virtues of inside trading depend on the existence of established contracts between the owners of a firm and people in a position to affect the firm's earnings. Inside trading by third parties who have no contractual ties with the firm may well be detrimental to the firm's owners. However, the critics of inside trading seldom restrict their condemnation of inside trading to that engaged in by third parties. Yet these critics fail to explain the dearth of corporate restrictions on senior management in such trading, or the relative absence of reprisals in the managerial labor market when such trading is detected. This paper provides one such explanation, based on the ameliorative effects of inside trading on managerial contracts.

Appendix A

Proof of Theorem

I begin by showing how conditions i–vi of the theorem imply that a single principal contracting with a single agent can be made strictly better off by offering a family of contracts contingent on the agent's announced value of his private information.

The perturbation $s(x) + \delta s(x, y)$ of $s(x)$ defined by

$$s(x) + \delta s(x, y) = \begin{cases} s(x) + n_1(x), & y \in Y \\ s(x) + n_2(x), & y \notin Y \end{cases}$$

has the following first-order effects on the expected utilities of the principal and agent (here $\hat{V}(y) = V(W + y)$, where W denotes wealth)

$$\begin{aligned} &-\int_Y\int_X \hat{V}'[x - s(x)]n_1(x)f(x|y)g(y|a)dxdy \\ &-\int_{Y^c}\int_X \hat{V}'[x - s(x)]n_2(x)f(x|y)g(y|a)dxdy \end{aligned} \tag{A1}$$

$$\begin{aligned} &\int_Y\int_X U'[s(x)]n_1(x)f(x|y)g(y|a)dxdy \\ &+\int_{Y^c}\int_X U'[s(x)]n(x)f(x|y)g(y|a)dxdy, \end{aligned} \tag{A2}$$

provided the agent takes the same action a under both $s(x)$ and $s(x) + \delta s(x, y)$. Following Holmström (1979) the latter occurs when the first-order conditions for the agent's utility-maximizing action is the same for both of these contracts, which, up to linear approximation, requires

$$\begin{aligned} &\int_Y\int_X U'[s(x)]n_1(x)f(x|y)g_a(y|a)dxdy \\ &+\int_{Y^c}\int_X U'[s(x)]n_2(x)f(x|y)g_a(y|a)dxdy = 0. \end{aligned} \tag{A3}$$

Since y is observable only to the agent, the agent will elect to be compensated with $s(x) + n_1(x)$, that is, announce $y \in Y$, when Y is defined by

$$Y = \left\{y \middle| \int_X U'[s(x)]n_1(x)f(x|y)dx \geqslant \int_X U'[s(x)]n_2(x)f(x|y)dx\right\}. \tag{A4}$$

Our objective is to show that there exists a variation n_1, n_2 such that (A1) and (A2) are both positive when (A3) holds and Y is defined by (A4). With $n_1(x) =$

$\{(cx + d)/U'[s(x)]\}$, $n_2(x) = \{hx + 1/U'[s(x)\}$ we proceed as follows: Define $z = (1 - d)/(c - h)$, $\underline{y}(z)$ by $E[x|\underline{y}(z)] = z$ and $\mu(a) = E[x|a]$. Then (A3) equals

$$\frac{c}{c-h} = -\frac{1}{\mu'(a)}\int_s^{\underline{y}(z)} [z - E(x|y)]g_a(y|a)dy, \qquad \text{(A3')}$$

and (A2) is satisfied if there exists some $e > 0$ such that

$$\frac{c}{c-h}\mu(a) + \frac{d}{c-h} + \int_s^{\underline{y}(z)} [z - E(x|y)]g(y|a) = e. \qquad \text{(A2')}$$

With $r(y) = \int_{\underline{x}}^{\bar{x}} V'[x - s(x)]/U'[s(x)]\, f(x|y)dx$, $r = E[r(y)|a]$, $m(y) = \int_X V'[x - s(x)]/U'[s(x)] f(x|y)dx$, $m = E[m(y)|a]$, (A1) is satisfied when

$$\frac{c}{c-h}r + \frac{d}{c-h}m + \int_s^{\underline{y}(z)} [zm(y) - r(y)]g(y|a)dy < 0. \qquad \text{(A1')}$$

