Signaling with Dividends and Share Repurchases: A Choice between Deterministic and Stochastic Cash Disbursements

Donald B. Hausch
University of Wisconsin-Madison
James K. Seward
Dartmouth College

We study firms signaling with cash disbursements and show that the choice of a deterministic or a stochastic disbursement depends on a property of the firm's production function that is analogous to absolute risk aversion for a utility function. With decreasing (increasing) absolute risk aversion, the high-quality firm prefers to distinguish itself from the low-quality firm with a stochastic (deterministic) outlay. We then study in detail two common forms of corporate cash distributions: dividends, a deterministic disbursement and share repurchases, a stochastic disbursement.

Corporations possess a variety of different mechanisms to distribute cash to their shareholders. These mechanisms can be distinguished along a number of dimensions such as taxation (ordinary income versus capital gains), timing (regular quarterly disbursements versus irregular periodic disbursements), and

The authors thank David Brown, Bob Dammon. Rick Green (the editor), Bob Hansen, Kose John, Sreenivas Kamma. George Kanatas, Dennis Logue. David Matter, Steve Raymar, Larry Samuelson, Lemma Senbet, Anant Sundaram, Anjan Thakor, Charles Trzcinka, Subu Venkataraman, an anonymous referee, and seminar participants at Boston College, Cornell, Florida, Mary land, Wharton, and Wisconsin for comments on earlier versions of the article.
Address correspondence and reprint requests to Donald B. Hausch, Graduate School of Business, University of Wisconsin-Madison, Madison, WI 53706.

The Review of Financia1 Studies 1993 Volume 6, number 1, pp. 121-154

changes in fractional ownership (share repurchase versus dividends). In this article, we investigate the general properties of stochastic and deterministic corporate cash disbursement policies. A deterministic disbursement policy has the property that the firm will (with certainty) distribute a known, declared amount of cash to its current shareholders. Under a stochastic disbursement policy, the firm announces its choice of a particular set of decision variables that precommit the firm to a range of feasible cash distributions. However, the actual cash distribution is unknown at the time of this corporate announcement because it depends on the realization of a random variable. We show that the stochastic disbursement policy may be advantageous to certain types of firms when corporate cash distributions serve as a signaling mechanism to outside investors.

We show that the firm's choice of signaling with a deterministic or a stochastic cash disbursement depends upon a property of the firm's production function that is analogous to absolute risk aversion for a utility function. The risk aversion of the firm's production technology affects the relative marginal costs of the signal for the low and high type firm and, in particular, with decreasing (increasing) absolute risk aversion the firm prefers to signal with a stochastic (deterministic) outlay. We establish the intuition for this result by assuming that all firms face the same production possibilities but differ in the level of internally generated cash available for investment. Since decreasing (increasing) absolute risk aversion means that the more cash available to the firm, the lower (higher) the relative cost of choosing a stochastic disbursement, the high-quality firm can more efficiently distinguish itself from the low-quality firm using a stochastic (deterministic) disbursement.

We then apply our general results on deterministic and stochastic cash disbursements to the study of observed corporate cash distribution decisions. We propose cash dividend payments as an explicit example of a deterministic cash disbursement and share repurchases as an example of a stochastic cash disbursement. Generally, share repurchase programs rely on the bidding and tendering behavior of shareholders. Consequently, unlike dividends, a precommitment by a corporation to repurchase shares involves some degree of uncertainty about the ultimate magnitude of the cash disbursement. Since different share repurchase techniques (e.g., auction and fixed-price) involve different actions by firms and shareholders, these programs differ in their ability to generate ranges of feasible cash distributions.

Summary data on recent outcomes of auction-based tender-offer share repurchases is presented in Table 1. Of particular interest is the final repurchase price established as an outcome of the auction. In some cases, it is the minimum tender price set by the firm; in other

