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Source: *The Journal of Finance*, Vol. 47, No. 5 (Dec., 1992), pp. 1905-1934
Published by: Blackwell Publishing for the American Finance Association
Stable URL: http://www.jstor.org/stable/2329001
Accessed: 25/11/2009 12:00

THE JOURNAL OF FINANCE • VOL. XLVII, NO. 5 • DECEMBER 1992

Insider Trading in Financial Signaling Models

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ABSTRACT

We study the impact of *voluntary* trade by the manager. We find that, in contrast to standard signaling models, an action is good news for some firms and bad news for others, depending on observable characteristics of the firm, its managers, and their compensation plans. Further, voluntary trade eliminates separating equilibria and thus the possibility of exactly inferring the manager's private information. This may cause the manager to take inefficient actions so as to earn trading profits. Such undesirable behavior can be more effectively constrained by compensation contracts based on phantom shares or nontradeable options instead of large stockholdings.

FINANCIAL SIGNALING MODELS HAVE become a popular means of explaining managerial decisions and their associated announcement effects.[1] However, it is well known that the implications of such models are not robust to changes in the manager's exogenously specified objective function. Recently, Dybvig and Zender (1991) have proposed that one endogenize the manager's incentives by incorporating contracts between the manager and the firm's owners into the models. In this paper, we wish to highlight an additional endogenous source of incentives for the manager—his profits from trading in the firm's stock. Permitting such trade has important implications because it eliminates separating equilibria even in signaling models that have them when the manager is prohibited from trading. As a consequence, equilibrium price reactions depend on both the nature of the manager's compensation contract and how much of his holdings he can trade. Further, sometimes the manager makes inefficient operating decisions so as to make trading profits even in the presence of incentive contracts designed to prevent such decisions.

We use a "standard" signaling model in that the manager possesses better information than the market and chooses an observable action by the firm such as issuing securities, repurchasing shares, announcing special dividends, going public, or making a takeover attempt. Our model differs in one critical respect; we permit the manager to voluntarily trade in the firm's

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[1] An excellent survey of the theory of capital structure is Harris and Raviv (1991).

stock after the competitive market makers and noise traders have observed the action.[2] Because the manager trades voluntarily, he will trade only when he expects to profit from so doing, causing a market maker to sell (buy) more shares when the manager believes that their value exceeds the ask (is less than the bid). This adverse selection problem forces the market makers to adjust the equilibrium bids and asks to account for it. Our other important assumptions are that the manager is risk neutral and maximizes his expected wealth and that the market makers are risk neutral, competitive, quote bids and asks, and stand ready to buy or sell all shares demanded at those prices. Finally, to emphasize that our results apply to much of the extant signaling literature, we only report results that are true in every sequential equilibrium and hence must be true under whatever refinement of this set of equilibria is deemed appropriate.

To see why signaling models that have separating equilibria without insider trading only have partially pooling equilibria when such trading is permitted, suppose that there is a separating equilibrium with insider trading. In this case, the manager's action choice would reveal his information, the market makers would price the firm fairly and the manager would be unable to earn trading profits. If the manager deviates either by mimicking a higher type and selling the overpriced shares or by mimicking a lower type and buying the underpriced shares he can make a trading profit. Thus, to keep him from mimicking either type, the losses on his remaining stockholdings from choosing the "inappropriate" action must offset his trading profits. For this to happen, he must retain (either through his compensation or through trading restrictions) a sufficiently large position in the firm *and*, more importantly, two very similar types must have very different payoffs from choosing the same action. If they don't, then the non-mimicry conditions cannot be satisfied and the market cannot infer the manager's private information from his actions.

Equilibrium price reactions depend on both the nature of the manager's compensation contract and how much of his holdings he can liquidate through trade. To see why, suppose that his compensation is a straight salary and that he can sell every share he owns. In this case, if he sells his position, his payoff depends only on the price received but not on the subsequent value of the firm. Thus, the market maker's equilibrium bids cannot depend on the manager's action choice. If they did, he would choose the action that leads to the largest bid thereby eliminating the adverse selection problem in the bids following all other actions. As a result, the market makers would set fair prices for the stock after the other actions making these bids higher than the supposed highest bid, which is a contradiction. Hence, if the manager is paid a straight salary and can fully liquidate his initial position in the firm, the unique equilibrium outcome is that all actions lead to the same bid and so it

[2] To the best of our knowledge, only two other papers, John and Mishra (1990) and John and Lang (1991), permit voluntary trade by the manager. We will discuss the relationship between their work and ours below.

does not reflect the information contained in the manager's choice of action. However, if the manager's compensation depends on the future value of the firm or if he is prohibited from selling all of his shares (so that he cares about the future value), the equilibrium bids will be different after different action choices and will reflect (some of) his information. If the manager intends to buy shares, he does care about their future value regardless of the compensation scheme and, as a result, the equilibrium asks will reflect (some of) his information.

When the equilibrium bids and asks reflect some of the manager's information, some actions are good news and others bad. The surprising part is that whether or not an action is good news is *firm-specific*, i.e., depends on the observable characteristics of the firm such as the original size of the firm, the existing holdings of the insiders, the exogenous restrictions on the insiders' trading, average volume in the firm's shares, the original stock price, the original number of shares outstanding, the original debt/equity ratio, the existing level of dividends, or the firm's line(s) of business. This means that the *same action* can be good news for some firms and bad news for others and is reflected in higher bids and/or asks for some firms and lower bids and/or asks for others.

These results concerning the equilibrium bids and asks are very different from those of the "standard" signaling model in which the action is either good or bad news independently of the firm's characteristics. Such an *action-specific* signal can readily rationalize average announcement effects. However, when the signal is *firm-specific*, such a rationalization is more difficult. Since, for some firms the action will be good news while for others it will be bad, the average announcement effect can be either positive or negative depending on the choice of sample.

In standard signaling models, every firm taking a particular action experiences the same directional change in its stock price. Most empirical studies provide evidence that such is not the case.[3] With an *action-specific* signal, there are at least two potential explanations. First, there may be noise in the form of (hard to identify) confounding announcements. Second, the correct model (as argued in John and Mishra (1990)) is a multidimensional signaling model and the empirical work is focused on only part of the picture. Our model provides a natural explanation for firm-specific announcement effects by introducing voluntary trade by the manager.

We do not intend to suggest that ours is either the first or the only approach to firm-specific signaling. Brennan and Copeland (1988), among

[3] We cite but a few examples where a significant portion of the sample produced a different directional change. In Masulis (1980) 69% and 58% of the firms had a positive announcement effect on day 0 and 1 respectively. Asquith and Mullins (1986) report that 66% of the utilities and 80% of the industrials have negative announcement day returns. Mikkelson and Partch (1986) report that 75% have negative excess returns and Masulis and Korwar (1986) find that 71% of the industrials and 58% of the utilities have negative returns on the day after the announcement. In each, a sizable proportion of the firms in the sample experience announcement effects in the opposite direction of the average announcement effect.

others, have realized that the magnitude of the predicted announcement effects depend on firm-specific characteristics. Also, two other papers have derived firm-specific signaling in models of new investment financing. In Raymar (1990), the firm has outstanding debt and the payoff stream for existing assets and the payoff stream for the new project are correlated. He shows that the decision to undertake the new project can alter the riskiness of the original debt and this potential wealth transfer (to or from the original bondholders) alters the manager's incentives and leads to firm-specific signaling. In an extension of the original Myers and Majluf model, Cooney and Kalay (1990) introduce the possibility that the new project has a negative net present value. This change, combined with the requirement that the manager who issues shares is forced to undertake even a negative net present value project, leads to the possibility that issuing equity is a firm-specific signal.

In addition to generating *firm-specific* signaling, our model has other empirical implications. First, if the manager is permitted to sell all of his shares but cannot be short, then the bids should not vary with the manager's action choice but the asks should. Second, for some firms, an action should increase the bid/ask spread while, for other firms, the same action should narrow it. Third, if there is evidence that after a "better" action, some managers neither bought or sold additional shares, then the ask following this action should exceed the ask following an "inferior" action. Fourth, if there is evidence that after an "inferior" action, some managers neither bought nor sold additional shares, then the bid following this action should be smaller than the bid following a "superior" action.

Although we will refer to the manager's action choice, a, as if it were a single action, our results hold when a is a vector of actions. As a result, our conclusions also apply to multidimensional signaling models. Recognizing this allows us to compare our work with John and Mishra (1990) and John and Lang (1991). In their work, the focus is on insider trading around an announcement. Their view is that for such trading to be legal, it must be disclosed. Therefore, they take such insider trading as an additional signal. In their multidimensional signaling model, they show the existence of firm-specific signaling. In contrast to the type of insider trading we consider, their insider trading would be an action in our model because it is announced. Consequently, in our model, firm-specific signaling is present with or without insider trading that is disclosed prior to or concurrently with an additional action choice.

The above discussion focused on how the manager's opportunity to trade altered the types of signaling equilibria and the equilibrium price of the firm. The remaining issues involve determining how the potential for trading profits alters the manager's incentives to maximize the value of the firm and what stockholders might do to mitigate the effects. Such a conflict arises because none of the equilibria reveal the manager's private information. Hence, the manager faces a trade-off. He can choose the action that maximizes his expectation of the value of the shares he already owns and buy additional shares at the ask associated with this action, or choose an action that does not maximize his expectation of the value of the shares that he owns but which allows him to acquire additional shares at a lower price. A similar phenomenon arises with the manager's sell option.

When the manager can trade, he sometimes finds it optimal to choose an inefficient action which creates a wealth loss for the firm's other stockholders. Hence, they want to align his incentives with their own. One way to do so is to give the manager a large stake in the firm while restricting his ability to trade large quantities. Since such restrictions may be hard to enforce, compensating the manager with phantom shares or nontradeable warrants or options may dominate giving him a large stake.