For a fixed $e > 0$, $d/(c - h)$ is defined by the remaining terms in (A2'). Substitute $d/(c - h)$ so defined, together with $c/(c - h)$ defined from (A3') into (A1'). The result is (with $\mu_y \equiv E[\bar{x}|y]$)

$$\int_s^{\underline{y}(z)} \left\{\frac{r - \mu(a)m}{\mu'(a)}(\mu_y - z)\frac{g_a(y|a)}{g(y|a)} + z[m(y) - m] + \mu_y m - r(y)\right\}$$

$$g(y|a)dy < -em. \qquad \text{(A4')}$$

If z can be found so that (A4') holds for some z, then $c/(c - h)$ is defined by this z through (A3'), so (A3) holds; there exists $e > 0$ such that (A4') holds; for this e, $d/(c - h)$ is defined through (A2') so that (A2) holds; and for these definitions of z, $c/(c - h)$, $d/(c - h)$, (A1) holds. It is easy to show that the derivative of (A4') with respect to z is strictly negative at $z = s$ and so there exists a neighborhood of s such that (A4') holds for each z in this neighborhood. To extend the proof to multiple principals, I show that under the theorem's hypotheses each investor is strictly better off implementing a contract $s(x, y)$ to $s(x)$ if each retains the same fraction of ownership in the firm under $s(x, y)$ as under $s(x)$, and then I show that this last qualification can be dropped; that is, investors will desire to implement $s(x, y)$ instead of $s(x)$ even after adjusting their equilibrium purchases of the firm's shares to reflect the fact that the manager is being compensated with a different contract.

To prove the first claim, define $\hat{V}^i(y) = V^i[W^i + \theta^i y + (\bar{\theta}^i - \theta^i)P]$ for each $i = 1, 2, \ldots, n$. Additionally define

$$r^i(y) = \int \frac{\hat{V}^{i\prime}[x - s(x)]}{U'[s(x)]} xf(x|y)dx \qquad E_a r^i(y) = r^i$$

$$m^i(y) = \int \frac{\hat{V}^{i\prime}[x - s(x)]}{U'[s(x)]} f(x|y)dx \qquad E_a m^i(y) = m^i.$$

Substitute r^i, m^i, $r^i(y)$, $m^i(y)$ for r, m, $r(y)$, $m(y)$ above. Conclude, from this proof that, for any fixed i, there exists $z_i > p$ such that for all $z \in (p, z_i)$, (A4') is negative. Thus, there exists $e > 0$ and $z \in (p, \min\{z_i\}_{i=1}^n)$ such that (A4') is satisfied for each investor $i = 1, 2, \ldots, n$. Then, this z and e defines $c/(c - h)$ through (A3') and, given this $c/(c - h)$, $d/(c - h)$ is defined through (A2'). Notice that $c/(c - h)$, $d/(c - h)$ depend only on the manager's preferences, once z is given. Hence, a variation exists which is unanimously preferred by all investors (i.e., [A4′] is satisfied for each i) and by the manager ([A2′] is satisfied), which induces the manager to take his original action ([A3′] holds), and which is incentive compatible (by construction through the definition of Y). For future reference, this unanimity result is summarized by the following inequalities:

$$\begin{aligned} &E_aV^i\{W^i + \theta^i[x - s(x) - \delta s(x, y)] + (\bar{\theta}^i - \theta^i)P\} \\ &\quad > E_aV^i\{W^i + \theta^i[x - s(x)] + (\bar{\theta}^i - \theta^i)P\} \\ &E_aU[s(x, y)] - g(a) > E_aU[s(x)] - g(a). \end{aligned} \tag{A5}$$

To complete the proof, we must account for the fact that when the manager is compensated by contracts of the form $s(x, y)$ the equilibrium purchases of the firm change. To that end, note that if $s(x, y) = s(x) + \delta s(x, y)$ is replaced by $s^{\gamma}(x, y) = s(x) + \gamma \times \delta s(x, y)$, where γ is any small, positive constant, then the first-order effects of this replacement are as follows:

i) the manager's optimal action is the same under $s^{\gamma}(x, y)$ as under $s(x, y)$;
ii) if $s(x, y)$ is incentive compatible (i.e., the manager announces $y \geqslant \underline{y}$ if and only if y actually exceeds $\underline{y}$), then so is $s^{\gamma}(x, y)$;
iii) the inequalities in (A5) above hold strictly with $s^{\gamma}(x, y)$ replacing $s(x, y)$.