Table 1
Analysis of selected Dutch auction self-tenders

Dates: Announced Completed	Company	Price: 1 day before announcement ($)	Announced price range of auction ($)	Auction range premium over previous day (%)	Price: 1 day after announcement ($)	% Change from day before to day after: gross & relative to market	Completed auction price ($)	No. of shares repurchased (millions)	Market price upon completion ($)
09/17/87 01/12/88	Hospital Corp. of America (HCA)	45.38	47.00–51.00	4–12	45.25	−0.3 −0.3	47.00	12.0	28.00
09/05/87 10/07/87	Caesars World, Inc. (CAW)	28.75	29.50–34.00	3–18	29.50	2.6 3.6	29.50	11.0	28.00
06/08/87 07/08/87	Tektronix, Inc. (TEK)	33.88	35.00–40.00	3–18	37.63	11.1 9.8	39.75	6.0	39.00
11/26/86 12/26/86	Smithkline Bechman Corp. (SKB)	86.75	86.00–96.00	−1–11	91.88	5.9 5.4	96.00	12.6	94.00
03/28/88 04/26/88	RJR Nabisco, Inc. (RJR)	48.25	52.00–58.00	8–20	52.13	8.0 7.2	53.50	21.0	52.75
03/07/88 04/04/88	Quantum Chemical Corp. (CUE)	81.50	82.00–91.00	1–12	88.13	8.1 7.0	91.00	3.0	88.75
03/02/88 04/06/88	Geico Corp. (GEC)	104.00	115.00–125.00	11–20	121.00	16.3 16.1	125.00	0.65	124.00
12/17/87 01/21/88	Torchmark Corp. (TMK)	24.00	26.00–30.00	8–25	25.13	4.7 4.3	28.00	5.1	26.50
11/10/88 12/18/88	Standard Brands Paint Co. (SBP)	21.25	25.00—28.00	18–32	21.75	2.4 2.8	25.00	6.0	25.00

cases, it is the maximum tender price set by the firm; and in still others, it is somewhere in between the minimum and maximum tender price. These results suggest that there is considerable uncertainty (within the established range) over the actual repurchase price that firms must ultimately pay to shareholders when auctions are used to repurchase shares.

Although we focus exclusively on deterministic and stochastic outflows associated with corporate cash distribution to shareholders in this article, there are other classes of observed corporate investment and financial policies where the distinction also matters. For example, the acquisition price in some corporate control contests includes a contingent payout component. A specific case of this form of stochastic disbursement is the contingent-value right issued by Dow Chemical when the firm merged its Merrell Dow drug unit with Marion Laboratories. This security was issued by Dow Chemical to the Marion Lab's equity holders, and its payoff is a function of the future share price performance of the combined company, Marion Merrell Dow. If Marion Merrell Dow shares trade for less than $45.77 on September 30, 1991, then the contingent-value right will pay the holders a one-time bonus equal to the shortfall or $15.77, whichever is less. Thus, in order to complete the merger, Dow Chemical has committed to a future cash outflow that is stochastic.[1]

Another example of this property is the design of the payout properties of certain types of senior financial securities. Finnerty (1988) provides extensive documentation about the payoff characteristics of a variety of debt and preferred stock innovations. Securities such as auction rate notes and debentures, remarketed reset notes, real yield securities, auction rate preferred stock, and single point adjustable rate preferred stock can all be viewed as financial claims that commit the firm to some form of future stochastic payout. Thus, the choice between deterministic and stochastic cash outflows represents a useful distinction that extends to many other dimensions of corporate financial and investment decision-making. More recently, the failed Time Warner variable-price rights offer can be viewed as an attempt to raise equity capital through a stochastic mechanism.

The remainder of the article is organized as follows. In the next section, we provide a general treatment of deterministic and stochastic corporate cash disbursement policies. We then link our general results on deterministic and stochastic cash disbursements to

[1] Clearly, the nature of stochastic outflows is a broad issue that arises in any takeover transaction in which the purchase price is contingent due to the use of securities rather than cash. Our point here is that certain types of consideration utilized by some firms involved in corporate control contests precommit the acquiring firm to an uncertain future cash payment to the target firm shareholders.

observed corporate cash distribution methods and policies. In the case of the share repurchase decision, we also demonstrate how shareholder bidding and tendering strategies impact the corporate manager's signaling problem. A numerical example of corporate dividend and share repurchase policies is contained in Section 3. In the final section, we discuss some empirical implications of our model, make our concluding remarks, and provide direction for future research.

1. Corporate Cash Distributions as Deterministic and Stochastic Disbursements

1.1 The general model

In this section, we consider the corporate manager's general problem of selecting a cash distribution method. In our formulation, the choice between deterministic and stochastic cash distribution matters because of their distinct signaling properties. Elsewhere, multiple signals have been shown to be used simultaneously in equilibrium provided that they have different deterministic cost functions [see, e.g., Ambarish, John, and Williams (1987) and Milgrom and Roberts (1986)]. Here, we compare deterministic and stochastic cost functions and establish a sufficient condition for univariate signaling despite the availability of multiple signals.