In Section I, we present the model and its equilibria. In Section II, we study the implications of permitting the manager to voluntarily trade. In Section III, we study how stockholders can limit the costs of voluntary trade by the manager, and we present conclusions in Section IV. All proofs are contained in the Appendix.

I. The Model

A. The Order of Play, Information Structure, and Payoffs

We study a fairly general signaling model which is designed to capture the important aspects of many of the models that have been analyzed. The firm is run by a manager who has private information about its value which can be affected by the manager's actions *and* the market's response to them. Let A be the set of actions that the manager can take. To show that insider trading is an equilibrium phenomenon, A can be finite or a continuum; but to prove Theorems 2, 3, and 4, A will be a finite set. Also, let the per share terminal value of the firm be $v(a) = V(a, w)$ where w is a random variable that is (possibly perfectly) correlated with the manager's type. Since the manager knows his type and the action choice, he can compute his expectation of the terminal value of a share given his type.

We assume that the manager is risk neutral, seeks to maximize his expected wealth and, for this section, that his compensation is independent of his action. The manager holds some shares in the firm, n_m, and is permitted to voluntarily trade in the firm's stock. We also assume that there is a probability, $\phi \in [0, 1)$, that the manager is forced to liquidate his position in this firm.[4] Thus, if s_1 is the number of shares that the manager sells at price $b(\cdot)$, s_2 is the number he purchases at price $\alpha(\cdot)$, and if t represents the manager's private information, then the manager seeks to maximize

$$E[s_1 b(a) - s_2 \alpha(a) + (n_m - s_1 + s_2)v(a) | t]$$

[4] Including this probability is costless and has no impact on the analysis. However, its inclusion allows us to replicate the objective function used by Miller and Rock (1985) thereby extending the class of models to which our analysis applies.

by choosing a, s_1, and s_2. If the manager is forced to liquidate his position, s_2 is constrained to be zero and s_1 is constrained to be n_m.

We must impose trading constraints on the manager because we have assumed that he is risk neutral and may, for certain realizations of his private information wish to trade to an infinite position. So, we assume that he cannot own more than $\bar{n}$ shares and that his final position cannot be smaller than $\underline{n}$ if he sells. If $\underline{n} > 0$, then the manager is prohibited from selling all of his n_m shares. If negative, which would permit the manager to be short (a violation of SEC regulations), it limits how short the manager can get and, if it is zero, then the manager can sell his initial position but cannot short the firm's stock. One should interpret these constraints as proxying for the impact of the manager's aversion to risk and possibly the effects of a long-term relationship with the firm.[5] Proxying in this way allows us to avoid the complexity of introducing a risk-averse manager.

We will assume that the manager's information or type is a real number $t \in T \equiv [\underline{t}, \bar{t}]$, some finite interval of $\mathscr{R}$. What is important for our analysis is how the manager's expectation of the per share terminal value of the firm varies with his information. So, rather than make assumptions about the underlying joint probability distribution, we make assumptions about this expectation directly. We assume that for all a, $\mathrm{E}[v(a)|t]$ is bounded, continuous, and strictly increasing in $t \in T$. Since we will also need to calculate the investors' expectations given an action, we must specify their priors because the manager's information, t, is a random variable from their perspective. Let their priors be represented by any probability density whose support is T. Finally, we assume the single-crossing property. That is, for any distinct $a_1, a_2 \in A$, as a function of t, $\mathrm{E}[v(a_1)|t]$ and $\mathrm{E}[v(a_2)|t]$ cross once.

In our model, the order of play is as follows. The manager chooses an action $a \in A$. Everyone observes this choice and then the market for the firm's stock opens.[6] This market consists of M perfectly competitive market makers and some noise traders. The market makers are assumed to quote bids and asks and are required to stand ready to buy or sell all shares that the market participants wish to trade at these prices.[7] The only important features of the noise traders are the expected number of shares that they buy and sell, γ_1 and γ_2 respectively, both strictly positive. Finally, the remaining participants

[5] That is, $\underline{n} > 0$ means that the manager maintains a stake in the firm even if he sells as many shares as he can. This linking of his welfare with the value of the firm can be thought of as the value of maintaining a reputation or the value of his firm-specific human capital or long-term contingent compensation such as warrants or options that cannot be sold.

[6] This order ensures that the form of insider trading we analyze conforms to current SEC regulation—the manager trades only after announcing the action. Obviously, there are questions concerning the enforcement of such regulations and it will be useful to extend our analysis to include "illegal" insider trading.

[7] This is similar to the model of market making employed by Admati and Pfleiderer (1989), Easley and O'Hara (1990), and Bagnoli and Lipman (1991) but differs from the model employed by Kyle (1985, 1989) Admati and Pfleiderer (1988), and many others. The impact of this choice is discussed in the conclusion.

are also risk neutral and their payoff is simply the expected value of their position. After the market closes, the terminal value of the firm is realized and the game ends. Hence, a market maker's payoff is the expected value of the shares purchased at $b(a)$ and those sold at $\alpha(a)$,

$$\mathrm{E}[n_b(v(a) - b(a)) + n_s(\alpha(a) - v(a))]$$

where n_b is the number of shares this market maker buys and n_s the number he sells.

We will seek a sequential equilibrium to this game, a vector of strategies, one for each player, and a set of beliefs so that given the beliefs, each player's strategy is a best reply to the strategies of the others and the beliefs satisfy Bayes' rule where possible. As is standard, there will be a large number of such equilibria and the usual approach is to refine the set of equilibria by imposing some sort of additional restrictions on beliefs. Since our objective is to understand the impact of the ability of the manager to trade in the firm's stock on signaling models, we will avoid the use of additional refinements.

B. Equilibrium

To solve the game, we begin in the last stage when the manager's action has been observed, the market makers have set their bids and asks, and all the manager can choose is how many shares to buy or sell. He is risk neutral and has formed his expectation of the value of a share given his prior action choice. Therefore, if the expectation exceeds the ask, his optimal choice is to purchase as many shares as he is permitted, $\bar{n} - n_m$. If the expectation is between the ask and the bid, he chooses to neither buy nor sell additional shares and, if the expectation is smaller than the bid, he chooses to sell as many shares as he is permitted, $n_m - \underline{n}$.

Knowing the manager's trading strategy in the final stage, we can back up to the point where the market makers choose their bids and asks. Since the market makers are competitive, they all quote the same bid-ask pairs. Based on the manager's trading strategy, the market makers know that there is an adverse selection problem, i.e., they are buying more (fewer) shares when the manager's expectation of the terminal value of a share is low (high). This adverse selection problem forces them to set the equilibrium bid below the expected value of a share given the manager's action and the equilibrium ask above it. Further, the market makers must, in expectation, earn zero profits on their purchases and zero profits on their sales, not just zero expected profits in total. The reason is that if either the bid or the ask allows them to make positive profits on one side of the market, a competitor could offer the market a slightly better price and earn positive profits.

We start by focusing on the equilibrium bid. A market maker earns zero expected profits on purchased shares if $\mathrm{E}[n_b(v(a) - b)|a] = 0$, where the notation is meant to highlight the conditioning on the manager's equilibrium strategy to infer what subset of manager types choose that action. By definition,

$$\mathrm{E}[n_b(v(a) - b)|a] \equiv \mathrm{E}[n_b|a]\mathrm{E}[v(a) - b|a] + \mathrm{cov}[n_b, v(a) - b|a].$$

As explained above, the covariance is negative because of the adverse selection problem. Since the expected number of shares purchased is non-negative for any $a \in A$ chosen in equilibrium, $b(a) \leq \mathrm{E}[v(a)|a]$. Further, if the manager actually will sell shares after taking the action, then the bid is strictly smaller than the market makers' conditional expectation of the value of a share.

As with the equilibrium bids, there is a lemon's effect in the asks. The market maker is now selling more shares when the manager chooses to buy than he is when the manager chooses not to buy and so he sets the ask above the expected terminal value of a share in order to earn zero profits. Therefore,

$$0 = \mathrm{E}[n_s(\alpha - v(a))|a] \equiv \mathrm{E}[n_s|a]\mathrm{E}[\alpha - v(a)|a] + \mathrm{cov}[n_s, \alpha - v(a)|a].$$

The covariance is again negative because, when $\alpha - v(a)$ is positive, the manager does not want to buy additional shares because the price, α, exceeds their value. If it is negative, the manager does want to buy shares. Hence, the number of shares that the market maker sells is negatively correlated with the difference between the ask and the per share terminal value. Therefore, we see that for any a chosen in equilibrium, $\alpha(a) \geq \mathrm{E}[v(a)|a]$ and that if the manager actually will buy shares after choosing a, the ask is strictly larger than the market makers' conditional expectation of the value of a share.[8]

Computing the equilibrium bids and asks as a function of the set of manager types that choose each action is relatively straightforward from the above equations. Doing so shows that increases in the expected volume of noise trading or an increase in ϕ, the probability that the manager is required to liquidate his position, reduces the difference between the equilibrium bid and $\mathrm{E}[v(a)|a]$. The former also reduces the difference between the equilibrium ask and the conditional expected value of a share. In both cases, the effect is generated because there is a reduction in the adverse selection problem facing the market makers. There is little else to be learned from the computations and the interested reader is referred to our working paper for them.

To determine the manager's action choice, notice that after any action the manager can choose to buy additional shares, sell shares, or do neither. Hence, we need to know the payoff from each action, trading strategy combination. The manager's payoff from choosing action a and selling all he is permitted to is

$$\pi^s(a;t) = (n_m - \underline{n})b(a) + \underline{n}\mathrm{E}[v(a)|t].$$

[8] We thank the referee for pointing out this simplified approach to analyzing the equilibrium bids and asks.