By letting $\theta^i(P, \gamma)$ denote investor i's unconditional demand for the firm's shares when the market price is P and the manager is compensated with $s^{\gamma}(x, y)$, then under standard conditions (see Berge 1966), $\theta^i(P, \gamma)$ is continuous in (P, γ) and $\theta^i(P^*, 0) = \theta^i$, if P^* was the equilibrium price of the firm when the manager was compensated with $s(x)$. The equilibrium price of the firm P^{γ}; that is, the solution to $1 = \Sigma_1^n \theta^i(P, \gamma)$, is continuous in γ also. Appealing to these continuity results (along with i–iii above), it is clear that for sufficiently small γ, the strict inequalities in (A5) continue to hold with $\theta^i(P^{\gamma}, \gamma)$, P^{γ}, and $s^{\gamma}(x, y)$ respectively replacing θ^i, P, and $s(x, y)$. This finishes the proof of the theorem.

Appendix B

Proof of Corollary 1

From the theorem, there exists a contract $\hat{s}(x, y)$ of the form

$$\hat{s}(x, y) = \begin{cases} s'(x) + n_1(x), & y \in Y \\ s'(x) + n_2(x), & y \notin Y, \end{cases}$$

such that if $\hat{\theta}^i = \theta^i(\hat{P}, \hat{s})$ denotes investor i's demand for the firm's shares when the manager is compensated with $\hat{s}$, and if $\hat{P}$ is the equilibrium price of the firm in that case (with $\theta^i = \theta^i[P', s']$ the corresponding quantities relative to the contract s'), then

$$\begin{aligned} &E_aV^i\{W^i + \hat{\theta}^i[x - \hat{s}(x, y) - \hat{P}] + \bar{\theta}^i\hat{P}\} \\ &\quad > E_aV^i\{W^i + \theta^i[x - s'(x) - P'] + \bar{\theta}^iP'\}, \end{aligned} \tag{B1}$$

$$E_aU[\hat{s}(x, y)] - g(a) > E_aU[s'(x)] - g(a). \tag{B2}$$

Next define $s(x, \theta^0, P)$, the manager's compensation based on his inside trading, by

$$s(x, \theta^0, P) = \begin{cases} s'(x) + n_1(x), & \theta^0 = 0 \\ [s'(x) + n_2(x) + \theta^0(P - x)]\dfrac{1}{1 - \theta^0}, & \theta^0 \neq 0, 1 \\ -M, \theta^0 = 1. \end{cases}$$

The manager's net compensation $s(x, \theta^0, P) + \theta^0[x - s(x, \theta^0, P) - P]$ is identical (in distribution) to $\hat{s}(x, y)$, provided the manager selects $1 > \theta^0 > 0$ if and only if $y \notin Y$. To eliminate the manager's indifference toward positive choices of θ^0, assume that, when $\theta^0 > 0$, $\theta^0 = \alpha$, where α is a constant to be specified below. Let

$$\tilde{\theta}^0_\alpha = \begin{matrix} 0, y \in Y \\ \alpha, y \notin Y. \end{matrix}$$

Let $\theta^i_\alpha(P)$ be i's unconditional demand for shares in the firm, when i believes that the manager purchases shares in the firm *only* when $y \notin Y$ and that, when he does purchase, the manager purchases fraction α of the firm. (The investor cares about the manager's purchases even when the investor is not attempting to infer the value of the manager's information, because changes in the amount the manager purchases change the residual claim the investor has on the firm's earnings.) That is

$$\theta^i_\alpha(P) \in \arg\max_{\theta^i} E\big(V^i\{W^i + \bar{\theta}^i P + \theta^i[\tilde{x} - s(\tilde{x}, \tilde{\theta}^0_\alpha, P) - P]\}\big)$$

$$\theta^i \leq \bar{\theta}^i + W^i/P, \quad 0 \leq \theta^i \leq 1.$$

Define P^1_α, P^2_α by

$$\sum_{i=1}^{n} \theta^i_\alpha(P^1_\alpha) = 1, \sum_{i=1}^{n} \theta^i_\alpha(P^2_\alpha) = 1 - \alpha,$$

and let

$$\tilde{P}_\alpha = \begin{cases} P^1_\alpha, y \in Y, \\ P^2_\alpha, y \notin Y. \end{cases}$$