In order to establish this result formally, we consider a single-period economy with two types of firms, a "high" quality firm and a "low" quality firm. Quality differences are characterized by each firm's level of internally generated cash, X, which takes on the value X_H or X_L, where $X_H > X_L$. Corporate managers observe the true value of their own X, but outside investors do not. Hence, differences in unobservable firm attributes are modeled in a manner similar to that in Miller and Rock (1985), rather than in John and Williams (1985) and Ambarish, John, and Williams (1987). For analytical convenience, the discount rate is assumed to be zero.

Each firm's aggregate future cash flow is described by the production function, $F(X)$. The common production function is assumed to have the usual properties: $F(0) = 0$; $F' > 0$; $F'' < 0$. In addition, we assume that $F'(X_H) \geq 1$; this ensures that the high-quality firm has enough positive net present value (NPV) projects to profitably reinvest all its internally generated cash.[2] Within this general framework, cash disbursements can serve as a signal about the firm's quality. This follows because $F'(X_L) > F'(X_H)$ means that the marginal product lost through a cash disbursement is greater for the X_L firm than for

[2] This condition is not necessary for our results but facilitates the characterization of each firm's full information investment and cash disbursement decisions.

the X_H firm. We extend this underinvestment result to consider the choice between deterministic and stochastic cash disbursements as signals. The choice depends on the relative abilities of the X_H and X_L firms to tolerate the risk created by a random cash distribution policy. We show that if the X_H firm has more (less) tolerance for a risky disbursement, then a stochastic (deterministic) disbursement is more efficient.[3]

We assume the existence of a managerial compensation scheme that is a function of present and future share prices. Corporate managers are assumed to maximize the aggregate present value of their own wealth by assigning weight k to the current share price, and weight $(1 - k)$ to the future share price. At this future date, we suppose that the uncertainty about X is resolved. However, unlike similar previous specifications, such as Ross (1977) and Miller and Rock (1985), we suppose the managers can disburse a deterministic amount D and/or a stochastic amount $Z(f, \tilde{\Theta})$, where $\tilde{\Theta}$ is a publicly known random variable and f is announced by the firm. Later, when we model auction-based repurchases, f is taken to be the fraction of shares the firm announces it will repurchase, and $\tilde{\Theta}$ describes the uncertainty about the reservation prices of the shareholders and, therefore, uncertainty about the final repurchase price. We suppose that $Z(f, \tilde{\Theta})$ is a nonnegative, nondegenerate random variable $f > 0$, while $Z(0, \theta)$ is zero for all realizations, θ of $\tilde{\Theta}$. Furthermore, we suppose that the following partial derivatives exist and have the indicated signs: $Z_1(f, \theta) > 0$, $Z_2(f, \theta) > 0$ for $f > 0$, and $Z_{12}(f, \theta) \geq 0$. The assumption that $Z_1 > 0$ means the distribution of disbursements with f stochastically dominates that with f' if $f > f'$. The assumption that $Z_2 > 0$ requires the realizations of the random variable be ordered so that increased realizations mean increased disbursements. The assumption that $Z_{12} > 0$ essentially means increasing f increases not only the expected disbursement but also the underlying uncertainty about the disbursement for any distribution on $\tilde{\Theta}$.

Our assumption on the marginal productivity of investment capital leads to a straightforward characterization of the full information solution. The manager will reinvest all internally generated funds in the firm's productive opportunities, and therefore make no cash distribution to the firm's equity claimants: $D = f = 0$.

Assuming that the market is unaware of whether a firm is X_L or X_H, we investigate separating signaling equilibria.[4] Suppose that by choos-

[3] Subsequently, we show that the appropriate measure of tolerance is the absolute risk aversion of the firm's production function, including disbursements.

[4] In Section 1.3, we show that pooling equilibria do not exist satisfying the Intuitive Criterion of Cho and Kreps (1987). Without getting too far ahead of ourselves, we alert the reader to the fact that share repurchases do not perfectly fit the stochastic disbursements modeled here and, as seen in Section 1.3, this difference can permit pooling.

ing a particular f and D, an X_L firm is initially viewed to be X_H; while if it does not, then it is taken to be X_L. Then the X_L firm will not proceed with f and D if

$$F(X_L) \geq E[k \cdot F(X_H - D - Z(f, \tilde{\theta})) + (1 - k) F(X_L - D - Z(f, \tilde{\theta})) + D + Z(f, \tilde{\theta})], \quad (1)$$

where E represents expectation over $\tilde{\theta}$. For the X_H firm, suppose that by choosing f and D, it is taken to be X_H; while if it does not, it is initially viewed to be X_L. An X_H firm will adopt f and D if

$$E[F(X_H - D - Z(f, \tilde{\theta})) + D + Z(f, \tilde{\theta})] \geq k \cdot F(X_L) + (1 - k) F(X_H). \quad (2)$$