Notice that if $\underline{n} < 0$, the second term is interpreted as the cost of covering the short position rather than the value of the unsold shares. If the manager chooses to neither buy nor sell additional shares after the action, his payoff is

$$\pi^h(a;t) = n_m \mathrm{E}[v(a)|t],$$

while his payoff from doing a and buying additional shares is

$$\begin{aligned}\pi^b(a;t) &= n_m \mathrm{E}[v(a)|t] + (\bar{n} - n_m)(\mathrm{E}[v(a)|t] - \alpha(a)) \\ &= \bar{n}\mathrm{E}[v(a)|t] - (\bar{n} - n_m)\alpha(a).\end{aligned}$$

When A is finite and these payoffs are evaluated after the manager has chosen a_i, we will, for convenience, write them as $\pi_i^j(t)$. Which types choose which action follows from choosing the largest of these payoffs as a function of the manager's type. We will identify the set of types for whom $\pi_j^i(t)$ is optimal as $T^i(a_j)$ for $i = s, h, b$ and $j = 1, 2, \dots, m$. Finally, notice for future reference that the type indifferent between selling and holding is the type for whom the bid just equals his expectation of the value of a share. Similarly, the type that is indifferent between holding and buying additional shares is the one for whom the ask equals his expectation of the value of a share.

Our goal is to determine what is true in every sequential equilibrium.[9] We begin by showing that in every sequential equilibrium, after any equilibrium action, there is insider trading. By this we mean that there is a positive probability that the manager sells his position and a positive probability that the manager purchases additional shares. To show this, we must actually prove (1) that in every sequential equilibrium that is not separating, there is insider trading and (2) there are no separating equilibria in our model. The intuition for the former is that if multiple types choose the same action, the market makers set their equilibrium bids and asks to be a weighted average of the possible terminal values. Hence, there are always manager types who have chosen the action whose expected terminal value is above the equilibrium ask or below the equilibrium bid. As we have shown, in such cases, the manager buys (sells) shares and we will have insider trading in such equilibria.

Given that we have a continuum of types, there are no separating equilibria in our model when the manager is permitted to trade. Such a result is trivial and uninteresting if the set of actions is "smaller" than the set of types but we show in the Appendix that there are no separating equilibria even if there are at least as many actions as types. The intuition for the lack of a separating equilibrium in such cases is relatively simple. To keep the manager from mimicking a better type and then selling all the shares that he can, the loss on the shares he is required to continue to hold must offset the gain from selling overpriced shares to the market makers. This means that this

[9] A straightforward extension of the argument in Kreps and Wilson (1982) or the discussion in Fudenberg and Tirole (1991) is sufficient to ensure that a sequential equilibrium exists for our model.

type's expectation of the per share terminal value of the firm must fall enough if he mimics. However, if it does fall enough, then the type that he was kept from mimicking can profitably mimic and buy the underpriced shares. One can immediately conclude that if $\underline{n} \leq 0$, there are no separating equilibria because the manager can always avoid the cost of mimicking another type by selling all of his initial position. If $\underline{n} > 0$, then the argument requires that one be able to select types that are not too different to show a violation of the non-mimicry conditions. Assuming that there is a continuum of types and that payoffs are continuous in type is a natural way of satisfying this condition. Thus,

Theorem 1: *There is insider trading in every sequential equilibrium.*

One important implication of this theorem is that even if we impose the extra constraints that Mailath (1987) has shown to be necessary and sufficient for there to be a separating equilibrium when the manager is barred from trading, there are no separating equilibria when he can trade.

Before proceeding, a few comments about our decision to work with a continuum of types are needed. Doing so allows us to use continuity of the manager's payoff in his type to completely define what it means for types to be similar or different. It is intuitive to think that types that are similar are close together in the way that they are labelled and in their payoffs, and types that are reasonably different are far apart and differ in their payoffs. However, when there are a finite number of types, one must specify a vector of payoffs for them, one for each type. After ordering the types, similar types are those whose subscripts are close together but this tells us virtually nothing about how different their payoffs are. Unfortunately, this is exactly what is needed to determine whether or not there is a separating equilibrium. That is, whether or not one can satisfy the non-mimicry conditions usually depends on how different the payoffs from a given action are for similar types.

To see this more clearly, assume that there are two actions and two types. Expected terminal values are then four numbers $v(1,1)$, $v(2,1)$, $v(1,2)$, and $v(2,2)$ where the first argument is the action and the second is the type. Single crossing means that $v(1,1) > v(1,2)$ and $v(2,2) > v(2,1)$. Separation requires that neither type wishes to mimic the other. So without voluntary trading, if we want type 1 to do action 1, we must have $v(1,1) > v(2,1)$. For type 2 to do action 2, $v(2,2) > v(1,2)$. Now, introduce the possibility of insider trading and ask if there can be a separating equilibrium. If there is, then the market maker's prices are the manager's expectation of the terminal value and so the analogous equilibrium payoffs are $n_m v(1,1)$ and $n_m v(2,2)$. The non-mimicry conditions change. For type 1, if he deviates to the second action, he will sell shares because $b(2) = v(2,2) > v(2,1)$. The type 2 deviator will also sell because $b(1) = v(1,1) > v(1,2)$. For type 1 to not deviate, $n_m v(1,1) > n_m v(2,2) + \underline{n}(v(2,1) - v(2,2))$ and there is a similar expression for type 2. Notice that whether or not these conditions are satisfied is simply a condition of $n_m, \underline{n}$ and the terminal values. That is, for fixed $n_m, \underline{n}$, satisfying the non-mimicry conditions is only a question of how similar or different the payoffs of the two types are.

In spite of the generality of the model, we can derive some results concerning the equilibrium bids and asks. To do so, we examine the relationships between the sets of types that choose each strategy and simplify the analysis by assuming that A is a finite set. To simplify the description, we will say that one set $T^i(a_1)$, the set of types for whom the action a_1 and trading strategy i is optimal, is "better" than $T^j(a_2)$ if $\max\{t \in T^j(a_2)\} \leq \min\{t \in T^i(a_1)\}$. With some reluctance, we will write this as $T^i(a_1) > T^j(a_2)$.

Our first task is to sort out the types that choose to sell, hold, or buy after choosing a given observable action, a. We will show that the set of types that sells is worse than the set that holds which, in turn, is worse than the set that buys. The intuition is that the equilibrium bids and asks are weighted averages of the manager's expected per share terminal value of the firm. Since the very worst types that choose an action believe that the firm's terminal value per share is smaller than the equilibrium bid, they profit from selling. The best set of types choosing the action buy additional shares because the equilibrium ask is below what they believe the value of a share is. The middle group of types believe that the per share terminal value of the firm falls between the equilibrium bid and ask. For them, it is unprofitable to either buy or sell additional shares because the lemon's effect has forced the market makers to set too high an ask and too low a bid. Thus, we have that for every action taken in equilibrium, $T^s(a) < T^h(a) < T^b(a)$.

The next step is to determine how actions are related to types when the manager chooses not to trade. To simplify, we use the single-crossing property to label the actions so that if $i < j$ then $\mathrm{E}[v(a_i)|\bar{t}] > \mathrm{E}[v(a_j)|\bar{t}]$. We show that if, after these two distinct actions, there are manager types that hold, then a_i is chosen by the better types. The intuition here is that if the manager chooses a_i and holds, the expected value of doing so must exceed the expectation of doing a_j and holding and vice versa. Since the two expectation functions cross once, and we have assumed without loss of generality that at $\bar{t}, \mathrm{E}[v(a_i)|\bar{t} > \mathrm{E}[v(a_j)|\bar{t}]$, then the set that does a_j and holds must be worse than the type that is indifferent and the set that does a_i and holds must be better. Thus, if there are types that do each action and hold ($T^h(a_i)$ and $T^h(a_j)$) are nonempty, then $T^h(a_j) < T^h(a_i)$.

Ordering the remaining sets of types is complicated by the fact that we have not specified whether $\underline{n}$ is positive, negative or zero. Its value dramatically alters the incentives of a manager type that intends to sell after choosing an action. To see why, recall that we have shown that the manager will *choose* to sell all of the shares that he can if he chooses to sell any. Thus, if $\underline{n} = 0$, the manager ends up with no position in the firm making his action choice unimportant *to him* and eliminating the dependence of the equilibrium bids on his action choice. If $\underline{n} < 0$, then the manager is shorting the stock whenever he chooses to sell shares. In this case, if two actions lead to the same bid, knowing that he must cover his position by buying shares at his expectation of the value of the shares given the action, he prefers the action that minimizes his expectation of the terminal value of the firm. Similarly, if $\underline{n} > 0$, then the manager must retain a position in the firm. In this case, if two actions lead to the same bid, the manager prefers the action that maximizes the expected terminal value.

The equilibrium bids will depend on the sign of $\underline{n}$. This dependence is important because, if the relative sizes of the bids depend on exogenous restrictions on the manager's ability to sell shares, then using the bids as indicators of the market's perception about the value of the firm will be misleading. For example, if the bids are equal after some pair of actions it does not mean that the market's expectation of the terminal per share value of the firm is the same after either action. Similarly, the fact that the bid is higher after one action than after another does not imply that the expected terminal value of a share is larger. Hence, clarifying the dependence of the bid on the selling restrictions is quite important and is done in the following theorems.

Theorem 2: *If $\underline{n} = 0$, then in every sequential equilibrium, the equilibrium bid is independent of the action.*

Thus, if the legal restriction to not selling the firm short is enforced and if the manager cannot be forced to maintain a position in the firm, then the price he receives for his shares will not depend on his action.[10] The bids do not reflect the information contained in his action choice.