As α converges to zero, $s(\tilde{x}, \tilde{\theta}^0_\alpha, \tilde{P}_\alpha)$ converges in distribution to $\hat{s}(x, y)$, $\tilde{P}_\alpha$ converges in distribution to $\hat{P}$, $\theta^i_\alpha(\tilde{P}_\alpha)$ converges in distribution to $\hat{\theta}^i$, so there exists a sufficiently small (but positive) value of α such that the inequalities (B1) and (B2) remain valid with $\tilde{\theta}^0_\alpha$ replacing θ^0, $\tilde{P}_\alpha$ replacing $\hat{P}$, $\theta^i_\alpha(\tilde{P}_\alpha)$ replacing $\hat{\theta}^i$, and $s(\tilde{x}, \tilde{\theta}^0_\alpha, \tilde{P}_\alpha)$ replacing $\hat{s}(x, y)$.

Appendix C

Proof of Corollary 3

Suppose the insider is compensated with a function $s(x, y)$ based on the announced value of his private information (as in the theorem), and he is prohibited from trading. Given the posited preferences of investors and the market positions they took on the (chronologically) first market, each investor's demand for shares on the last market, after y has been announced, is independent of his wealth. Hence, the equilibrium price must adjust until each of the n investors holds fraction $1/n$ of the firm's shares. Similarly, on the first market (before y is announced), the equilibrium demand of each investor is also $1/n$, and hence the second market is inactive. Thus, the equilibrium price on the first market and each investor's expected utility coincide with the situation associated with the theorem, in which y is revealed after all markets close. The hypotheses of the theorem specify conditions sufficient for a contract $s(x, y)$ to be strictly superior to an output-contingent contract $s(x)$. As in the proof of corollary 1, this contract $s(x, y)$ may be converted to a contract $s(x, \theta^0, P)$ and the sanctions against inside trading may be lifted so that (1) each investor's final market position, after the value of insider's information is inferred, is arbitrarily close to what it was when the manager was compensated with $s(x, y)$; (2) with the implementation of $s(x, \theta^0, P)$ the levels of expected utility achievable by the investors and the manager are arbitrarily close to the levels obtained under $s(x, y)$ and so dominate the levels obtained with $s(x)$.

Appendix D

Proof of Corollary 4

Observe that given any contract $s(x, y)$ that depends on the manager's announced value of y after the market closes (including as a special case $s(x, y) \equiv s(x)$), for any realization of y and for any announcement $\hat{y}$ of y, the manager will purchase none of firm j's shares $j = 2, \ldots, m$. To see this, note

i) $P^j = E[z_j|y]$ for any y;

ii)
$$\frac{d}{d\theta_j^0} E\Big\{U(W^0 + \bar{\theta}_1^0 P^1 + \sum_{j=2}^{m} \bar{\theta}_j^0 P^j + \theta_j^0(z_j - P^j) + \theta_1^0(x - s(x, \hat{y}) - P^1))|y\Big\}$$

$= E[U'(\cdot)(z_j - P^j)|y]$, for $j = 2, \ldots, m$, where the argument of $U'(\cdot)$ is as above.

iii) Holding x and z_k fixed for $k \neq j$,

$$E[U'(\cdot)(z_j - P^j)|x, y, z_k, k \neq j] \leq E[U'(\cdot)|x, y, z_k, k = j] \cdot 0;$$

iii follows from $\theta_j^0 \geq 0$, U is concave, and i holds. Taking expectations over x and all z_k, conclude that the derivative in ii is nonpositive. Thus, if the manager is initially endowed with shares of any of the firms $2, \ldots, m$, he will sell them and at most reenter the stock market to purchase shares in his own firm. Therefore, the arguments of the theorem and its corollary are immediately applicable.

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