Let S represent the set of pairs (f, D) that satisfy (1) and (2). Any $(f, D) \in S$ characterizes a separating Nash equilibrium. The beliefs of the market that support this are that the firm is taken to be X_H if (f, D) is observed and X_L otherwise. Then the X_H firm will indeed choose (f, D), while the X_L firm will not. These actions support the beliefs and we have a Nash equilibrium. The following lemma shows that separating equilibria always exist.

Lemma 1. *S is nonempty.*

Proof. See Appendix A.

While all pairs $(f, D) \in S$ characterize a separating Nash equilibrium, some are based on unreasonable out-of-equilibrium beliefs. The Intuitive Criterion of Cho and Kreps (1987) allows us to eliminate as equilibria all $(f, D) \in S$ except those that solve the following optimization problem:[5]

$$\underset{f \geq 0,\ D \geq 0}{\text{Maximize}}\ E[F(X_H - D - Z(f, \tilde{\theta})) + D + Z(f, \tilde{\theta})], \quad (3)$$

subject to

$$(f, D) \in S. \quad (4)$$

To see this, let (f^*, D^*) be a solution of the optimization problem. Consider $(f', D') \in S$ that is not a solution. As noted (f', D') characterizes a Nash equilibrium. However, by continuity there is a third

[5] Note that f and D are assumed to be nonnegative. Theorem 1 shows that if the deterministic disbursement is more efficient, then the X_H firm optimally sets $f = 0$ and $D > 0$ (i.e.. signals solely with the deterministic disbursement). In this case, the nonnegativity constraint is typically not serious because the disbursement is stochastic with $f < 0$. However, if the stochastic signal is more efficient, then the nonnegativity constraint can be serious because having $f < 0$ together with $D > 0$ or $D < 0$ with $f > 0$ may be more efficient than $D = 0$ and $f > 0$. In our future work, we hope to investigate these forms of multiple signals. Here, though, the nonnegativity constraint allows us to focus on the distinction between deterministic and stochastic disbursements.

point $(f'', D'') \in S$ that does not solve the optimization problem [although it may be close to (f^*, D^*)] and market beliefs such that the X_H firm prefers (f'', D'') with those market beliefs to (f', D'). On the other hand, there are no market beliefs that make the X_L firm prefer (f'', D'') to $(0, 0)$ with the belief it is the X_L firm with probability 1. Therefore, the Intuitive Criterion requires the market to believe that (f'', D'') signals an X_H firm with probability 1. Thus, (f', D') does not satisfy the Intuitive Criterion. By contrast, it is an equilibrium satisfying the Intuitive Criterion for the X_H firm to choose (f^*, D^*), the X_L firm to choose (0, 0), and the market to believe that a firm disbursing (f^*, D^*) is surely the X_H firm, while it is certainly the X_L firm for any other disbursement.

For the manager's optimization problem, it is possible to reduce the constraint that $(f, D) \in S$ to just inequality (1). We can reduce the inequality further to an equality because, when (1) is binding, then adapting Lemma 1 shows that (2) is not binding. But (1) will be binding because both the objective function and the right-hand side of (1) are decreasing in f and D. Thus, the manager's problem can be written as[6]

$$\underset{f \geq 0,\, D \geq 0}{\text{Maximize}}\; E[F(X_H - D - Z(f, \tilde{\Theta})) + D + Z(f, \tilde{\Theta})], \tag{5}$$

subject to

$$F(X_L) = E[k \cdot F(X_H - D - Z(f, \tilde{\Theta})) + (1 - k)F(X_L - D - Z(f, \tilde{\Theta})) + D + Z(f, \tilde{\Theta})]. \tag{6}$$

Now, suppose that X_H is the level of internally generated cash and C is disbursed to shareholders. Let $X \equiv X_H - C$. For a given X_H, $F(X) + (X_H - X)$ is the cash flow from productive investment plus disbursements. Define

$$R_A(X) \equiv \frac{-F''(X)}{F'(X) - 1}. \tag{7}$$

Notice that $R_A(X)$ is the absolute risk aversion measure of the function $F(X) + X_H - X$. We now show that $R_A(X)$ can be useful in determining a firm's choice of stochastic or deterministic disbursements.