Theorem 3: *In every sequential equilibrium, if a_1 and a_2 are actions taken in equilibrium and $T^h(a_2)$ is nonempty, then* (1) *if $\underline{n} > 0$, then $b(a_1) > b(a_2)$ and* (2) *if $\underline{n} < 0$, then $b(a_1) < b(a_2)$.*

Hence, for any pair of actions taken in equilibrium, if there are manager types that choose to hold after taking a_2, then whether a_1 or a_2 leads to a higher bid depends solely on whether or not the manager must retain a position in the firm, $\underline{n} > 0$. If one examines Figures 1 and 2, it is intuitively clear why Theorem 3 is true and examining Figure 3 shows why it is necessary that there is a set of types who choose a_2 and hold ($T^h(a_2)$ be nonempty).[11] In Figure 1, drawn assuming $\underline{n} > 0$, the payoff to selling is increasing in the manager's type and our single-crossing assumption means that the payoff to selling after doing a_1 is steeper than after a_2. The figure indicates why the set of types that sell after a_2 are worse than the set that choose a_1 and sell ($T^s(a_2) < T^s(a_1)$) and, since as drawn, $T^h(a_2)$ is nonempty, we also have $b(a_2) < b(a_1)$. Analogously, Figure 2 is drawn assuming that $\underline{n} < 0$. In this case, the manager must cover his short position. Since his expectation of the per share terminal value of the firm is increasing in his

[10] However, see below when the manager's compensation can be made to depend on his action choice. In such a situation, the manager's payoff is no longer independent of his action choice unless he also chooses to leave the firm. If he does, then the analysis goes through and if he does not, the analysis is qualitatively the same as the analysis when $\underline{n} \neq 0$.

[11] Nothing in the analysis ensures that any of the payoff functions are linear yet all of the figures will be drawn assuming that they are.

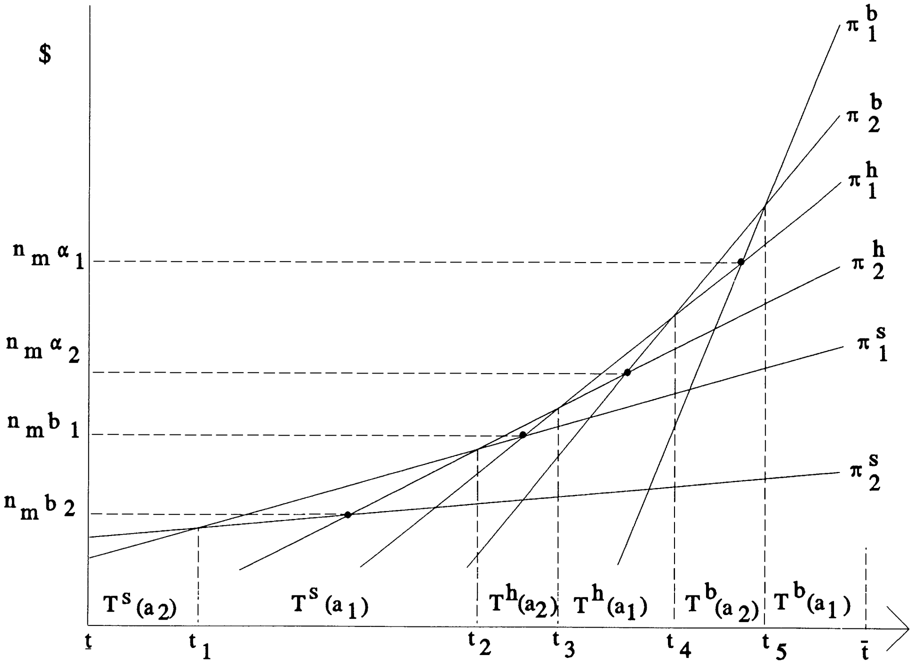

Figure 1. Equilibrium when the manager cannot sell all of his initial position. The manager is not allowed to sell all of his initial position, $\alpha_1 > \alpha_2$ and $b_1 > b_2$. That is, after observing the better action, a_1, the market makers set the bid, b_1, and the ask, α_1, higher than the bid, b_2, and ask, α_2, they set after observing the inferior action, a_2. π_i^j is the profit to the manager from choosing action a_i, for $i = 1, 2$ and trading strategy $j = s, h, b$ where s = sell, h = hold, and b = buy. $T^j(a_i)$ represents the set of types that take action a_i and follow trading strategy j while t_i is the type indifferent between the two action–strategy combinations that define it.

type, the payoff from shorting the firm's stock after an action is declining in the manager's type—the cost of covering the short position rises in his type. The fact that the manager's trading profits from selling are declining has important implications. First, from the single-crossing property, the relative slopes of π_1^2 and π_2^s remain the same in absolute value and this means that the order of the types reverses because the functions are downward sloping, i.e., $T^2(a_1) < T^s(a_2)$. In addition, when $T^h(a_2)$ is nonempty, the figure indicates why we must have $b(a_1) < b(a_2)$. Thus, it is possible for the same action to be good news for some firms and bad for others.

The following theorem provides the analogous relationship between the equilibrium asks. Some portions of the analysis are greatly simplified because the manager who buys additional shares necessarily has a long position in the firm. Consequently, the single-crossing property will ensure that if a_1 and a_2 are two actions taken in equilibrium, then the set of types that do a_2, the "worse" action, is worse than the set of types that does the "better" action, $T^b(a_2) < T^b(a_1)$. Unfortunately, this does not greatly reduce the

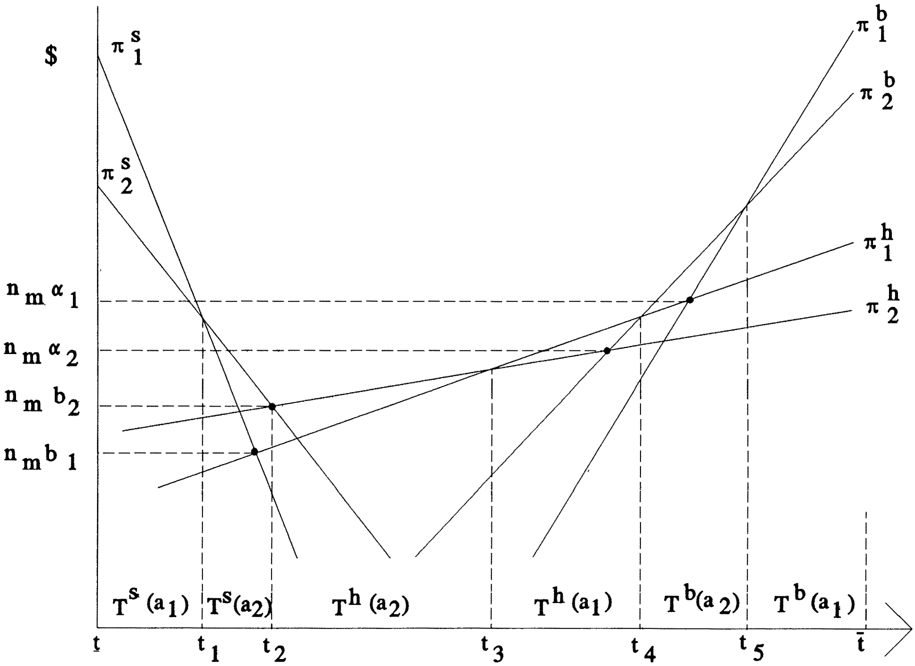

Figure 2. Equilibrium when the manager is allowed to sell short. The manager is permitted to short the firm, $\alpha_1 > \alpha_2$ and $b_1 < b_2$. That is, the market makers set a higher ask, α_1, after observing the better action, a_1, but set a higher bid, b_2, after observing the inferior action, a_2. As before, π_i^j is the profit to the manager from choosing action a_i, for $i = 1, 2$ and trading strategy $j = s, h, b$ where s = sell, h = hold, and b = buy. $T^j(a_i)$ represents the set of types that take action a_i and follow trading strategy j while t_i is the type indifferent between the two action–strategy combinations that define it.

complexity of using the asks to determine what the market infers from the action choice.

Theorem 4: *In every sequential equilibrium, if a_1 and a_2 are actions taken in equilibrium and $T^h(a_1)$ is nonempty, then $\alpha_1 > \alpha_2$.*

As with Theorem 3, this theorem is most easily understood by comparing Figures 1 and 4. In Figure 1, the intersection of π_i^h and π_i^b occurs at the height of $n_m \alpha_i$ reflecting the fact that the type indifferent between holding and buying after a_i believes that $\alpha(a_i)$ equals the terminal value of a share. So long as there are types that choose a_1 and hold ($T^h(a_1)$ is nonempty), then the manager's expected profit from this strategy, π_1^h, is in the upper envelope and $\alpha_1 > \alpha_2$. If $T^h(a_1)$ is empty, then, as shown in Figure 4, it is possible that this inequality can be reversed, i.e., $\alpha_1 < \alpha_2$.[12]

[12] The interested reader can obtain a numerical example of an equilibrium from the authors.

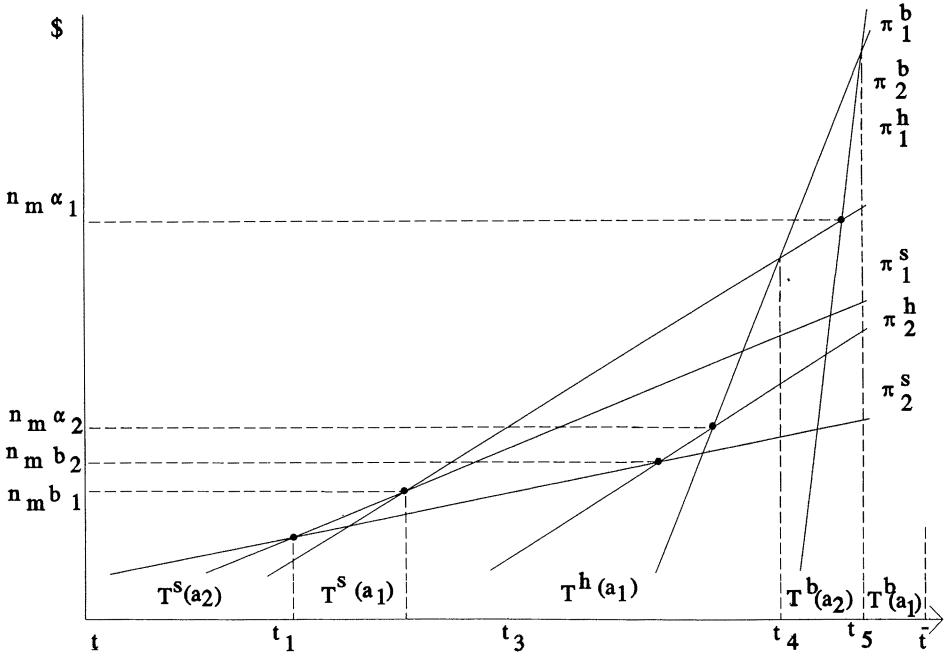

Figure 3. Equilibrium when no manager type holds after a_2. The manager is not allowed to sell all of his initial position and (like Figure 1), α_1, the ask following the better action, exceeds α_2 but (unlike Figure 1), b_2, the bid following the inferior action, exceeds b_1. As before, π_i^j is the profit to the manager from choosing action a_i, for $i = 1, 2$ and trading strategy $j = s, h, b$ where s = sell, h = hold, and b = buy. $T^j(a_i)$ represents the set of types that take action a_i and follow trading strategy j while t_i is the type indifferent between the two action–strategy combinations that define it.