Theorem 1. *If $R_A(X)$ is increasing (decreasing) in X, then the high-quality firm prefers to signal using deterministic (stochastic) disbursements alone.*

Proof. See Appendix B.

[6] Since we do not consider manager-shareholder agency conflicts in our model, we frequently refer to the manager's objective function in expression (5) as the expected value of the X_H firm.

As mentioned earlier, the marginal costs of dividends, a deterministic disbursement, is less for the X_H firm than for the X_L firm and, therefore, the ratio of marginal costs is less than 1. Similarly, the ratio of marginal costs of a stochastic disbursement is less than 1, too. The efficient choice of disbursements is the one with the lowest ratio of marginal costs, and this is the deterministic (stochastic) cash distribution for the case of increasing (decreasing) absolute risk aversion. This intuition is formalized in the proof of Theorem 1.

This result suggests that the functional form of the firm's investment opportunities serves a key role in determining the optimal form of a firm's cash disbursement to shareholders. Hence, in addition to the dollar magnitude of the distribution, the ability of a firm to impose risk on another firm by selecting a random method of cash distribution can create the conditions necessary to achieve a separating equilibrium. This result also establishes that, despite the availability of multiple signals, the high-quality firm may, under certain conditions, prefer to select a univariate signal.

1.2 Dividend and share repurchase decisions

In order to apply our general results on deterministic and stochastic cash disbursements to observed corporate practices, it is useful to consider a more detailed description of the economic environment. We suppose *both* firms and outside equity claimants are asymmetrically informed about each other. In order to represent our two-sided uncertainty as simply as possible, we assume that, for a given firm, each existing shareholder is identical except for his or her reservation price for the firm's stock and that each shareholder's reservation price is private information.[7] In our model, the reservation price represents the price at which a given shareholder would be willing to sell his or her existing ownership claims. Note that this value does not necessarily represent the price at which the shareholder would be willing to acquire additional shares. We also assume that corporate management does not know any shareholder's reservation price. Subsequently, we will explicitly describe the way in which we model this uncertainty.

We do not develop a model that endogenizes the signaling mechanism chosen by the firm within a framework where shareholder heterogeneity plays a role in optimal mechanism design. Such an approach would be difficult for two reasons. First, the mechanism

[7] Our analysis does not specifically characterize the way in which these differential reservation prices are established across investors. This step would require a more complete characterization of the individual's portfolio-consumption problem. This would complicate the notational and analytical burden without significantly contributing to the maincontent of the article. Bagwell (1992) provides evidence on the existence of an upward sloping supply curve in the case of share repurchases.

design problem requires incentive compatibility constraints for both different types of firms and different shareholders. Second, the bidding and tendering behavior of each shareholder may influence firm value (and hence share price), unlike the usual mechanism design problem where a buyer's report may influence the price paid upon winning but it does not influence that buyer's value for the good. These difficulties prevent us from solving an optimal mechanism design problem [see, e.g., Myerson (1981) and Harris and Raviv (1981a, 1981b)]. Rather, we simply compare a stochastic mechanism and a deterministic one.

The all-equity financed firm is initially owned by a continuum of risk-neutral shareholders on the interval [0, 1], with each claimant holding an equal portion of the one infinitely divisible share outstanding of the firm. In order to finance its chosen investment and cash distribution programs, a firm has access to external sources of capital. Cash distribution and incremental financing decisions are fully observable in our model, so that we will consider only net positive cash disbursements. Furthermore, in order to avoid any signaling effects via changes in capital structure, we assume that any additional external financing is accomplished by the sale of new shares of common stock.

For dividends, the firm chooses a deterministic level *D*. However, in a share repurchase program, the ability of corporate managers to select controls that reveal firm quality to outside investors is further constrained by the fact that management has imperfect information about the reservation prices of its existing shareholders. Hence, management must consider shareholder bidding and tendering strategies in a share repurchase program. The actual form of the shareholder bidding and tendering strategies depends on the *type* of share repurchase program announced by the firm.

Let f denote the fraction of the outstanding share that the firm offers to repurchase. A distinguishing feature of our analysis relative to previous articles on share repurchases is that we allow the optimal expected repurchase price to be determined endogenously.[8] Each current shareholder is distinguished by the parameter α_i, which influences the payoff from tendering his or her share to the firm. Let $W(R, \alpha)$ represent the tenderer's return when the repurchase price is Rand the shareholder's parameter is α. We assume that the partial derivatives of $W(R, a)$ exist and place three conditions on the function: (1) $W(R, \alpha) \leq R$ (i.e., there are costs associated with tendering); (2)

[8] Note that it is the distribution of repurchase prices, rather than the actual repurchase price, that is endogenously determined in our model. The actual repurchase price depends on the realized distribution of shareholder reservation prices, and hence may differ from the expected repurchase price ex post.

distribution, the actual distribution of types converges to the common distribution. Therefore, in the limit, there is no uncertainty about the actual distribution of premiums and, as a consequence of this, auction-based share repurchases are deterministic disbursement mechanisms, not stochastic.

Management is assumed to have no ownership stake in the firm. We model management's decision as the size of the repurchase premium or discount to offer shareholders. Since all shareholders are outside investors in our model, an assumption of homogeneous shareholders would result in equilibria where either all or no outstanding shares would be tendered in the event of a repurchase offer. Clearly, then, homogeneity implies that any tender offer for less than all outstanding shares results in pro rata repurchase. One can view this homogeneity as each current shareholder having an identical reservation price, where each shareholder's tendering strategy is conditional on the announced tender price being higher than the common reservation price. Thus, in contrast to Ofer and Thakor (1987) and Vermaelen (1984), share repurchases convey information without necessarily imposing costs on managers because they cannot tender. In our model, the premium paid to low reservation value shareholders is a cost borne by the nontendering, high reservation value shareholders.

Consider the equilibrium shareholder bidding strategies in the case of an auction-based share repurchase. The auction studied is the uniform-price auction used in practice: the firm announces that a fraction f of the shares will be repurchased, shareholders submit bids, the lowest fraction f of the bids are accepted, and the repurchase price is the highest bid of the accepted bids. In practice, firms also announce a minimum and maximum price. Rather than introduce multiple signals within a repurchase, we elect to ignore these prices and have the firm's only decision variable be the fraction f repurchased. Thus, the repurchase will always be successful and rationing will not occur.[10]

In the typical auction setting, a bidder wins and makes a profit, or loses for a profit of zero. Our setting is more complicated because losing means remaining as a shareholder, and losing with different bids leads to different expectations about the actual disbursement level and, therefore, different expectations about the value of remain-

[10] Another possible uniform-price auction would be to have the repurchase price set at the lowest rejected bid. This is the multiobject version of the Vickrey auction. With a continuum of bidders. as we have, this is identical to the auction studied since the highest accepted bid and the lowest rejected bid will be identical. A third possible auction is a discriminatory auction. Here, the lowest fraction f of the bids is accepted but each bidder pays the amount of his or her bid. However. this type of scheme is prohibited by the SEC since all validly tendered shares must be paid the same price.

ing as a shareholder. Supposing bidders maximize expected worth, which involves tendering if one's bid is accepted and remaining as a shareholder otherwise, Theorem 2 describes the equilibrium bidding strategy when f and D are announced. It is important to note that the theorem assumes f and D are jointly large enough to distinguish the firm as X_H. Later, we will determine the levels of f and D required for a separating equilibrium.

***Theorem* 2.** *Suppose a fraction f of outstanding shares is to be repurchased and this, together with a dividend of D, is a credible signal that the firm is type X_H. Then the equilibrium bid for a shareholder with a is B(a; f), where B(a; f), is the solution to*

$$\frac{F(X_H - D - f \cdot B(\alpha; f))}{(1 - f)} = W(B(\alpha; f), \alpha). \tag{8}$$

Also, $B_1(\alpha; f) > 0$ and $B_2(\alpha; f) < 0$.

Proof. See Appendix C.

The interpretation of expression (8) is relatively straightforward.[11] A small change in one's bid has no effect on expected profit unless one is the marginal bidder. In that role as marginal bidder, or price-setter, the shareholder must be indifferent between tendering and not. Expression (8) equates the values of these two outcomes for a bidder with α who is assumed to be the marginal bidder.