II. Implications

The usual way a signaling model "explains" an empirical regularity is for it to imply that the stock price falls (rises) in response to the action that leads to an observed negative (positive) average announcement effect in the data. We will refer to such a signaling explanation as *action-specific* signaling because the model produces a signal (an action that is good news and an action that is bad news) which is independent of the observable characteristics of the firm although it is well known that the magnitude of this effect depends on observable characteristics of the firm. With action-specific signaling, the signaling model, in explaining average announcement effects also predicts that all firms will experience the same directional change in their stock price. Our point is that *both* the magnitude and the *sign* depend on observable characteristics which include the manager's ability to trade in the firm's stock.

As we mentioned in the introduction, most studies of announcement effects find that a significant portion of the sample experiences the opposite (relative

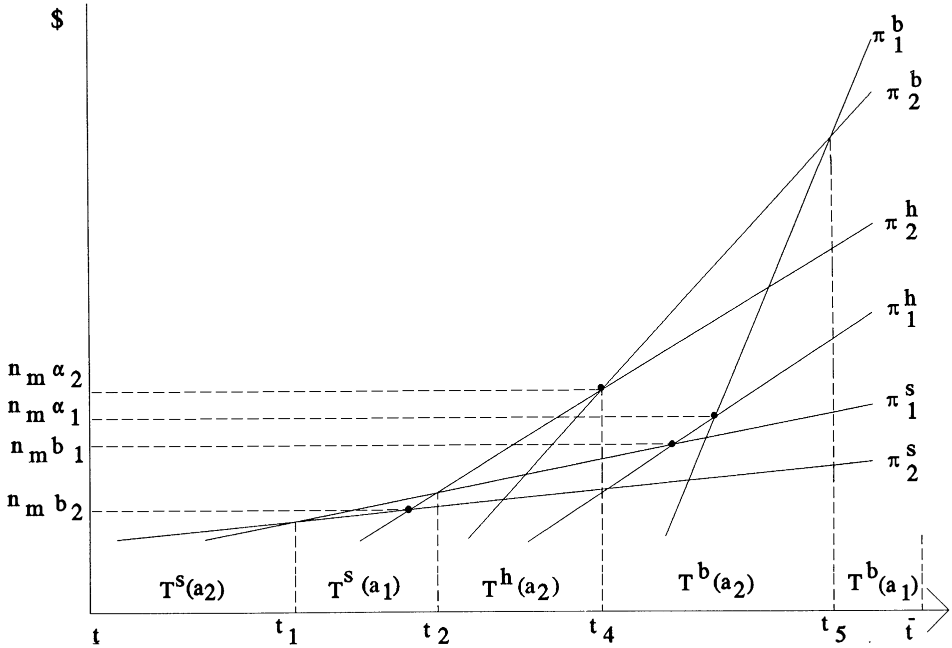

Figure 4. Equilibrium when no manager type holds after a_2. The manager is not allowed to sell all of his initial position and (like Figure 1), b_1, the bid after the better action, exceeds b_2, but (unlike Figure 1), α_2, the ask following the inferior action, exceeds α_1. As before, π_i^j is the profit to the manager from choosing action a_i, for $i = 1, 2$ and trading strategy $j = s, h, b$ where s = sell, h = hold, and b = buy. $T^j(a_i)$ represents the set of types that take action a_i and follow trading strategy j while t_i is the type indifferent between the two action–strategy combinations that define it.

to the average) announcement effect on their stock price. Thus, a standard signaling model must be adapted to explain this phenomenon. Our model is one such adaptation as it provides an explanation for firm-specific signaling. One important difference between the other explanations for firm-specific signaling and ours is that we provide a single mechanism for producing firm-specific signaling in any context in which the manager is free to trade in the firm's stock.

More important are our results on the equilibrium bids and asks. Since the manager cannot short the firm's stock legally and is not, in general, prohibited from selling all of the shares that he owns, the result of Theorem 2 applies. There, we showed that the equilibrium bids are independent of the actions taken by the manager at least so long as his compensation is not tightly tied to the value of the firm.[13] However, if there is reason to suspect that a reasonable fraction of the firms in a sample constrain the manager to

[13] Jensen and Murphy (1990) have documented that the latter situation is quite common, and so should provide a powerful test of our theory.

maintaining a position in the firm, then Theorem 3 can be used to test our model. In this situation, when there is evidence that some managers choose to neither buy nor sell after the "worse" action, then when the manager's minimum position in the firm must be positive, $\underline{n} > 0$, the equilibrium bid after that action is smaller than after a "better" action. In those countries that do not prohibit the manager from shorting the firm's stock, analogous tests can be constructed for the case when $\underline{n} < 0$. Similar tests based on the equilibrium asks can be constructed in the obvious way.

Another prediction is that no single action results in both the highest bid and the highest ask for all firms. That is, in our model, there are situations in which both actions, a_1 and a_2, are chosen in equilibrium and the result is that $b(a_1) < b(a_2)$ while $\alpha(a_1) > \alpha(a_2)$. There are other situations that will cause $b(a_1) > b(a_2)$ and $\alpha(a_1) < \alpha(a_2)$. The importance of this observation is that the model predicts differential impacts on the equilibrium bid-ask spread as a function of the observable characteristics of the firm.

Obviously, the next task should be to identify the conditions which determine the ordering of the bids by determining when there are manager types that neither buy nor sell additional shares after taking an action. Then, applying Theorems 3 and 4 provides an ordering for the equilibrium bids and asks. Unfortunately, in order to show that insider trading impacts virtually all signaling models, we have worked in an extremely general setting. To show that the relevant set is nonempty is to provide conditions under which the payoff from taking an action and neither buying nor selling shares is optimal for some set of types. Referring to our figures, this is equivalent to asking what conditions ensure that π_i^h is in the upper envelope of the payoffs. Clearly, one can write conditions on the manager's information, the number of shares he owns, n_m, the number he can sell, $n_m - \underline{n}$, and the number he can buy, $\overline{n} - n_m$, so that a set of types chooses to neither buy nor sell shares after certain actions. Unfortunately, such an exercise is not informative. Had we explored a specific application of a signaling model (as we do in Bagnoli and Khanna (1991)) such an analysis is not only feasible but central to deriving predictions from the model. In spite of this, a few important comments can be made.

The first is that the outcomes with insider trading are not efficient even if there are no dissipative signaling costs. To see this consider Figure 1. In that figure, there is a critical type which is indifferent between doing a_2 and holding and doing a_1 and holding. Given the payoff functions, the stockholders wish to have the manager choose a_1 if his type exceeds this critical type and wish to have him do a_2 otherwise. This figure shows that there are types above the critical value that choose a_2 and types below the critical value that choose a_1. In other words, for $t \in T^b(a_2)$, the manager has chosen an action that leads to a smaller expected terminal value in order to profit on buying additional shares. Similarly, for $t \in T^s(a_1)$, the manager has chosen an action that leads to a lower expected terminal value so that he can profit on the sale of his shares. Both create losses for the stockholders because the manager takes inferior actions in order to profit by trading in the firm's stock. Since this is undesirable, the firm's stockholders should respond by trying to mitigate these problems.

III. Contracting Issues

In this section, we examine some of the options stockholders might employ to reduce their losses from the manager choosing inefficient actions so as to make trading profits.

A. Altering Trading Constraints

We begin by examining the consequences of altering the constraints on the manager's ability to trade and his initial position. If $\bar{n}$ and $\underline{n}$ remain fixed but the manager's initial position in the firm, n_m, rises, the manager's trading profits are affected, First, because the manager owns more shares, his profits when he chooses not to trade, π^h, rise. His profits if he chooses to sell, π^s, for a fixed bid rise too because the manager has more shares that he can sell. His trading profits from buying additional shares decline for a fixed ask because he is unable to buy as many shares as he previously could. Thus, for any action, the π^h and π^s curves shift up and the π^b curves shift down. In addition, the π^h curves get steeper.

To determine the effects on the manager's actions, we must also determine how these changes depend on the action choice. In the following discussion, we assume that in equilibrium, each action/trading strategy combination is optimal for some set of manager types (all of the $T^i(a_j)$ sets are nonempty), $T^s(a_2) < T^s(a_1) < T^h(a_2) < T^h(a_1) < T^b(a_2) < T^b(a_2), \underline{n} > 0$ and that the boundary types are $t_1, t_2, \ldots, t_5$ respectively (see Figure 1).[14] With the appropriate derivatives, it is straightforward to show that t_1 falls when n_m rises. Since $b(a_1) > b(a_2)$ implies that the manager can sell the additional shares for a higher price if he chooses a_1, some types will switch from a_2 to a_1, lowering t_1. The type that is willing to hold after either action, t_3, remains unchanged and t_5, the type that is willing to buy after either action, falls. The reason is that t_3 is the type for whom both actions are equally good and t_5 falls because $\alpha_1 > \alpha_2$. The remaining derivatives cannot be signed because they depend on the relative magnitudes of the number of shares and how the manager's expectation of the terminal value varies with his type. Thus, all we can conclude about an increase in n_m is that $T^b(a_1)$ grows and that $T^s(a_2)$ shrinks. The former causes some types to switch to the efficient action but the latter causes some types to switch to the inefficient action.

Now, suppose that $\underline{n}$ rises. Such an increase only affects the payoffs from selling shares and causes them to fall for fixed bids since fewer shares can

[14] Recall that $T^s(a_i)$ is a set of types that find it optimal to sell after action a_i, and the h or b superscripts refer to holding or buying respectively. The t_i are the types that belong to two adjacent $T^j(a_i)$'s which means that such types are indifferent between the action, trading strategies represented by the two sets, e.g., t_1 is willing to do either action and sell which means that t_1 is in both $T^s(a_2)$ and $T^s(a_1)$.

now be sold. Taking the appropriate derivatives, we see that t_3, t_4, and t_5 are unchanged and that t_1 rises. The reason for this is that when $\underline{n}$ rises, the benefits to the low types from choosing the inefficient action (a_1) are reduced making more of these types willing to choose the efficient action (a_2). How the type that is indifferent between a_1 and selling, and a_2 and holding, t_2, changes depends on the magnitudes of $\underline{n}$, n_m and how the manager's expectation of the terminal value of the firm varies with his type. If t_2 falls, then $T^s(a_1)$, the set of types that choose a_1 when a_2 is efficient, shrinks enhancing the stockholders' welfare. If t_2 rises, then we cannot say whether the probability of an inefficient choice rises but we can say that the manager's choice leads to a smaller loss than before—the gap between $\mathrm{E}[v(a_1)|t]$ and $\mathrm{E}[v(a_2)|t]$ is smaller. Thus, one expects that in most cases, the stockholders benefit from having the manager retain a relatively large stake in the firm when he wants to sell his position. Below, we will suggest that this may well be a partial explanation for the types of contracts that we observe between the manager and the firm.

If the manager's maximum final position $\overline{n}$ rises, it only affects the payoff from buying additional shares and so t_1, t_2, and t_3 remain unchanged. The type that is willing to buy after either action, t_5, rises because the manager is able to buy more shares, increasing the relative benefits of choosing the inefficient action and trading against it. Unfortunately, analogous to the above, the effect on t_4, the type that is indifferent between a_1 and holding and a_2 and buying, is ambiguous. If it falls, then the set of types that choose the inefficient action and buy additional shares grows, making stockholders worse off. If t_4 rises, we cannot say whether this set of types grows, but we can conclude that the losses will be larger. Again, the intuition is that it pays the stockholders to make the manager's payoff mirror their own. That is, if $n_m - \underline{n}$, the number of shares the manager can sell, is increased, the stockholders are worse off as the manager finds it more profitable to choose the inefficient action and then sell. Similarly, if $\overline{n} - n_m$, the maximum number of shares that the manager can buy, is increased, the stockholders are worse off because the manager finds it more profitable to choose the inefficient action and then buy additional shares. Since controlling $\overline{n}$ and $\underline{n}$ may be difficult, and since the stockholders, for a wide variety of reasons want the manager to have a relatively large stake in the firm (a large n_m), some form of nontradeable assets whose value is correlated with the firm's stock price appears to be a good compromise.

B. Altering Managerial Compensation

An alternative approach to mitigating the problems associated with voluntary trade by the manager is for the stockholders to provide incentives through the manager's compensation contract. We will focus on a number of standard forms of compensation: warrants, options, bonuses, and reputational effects. All have the common feature that, regardless of the manager's trade, his payoff continues to depend on the action that he has chosen. It turns out to be relatively simple to analyze the effects of these compensation schemes in a common framework.

Assume that the manager's payoff is his trading profits plus $S(a, t)$ where S is his non-trading payoff which depends on both the manager's action and his type. Although the manager's type is private information, he values compensation such as options, warrants or future payments in stock, differently depending on his type. Hence, the manager's payoff can *implicitly* depend on his type.

There are two important cases: when S depends on t and when it does not. Examples of compensation schemes with S constant in the manager's type might be bonuses paid for making certain decisions—acquisitions, growth, divestitures, downsizing, etc., reputational effects that depend on the action not the realized payoff from the action or action-contingent salary. In these cases, the payment shifts all of the trading profit functions for a given action up or down by the same amount. For concreteness, consider the case in which $S(a_2, t) = 0$ and $S(a_1, t) = S$. Referring to Figure 1, all of the π_1 lines shift up by a constant amount, S. The result is that more manager types are induced to choose a_1 than before.

This has the following effects described for the case in which all $T^i(a_j)$ sets are nonempty and $T^s(a_2) < T^s(a_1) < T^h(a_2) < T^h(a_1) < T^b(a_2) < T^b(a_1)$. Some relatively high types switch from buying after a_2 to buying after a_1 while others switch to holding after a_1. Thus, the contract reduces the set of relatively high types that choose the inefficient action and buy additional shares. On the negative side, though, some of the types who hold after a_2 switch to the inefficient action, a_1, and hold while others switch to the inefficient action and sell. Also, some types who sell after a_2 switch to selling after taking the inefficient action, a_1. In all of these cases, the stockholders are inducing the manager to switch to an inefficient action. Hence, the impact on the stockholders from payments that depend only on the manager's action choice are ambiguous.

The other type of compensation scheme has S depending on both the manager's action and his type. Recall that compensation can depend on his type not because it is either observable or verifiable but because the stockholders can pay the manager in terms of shares of stock. If part of his compensation is in the form of phantom shares or nontradeable warrants or options or stock bonuses to be paid in the future, then $S(a, t) = h\mathrm{E}[v(a)|t]$ for some h. Essentially, this adds h shares to the final position of the manager. As when we considered changes in $\bar{n}$, n_m, and $\underline{n}$, t_3 remains unchanged and the impacts on t_2 and t_4 are ambiguous. The increase in h causes t_1 to rise because the manager is left with a larger stake in the firm as was the case when $\underline{n}$ rose. However, t_5 falls unlike when $\bar{n}$ rose. The reason is that now, the manager cannot take advantage of the increase in h to enhance his trading profits. When $\bar{n}$ rises, the manager is able to buy more shares but when h rises, the manager cannot buy additional shares but is left with a larger stake. Hence, this gives him the incentive to choose the optimal action more often for larger h.

Our analysis provides insight into the types of compensation a manager should receive. He should be made to maintain a relatively large stake in the firm even when interested in reducing that stake. This can be accomplished either by keeping the minimum number of shares he must own high or, more realistically, by offering compensation that is dependent upon the future value of the firm—nontradeable warrants and options, or bonuses tied to the subsequent value of the firm. In all of these cases, the manager's incentives are more closely aligned with the stockholders'. We showed that increasing the maximum position that the manager can acquire induces more types to choose the inefficient action and buy. Hence, stockholders wish to restrict his ability to voluntarily increase his position in the firm. In the literature, many reasons for having the manager have a large stake in the firm have been identified. Our analysis suggests that this stake should be given via phantom shares or nontradeable warrants or options rather than inducing the manager to purchase the position in the market. The latter creates poorer incentives than the former.

C. The Costs and Benefits of Permitting Insider Trading

Having determined how changes in the constraints on the manager's trades and his compensation contract affect our analysis, the remaining question is why stockholders permit voluntary trade by the manager. This question is similar to but differs from asking why the manager can or should trade in advance of the market learning the action he takes. There is a long literature on this question[15] but it is only tangentially related because, in our model, the stockholders' losses arise when the manager's trade is manipulative—when he trades against the observed action he took.

A formal analysis is quite complicated in our setting and would take us far afield because we would have to include other managerial tasks besides the action choice we study and the tensions between different stakeholders. However, because all we really need to do is explain why an optimal contract with the manager does not completely eliminate trade by the manager, we can forego the formal analysis.

We begin by noting that eliminating voluntary trade by the manager is not simple. There are at least two ways such trade might be eliminated: simply bar the manager from trading by using sufficient threats or adjust his compensation so that the amount the firm pays for his efforts is reduced by his trading profits. The former is, as far as we can ascertain, an unenforceable contract. What we mean is that the courts have permitted the firms to limit the trading by their managers but have been unwilling to allow them to bar such activities. The second is just as unlikely to work because it requires that the stockholders be able to determine what the manager's trading profits were. Since the manager has private information, only he

[15] See, for example, Carlton and Fischel (1983), Fishman and Hagerty (1989), Bradley, Khanna, and Slezak (1992), Leland (1990), Fishman and Hagerty (1991). For an optimal contracting perspective, see Fischer (1991).

knows what the value of his profits are. This lack of information coupled with limited liability combine to keep the stockholders from recovering all of the manager's trading profits. Further, their ability to recover is complicated by the fact that the manager may well have traded for non-informational reasons. That is, there is a positive probability the manager is selling his position for reasons unrelated to his information. Since it is equally possible that there are unmodelled reasons for the manager purchasing additional shares, this provides another reason why the stockholders will not be able to recover the manager's trading profits.

Thus, we believe that eliminating voluntary trade is unlikely to work. Also, there are reasons why the stockholders would not choose to eliminate such trade even if it were possible to do so. We will provide two arguments for why the stockholders would permit the manager to trade in the firm's stock. The first relies on an externality argument while the second relies on the relative costs and benefits of keeping the manager from trading.