Since $B_1(\alpha; f) > 0$ for any θ, the actual repurchase price is set by the shareholder with α solving $H(\alpha; \theta) = f$, or, equivalently, $\alpha = H^{-1}(f; \theta)$. Define $\hat{B}(f; \theta) \equiv B(H^{-1}(f; \theta); f)$ Then, for a given f and realization θ, $\hat{B}(f; \theta)$ is the repurchase price. Assuming a separating equilibrium, the manager's signaling problem using dividends and share repurchases is

$$\underset{f, D \geq 0}{\text{Maximize}}\ E[F(X_H - D - f \cdot \hat{B}(f; \theta)) + D + f \cdot \hat{B}(f; \theta)], \tag{9}$$

subject to

$$\begin{aligned} F(X_L) \geq E[&k \cdot F(X_H - D - f \cdot \hat{B}(f; \theta)) \\ &+ (1 - k)F(X_L - D - f \cdot \hat{B}(f; \theta)) \\ &+ D + f \cdot \hat{B}(f; \theta)]. \end{aligned} \tag{10}$$

To compare this formulation with the original formulation (5) subject to (6) that provides Theorem 1, we must ask whether $f \cdot \hat{B}(f; \theta)$ has

[11] An important property of the equilibrium bidding strategy described in Theorem 2 is that bidders cannot affect the purchase price but can only affect their probability of winning. This occurs because we assume that the number of bidders is large. Gay, Kale, and Noe (1990) consider the impact of a finite number of bidders in the case of share repurchases.

the three properties assumed of $Z(f, \theta)$: (i) $Z_1(f, \theta) > 0$; (ii) $Z_2(f, \theta) > 0$ for $f > 0$; and (iii) $Z_{12}(f, \theta) \geq 0$? Theorem 3 shows that property (i) is satisfied and property (ii) is easily seen to hold. However, property (iii) may not hold. In fact, it does not hold in general for the example studied in the next section. However, property (iii) is sufficient but not necessary for Theorem 1 and our numerical results for the numerical example in Section 2 follow the predictions of Theorem 1. First, we prove that disbursements are increasing in the two decision variables, f and D. Notice that f influences only the stochastic portion of the disbursement, while D influences the deterministic portion and, through (8), the stochastic portion.

Theorem 3. *For a fixed q, the disbursement* $D + f \cdot \hat{B}(f; \theta)$ *is increasing in f and D.*

Proof See Appendix D.

Theorem 3 establishes that increasing f and D increases the cash distributed, and not just in expectation but for any q. It follows that the objective function (9) and the right-hand side of the constraint (10) are decreasing in f and D. Therefore, the optimal f and D solve the constraint with equality.

A final observation is that if the manager is restricted from mixing dividends and repurchases (i.e., signaling can be all dividends or all share repurchases), then the required dividend is larger than the expectation of the required repurchase disbursement. This is a consequence of the concave production function, as is seen in Theorem 4.

Theorem 4. *Let D solve the firm's dividend signaling problem and let f solve the firm's share repurchase signaling problem. Then* $D > E[f \cdot \hat{B}(f; \theta)]$.

Proof. Since D and f solve their respective nonmimicry constraints with equality,

$$\begin{aligned}
&k \cdot F(X_H - D) + (1 - k)F(X_L - D) + D \\
&\quad = E[k \cdot F(X_H - f \cdot \hat{B}(f; \theta)) + (1 - k)F(X_L - f \cdot \hat{B}(f; \theta)) \\
&\qquad + f \cdot \hat{B}(f; \theta)] \\
&\quad < k \cdot F(X_H - E[f \cdot \hat{B}(f; \theta)]) + (1 - k)F(X_L - E[f \cdot \hat{B}(f; \theta)]) \\
&\qquad + E[f \cdot \hat{B}(f; \theta)],
\end{aligned}$$

where the last inequality holds by Jensen's inequality. But since $k \cdot F(X_H - C) + (1 - k)F(X_L - C) +$ is decreasing in C over the range that we restrict C, X_H, and X_L, then $D > E[f \cdot \hat{B}(f; \theta)]$. Q.E.D.

1.3 Equilibrium considerations

Our analysis of the choice between deterministic and stochastic cash disbursements thus far considers only separating equilibria. But can pooling equilibria exist? For instance, can a pooling equilibrium be supported in which neither firm, X_H nor X_L, pays a dividend? That the answer is yes for Nash equilibria is made clear by supposing that the market reacts to any positive dividend by assessing the firm to be of type X_L. While this might be considered perverse behavior by the market, it remains a Nash equilibrium-given the market's reaction to a dividend, neither type of firm wishes to pay a dividend, and given that no firm will pay a dividend (i.e., dividends are out-of-equilibrium actions), the market's reaction can be supported.