The particular form of the externality argument uses, as its key idea, an argument first discussed in Bradley, Khanna, and Slezak (1992).[16] The idea is the following. In any market with informed and uninformed traders and competitive market makers, the informed profit from their information by exploiting the uninformed. In our model, the uninformed traders are the firm's stockholders and the informed trader is the manager of the firm. Since the stockholders can choose the manager's compensation, they ought to try to avoid or at least mitigate such losses. However, the existence of other less well informed traders alters their incentives. The key idea (and the one that drives much of the Bradley, Khanna, and Slezak analysis of trade by an informed but non-manipulative manager) is that eliminating trade by the manager need not eliminate the stockholders' trading losses. If there are other traders with information that is correlated with, but less valuable than, the manager's, eliminating trade by the manager provides them with a profitable trading opportunity at the uninformed stockholders' expense. The difference between these and the losses incurred when the manager trades is that the stockholders have no means of recovering some or all of their losses through the manager's compensation. Hence, the stockholders face a tradeoff: their direct trading losses may be smaller if the manager does not trade but their net losses (computed after adjusting the manager's compensation for whatever portion of his trading profits they can recapture) if he trades may be either larger or smaller than their losses if the manager does not trade. In general, the stockholders reduce, but do not eliminate, the set of manager types that choose to trade.

The second reason that the stockholders do not eliminate trade by the manager is that there are costs to doing so. Thus, the stockholders reduce the amount of voluntary trading by the manager until the marginal benefits

[16] We thank Mike Fishman for his time and effort in helping us with these ideas. However, he is not responsible for the use to which they are put.

of the reduction equal the marginal costs. There are two sources of benefits from reducing the set of manager types that trade: some choose the efficient action when they otherwise would not and the probability that the manager trades is reduced. The latter reduces the adverse selection problem thereby reducing the per share losses incurred by an uninformed stockholder trading in the firm's stock. This means that as fewer and fewer types trade, the benefits of reducing the set that trades shrink. At the same time, reducing the set of manager types that trade makes it more profitable for those types that do trade because of the mitigation of the adverse selection problem. Since one expects that the cost of keeping a manager type from trading is increasing in the profitability of such trading, as the stockholders reduce the set of manager types that trade, the cost of further reductions grows. Hence, we would expect an interior equilibrium in which the set of manager types that trades is reduced by the stockholders but trade by the manager is not eliminated.[17]

IV. Conclusions

We study a signaling model in which the manager can voluntarily trade in the firm's stock. This leads to dramatically different results. First, we show that the manager has a positive incentive to trade. In every sequential equilibrium, the probability that the manager is selling shares and the probability that he is buying shares is positive. Hence those models that prohibit the manager from trading impose a binding restriction on his actions. Further, we show that there are no separating equilibria even if there is one when the manager cannot voluntarily trade. That is, his ability to trade eliminates the possibility of exactly inferring his information from his observable behavior.

Second, we show that if the manager can eliminate the dependence of his compensation on his action choice through trading, the equilibrium bid cannot be used to infer the manager's private information. If his compensation is independent of his action choice and the firm's stock price and $\underline{n} = 0$, then the bids are independent of his action choice. If this compensation depends on his action choice, then the difference in the equilibrium bids is determined solely by the differences in his compensation, not his private information. If his compensation depends on the future stock price, then this situation arises only if the manager can be short. In all other cases, the equilibrium bids reflect the manager's information, but extracting the infor-

[17] Notice that our discussion of why the relative costs and benefits of eliminating voluntary trade by the manager implies that unlike in the Dybvig and Zender (1991) model, the optimal contract does not eliminate signaling. In essence, either motivation for permitting some voluntary trade implies that one of Dybvig and Zender's assumptions does not hold in our framework. Intuitively, the incremental cost of bribing the manager to avoid the expected deadweight social costs of signaling rises as the probability that the manager engages in such behavior falls while the expected benefits shrink thus, the optimal contract does not eliminate the signaling.

mation is difficult and requires detailed information about the manager's compensation, his ability to trade, and observable characteristics of the firm. Third, we show that while the equilibrium asks depend on the manager's actions, which action leads to the higher equilibrium ask depends on firm-specific characteristics too. Fourth, we show that the opportunity to make trading profits causes the manager to select, relative to his private information, inefficient actions. That is, sometimes he takes the inefficient action and buys or sells shares. We also show that contingent future payments are better at mitigating these problems than simply giving the manager a larger initial position in the firm.

A number of questions remain concerning how sensitive our results are to some of our assumptions. For example, letting the market open more than once after the manager's action has been taken should present no remarkable changes. In fact, it is quite easy to extend the proof of Theorem 2 to show that if $\underline{n} = 0$, in every period in which the market is open, the equilibrium bid cannot depend on the manager's action. One can also show that the bids cannot differ through time unless the model is extended to permit some sort of additional information flows or a pattern to the volume of noise trading. Analogous extensions of Theorems 3 and 4 are possible. We do not believe that making the manager risk averse will have a large impact on our results. Ignoring portfolio effects, the risk-averse manager would still sell all of his original position if he can but might not go as short or as long as the risk-neutral manager would. Our model of market makers could be replaced by a model in which the market makers are able to alter the bids and asks based on the order flow such as in Kyle's model. Since models of this type still yield a (somewhat diminished) lemon's effect, we do not expect that such a change would significantly alter our conclusions.

Finally, permitting the manager to trade before his action is observed is an important extension which may require melding our analysis with Fischer (1992). Such an extension would require facing the problem that such transactions are probably a violation of existing insider trading laws. Though we believe that this is the case, we also believe that such trading takes place. Admitting this possibility ought to have only minor impacts on our conclusions. A possible exception may occur when the manager either buys all of the shares he wants or sells his holding prior to taking the action. If this happens, then the equilibrium would be similar to those computed when the manager is prohibited from trading. However, it appears that this situation cannot arise in equilibrium. The reason is that if the market makers know that there is no lemon's effect, the prices at which trades take place must equal the expected terminal value while the prices set before the action is taken must compensate for the adverse selection problem. But this means that, for example, the bid prior to the action must be smaller than at least one of the bids following the manager's choice. For such an action, the manager would increase his payoff by delaying his sale until after taking the action. Analogous reasoning implies that not all of the purchases can occur prior to taking the action either.

Appendix

Theorem 1: *There is insider trading in every sequential equilibrium.*

Proof: The proof is by contradiction. We begin by supposing that after some action chosen in equilibrium, a_i, no manager types sell their holdings. Since it is an action chosen in equilibrium, $T_i^h \cup T_i^b$ is a set of positive measure, where $T_i^j \equiv T^j(a_i)$. Since the market makers earn zero expected profits on their purchases,

$$b_i = \mathrm{E}[v(a_i)|a_i] = \mathrm{P}\{t \in T_i^h\}\mathrm{E}\left[v(a_i)|t \in T_i^h\right] + \mathrm{P}\{t \in T_i^b\}\mathrm{E}\left[v(a_i)|t \in T_i^b\right].$$

Next, note that T_i^h must be nonempty. To see why, suppose not. Then, from the definition of b_i, we see that there is a measurable set, say Z_1, such that for all $t \in Z_1, b_i > \mathrm{E}[v(a_i)|t]$. Since we have shown that $\alpha_i \geq b_i$, if no manager type chooses to sell shares after a_i, then it is optimal for some managers types to hold their position after taking that action. Using the definition of b_i again, there is a measurable set of types, say Z, such that $\mathrm{E}[v(a_i)|t] < b_i$. Hence, we have assumed that no types sell after an action taken in equilibrium and shown that there is a measurable set of types for whom it is optimal to sell. Thus, after every action taken in equilibrium, a measurable set of manager types sell. Mimicking this argument shows that there is also a measurable set of types that buy additional shares after either action.

Finally, we must show that there are no separating equilibria. Such a result is obvious when the number of actions is finite and the type space is an interval. However, it is not necessary to have fewer actions than types in this model. To see this, assume that $|A| \geq |T|$ and $\underline{n} \leq 0$. Assume by way of contradiction, that there is a separating equilibrium. If so, then every manager type is choosing a different action and the market makers can correctly infer the manager's information from the action taken and set their equilibrium bids and asks equal to his expectation of the terminal value of the firm given his action choice. Hence, the manager's payoff is simply

$$\pi^h(a_i;t) = n_m\mathrm{E}[v(a_i)|a_i] \equiv n_m\mathrm{E}[v(a_i)|t].$$

Since the manager types receive different payoffs from each action, there are actions that lead to lower equilibrium payoffs and actions that lead to higher payoffs. To derive the contradiction, select two manager types, one of whom, t_a, receives a relatively high equilibrium payoff and one of whom, t_b, receives a relatively low equilibrium payoff. Consider the following deviation from the proposed equilibrium: let t_b choose the action t_a is supposed to choose and sell his shares in the market. Doing so yields t_b, a payoff which is at least equal to t_a's because t_b sells his shares for what t_a's shares are worth.[18]

[18] If t_b can short the stock, he will actually earn more by mimicking t_a than t_a's equilibrium payoff.

But this is a contradiction because we chose these two types so that t_b's equilibrium payoff was less than t_a's.

This argument relies on $\underline{n} \leq 0$. Now, suppose that $\underline{n} > 0$. In this case, the manager cannot avoid the costs of mimicking other types completely because he retains a position in the firm. Assume that insider trading is possible ($\bar{n} > n_m > \underline{n}$) and that A and T are both intervals of the real line.[19] If one writes the no-mimicry conditions when insider trading is permitted, one can show that the manager's payoff in the absence of insider trading cannot satisfy these conditions and be continuous in his type. Since we have assumed that the payoff is continuous in his type, we have a contradiction. Hence, only if there are a finite number of types, more actions than types and $\underline{n} > 0$, can one make the types sufficiently different so that there is a separating equilibrium.

Thus, we have shown that with one unimportant exception, there are no separating equilibria. ■

Theorem 2: *If $\underline{n} = 0$, then in every sequential equilibrium, the equilibrium bid is independent of the action.*

Proof: Consider two distinct actions taken in equilibrium, a_1 and a_2. To prove the theorem we assume that $b_1 \neq b_2$, where these are the equilibrium bids following each action and derive a contradiction. Since $\underline{n} = 0$, the manager's payoff from selling his shares is independent of his type. Hence, in equilibrium, all of the manager types that choose to sell, choose the same action—the one that leads to the higher bid.

Suppose that $b_1 > b_2$. In this case, the manager never does a_2 and sell because he gets b_2 per share following that strategy but would receive $b_1 > b_2$ by switching to a_1 and selling. Since there are no manager types that sell shares after having done a_2, there is no lemon's effect in b_2, i.e., $b_2 = \mathrm{E}[v(a_2)|a_2]$. The set of types choosing a_2 either buy additional shares or hold their original position. The latter are the types such that $\mathrm{E}[v(a_2)|t] < \alpha(a_2)$ while the former are the types such that $\mathrm{E}[v(a_2)|t] > \alpha(a_2)$.

Hence, $\mathrm{E}[v(a_2)|t]$ is larger for the types that choose to buy additional shares than for the types that choose to hold their original position. Since for the latter types, $\mathrm{E}[v(a_2)|t] > b_1$, we see that for both sets of types, $\mathrm{E}[v(a_2)|t] > b_1$. But now we have a contradiction. We have assumed that $b_1 > b_2$ and have shown that $b_2 = \mathrm{E}[v(a_2)|a_2] > b_1$. That is, we have assumed that $b_1 > b_2$ and shown that it implies that $b_2 > b_1$. By relabelling, this proof also shows that $b_2 > b_1$ leads to a contradiction. Hence, we have that $b_1 = b_2$. ■

Theorem 3: *In every sequential equilibrium, if a_1 and a_2 are actions taken in equilibrium and $T^h(a_2)$ is nonempty, then* (1) *if $\underline{n} > 0$, then $b(a_1) > b(a_2)$ and* (2) *if $\underline{n} < 0$ then $b(a_1) < b(a_2)$.*

[19] This argument will also apply to the case in which A and T can be represented by the integers.

Proof: To prove (1), assume that $\underline{n} > 0$. Since $\bar{n} > n_m > \underline{n} > 0$ and (by our convention) $\mathrm{E}[v(a_1)|\bar{t}] > \mathrm{E}[v(a_2)|\bar{t}]$, then

$$\frac{\partial \pi_2^s}{\partial t} < \frac{\partial \pi_1^s}{\partial t}; \quad \frac{\partial \pi_2^h}{\partial t} < \frac{\partial \pi_1^h}{\partial t}; \quad \frac{\partial \pi_2^b}{\partial t} < \frac{\partial \pi_1^b}{\partial t}$$

and for $i = 1, 2$,

$$\frac{\partial \pi_i^s}{\partial t} < \frac{\partial \pi_i^h}{\partial t} < \frac{\partial \pi_i^b}{\partial t}.$$

Further, we know that if t_i satisfies $(n_m - \underline{n})b(a_i) - \underline{n}\mathrm{E}[v(a_i)|t_i] = n_m\mathrm{E}[v(a_i)|t_i]$ then $b(a_i) = \mathrm{E}[v(a_i)|t_i]$.

By Theorem 1, $T^s(a_1)$ and $T^s(a_2)$ are nonempty. By hypothesis, $T^h(a_2)$ is nonempty, then $b_1 > b_2$ will follow from showing that $n_m b_1 > \pi^* > n_m b_2$ where π^* is the profits earned by the type that is indifferent between a_1 and selling and a_2 and holding. Call this type t_a.[20] Since this type prefers either strategy to a_1 and holding, we have $(n_m - \underline{n})b_1 + \underline{n}\mathrm{E}[v_1|t_a] > n_m\mathrm{E}[v_1|t_a]$. Further, because the former rises slower than the latter, they intersect at a larger type (t_1 in the notation of the previous paragraph). Since all of the payoffs are increasing in type, $n_m b_1 > \pi^*$. Next, note that t_a also prefers a_2 and holding to a_2 and selling—$n_m\mathrm{E}[v_2|t_a] > (n_m - \underline{n})b_2 + \underline{n}\mathrm{E}[v_2|t_a]$. Since the former is steeper than the latter, they are equal for a smaller type (t_2). Again, since all of the payoffs are increasing in type, $\pi^* > n_m b_2$.

To prove (2), assume that $\underline{n} < 0$. Now, the inequalities on the slopes of the payoff functions change. The reason is that $\underline{n} < 0$, implies that the payoffs to selling after either action are now declining in the manager's type. Hence, the relative slopes are now

$$\frac{\partial \pi_1^s}{\partial t} < \frac{\partial \pi_2^s}{\partial t}; \quad \frac{\partial \pi_2^h}{\partial t} < \frac{\partial \pi_1^h}{\partial t}; \quad \frac{\partial \pi_2^b}{\partial t} < \frac{\partial \pi_1^b}{\partial t}.$$

As before, if t_i satisfies $(n_m - \underline{n})b(a_i) - \underline{n}\mathrm{E}[v(a_i)|t_i] = n_m\mathrm{E}[v(a_i)|t_i]$ then $b(a_i) = \mathrm{E}[v(a_i)|t_i]$. Again, by Theorem 1, both $T^s(a_1)$ and $T^s(a_2)$ are nonempty. Further, the relative slopes and the assumption that $T^h(a_2)$ is nonempty imply that there is a type, t_2, who finds it optimal to do a_2 and hold and who is indifferent between the strategy and doing a_2 and selling. The proof that $b_2 > b_1$ is done in three steps. First, it is shown that the type for whom a_2 and sell yields the same payoff as a_1 and hold, t_a, is such that $t_a > t_2$. Next, the type for whom the payoff from a_1 and hold is the same as the payoff from a_2 and sell, t_b, is such that $t_b < t_a$. Finally the relative slopes are used to show that $b_2 > b_1$.

So, to see that $t_2 < t_a$, simply notice that at t_2, the payoff from doing a_2 and selling is larger than the payoff from a_1 and holding. Since the latter is an increasing function of type and the former is a decreasing function of type,

[20] As the referee has pointed out, it is possible that this type does not exist when $\bar{n} > 0$. This can only arise if π_1^s is steeper than π_2^b. In this case, since T_1^s is nonempty, $b_1 > b_2$.

$t_2 < t_a$. Next, notice that t_2 is larger than the type that chooses to do a_1 and sell and who is indifferent between that strategy and doing a_2 and selling. Hence, $\mathrm{E}[v_1|t_a] < \mathrm{E}[v_2|t_a]$. Further, single-crossing and the fact that

$$\frac{\partial \pi_1^s}{\partial t} < \frac{\partial \pi_2^s}{\partial t}$$

implies that at t_a, $\pi_1^s < \pi_2^s$. Hence, when π_1^h and π_1^s intersect, they are equal to $n_m b_1$ and are smaller than $n_m \mathrm{E}[v_1|t_a]$. Combining we have shown that $b_2 > b_1$. ■

Theorem 4: *In every sequential equilibrium, if a_1 and a_2 are actions taken in equilibrium and $T^h(a_1)$ is nonempty, then $\alpha_1 > \alpha_2$.*

Proof: The proof is in two parts depending on whether or not

$$\frac{\partial \pi_2^b}{\partial t} \geq \frac{\partial \pi_1^h}{\partial t}$$

or not. Note that either case is possible because the former is $\bar{n}(\partial \mathrm{E}[v_2|\mathrm{t}]/\partial \mathrm{t})$ and the latter is $n_m(\partial \mathrm{E}[v_1|\mathrm{t}]/\partial \mathrm{t})$. The first derivative of the expectation is smaller than the second but $\bar{n} > n_m$.

So, first suppose that

$$\frac{\partial \pi_2^b}{\partial t} \geq \frac{\partial \pi_1^h}{\partial t}.$$

Since by Theorem 1, $T^b(a_2)$ is nonempty and by assumption $T^h(a_1)$ is nonempty, the inequality must be strict. The proof that $\alpha_2 < \alpha_1$ proceeds by showing that $n_m \alpha_2 < \pi^* < n_m \alpha_2$, where π^* is the payoff to the type, t_a, that does a_1 and hold and who is indifferent between that and α_2 and buy.[21] For this type, $n_m \mathrm{E}[v_1|t_a] > \bar{n}\mathrm{E}[v_1|t_a] - (\bar{n} - n_m)\alpha_1$. Since the latter is steeper than the former, these two payoffs are equal for some $t > t_a$ and, as a result, $n_m \alpha_1 > \pi^*$. Similarly, for t_a, $\bar{n}\mathrm{E}[v_2|t_a] - (\bar{n} - n_m)\alpha_2 > n_m \mathrm{E}[v_2|t_a]$. Because the former is steeper than the latter, they intersect for some $t < t_a$ and, as a result, $n_m \alpha_2 < \pi^*$.

Finally, suppose that

$$\frac{\partial \pi_2^b}{\partial t} < \frac{\partial \pi_1^h}{\partial t}.$$

In this case, we will show that $n_m \alpha_2 < \pi^* < n_m \alpha_1$ where π^* represents the payoff to the type who is indifferent between doing a_2 and buy and a_1 and hold.[22] Since that implies that the type that is indifferent between holding and buying additional shares after a_1 is larger, we have that $\pi^* < n_m \alpha_1$.

[21] Since, π_2^b is steeper than π_1^h (by assumption) which, in turn, is steeper than π_1^s, the fact that T_1^h and T_2^b are not empty imply that t_a exists.

[22] Here, it is possible that t_a does not exist. For this to arise, π_1^s must be steeper than π_2^b. As in the proof of Theorem 2, this immediately implies the result—$\alpha_1 > \alpha_2$.

Similarly, it implies that the type that is indifferent between holding and buying additional shares after a_2 is smaller. As a result, $n_m \alpha_2 < \pi^* < n_m \alpha_1$. ■

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