However, we now show that pooling equilibria are less likely to exist if we refine our notion of an equilibrium to one satisfying the Intuitive Criterion of Cho and Kreps (1987). The analysis and results are quite different for dividends and share repurchases. To make this distinction most clearly, we first suppose that firms can use only dividends and then restrict the firm to share repurchases. For dividends alone we prove that no pooling equilibria exist satisfying the Intuitive Criterion. Our proof follows very closely that used by Cho and Kreps (1987) to show nonexistence of pooling equilibria in a labor market à la Spence.

Suppose a pooling equilibrium exists where the firm, whether X_H or X_L, pays a dividend D and, upon seeing D, Q is the market's probability belief that the firm's type is X_H. Then the X_I firm's value $(I = L, H)$ is

$$\begin{aligned} V_I(Q, D) = {} & k[QF(X_H - D) + (1 - Q)F(X_L - D)] \\ & + (1 - k)F(X_I - D) + D. \end{aligned} \tag{11}$$

Using (11), Figure 1 shows the $V_I(Q, D)$ indifference curves through (Q, D), one for the X_H, firm and another for the X_L firm. For any pair (Q, D), the indifference curves are easily shown to have a positive slope and the X_H firm's curve is steeper than the X_L firm's. Since the indifference curves are increasing to the southeast, for any $Q < 1.0$ there are pairs that the X_H firm prefers to (Q, D) but that are less preferred by the X_L firm. Among them are pairs with a market estimate of 1.0. Such pairs are depicted in Figure 1 by the heavy line, and arbitrarily chosen from them is $(1.0, D^*)$. There are market beliefs Q^* such that the X_H firm prefers (Q^*, D^*). On the other hand, there are no market beliefs Q^* such that the X_L firm prefers (Q^*, D^*) to (Q, D). Therefore, the Intuitive Criterion requires $Q^* = 1$ for D^*, which breaks the pooling equilibrium.

In Section 1.1, the random variable $Z(f, \theta)$ is independent of the market's belief Q. This results in indifference curves that are positively

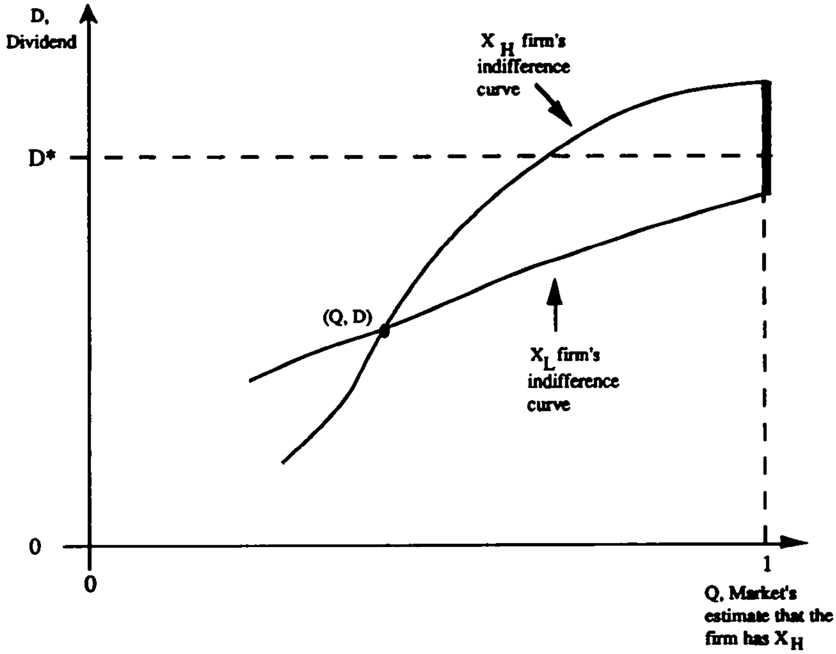

Figure 1
Nonexistence of pooling equilibria for dividends
Consider any pooling equilibrium candidate (Q, D) with $Q < 1$. The indifference curves through the point (Q, D) for the X_H firm and X_L firm have positive slopes and the X_H firm's curve is steeper than the X_L firm's. Therefore, a point such as $(1.0, D^*)$ exists that is preferred by the X_H firm to (Q, D) but is less preferred by X_L. Since there are market beliefs Q^* such that the X_H firm prefers (Q^*, D^*) but there are no beliefs such that the X_L firm prefers (Q^*, D^*), the Intuitive Criterion requires $Q^* = 1$ for D^*, which breaks the pooling equilibrium.

sloped. Therefore, just as with dividends, there are no pooling equilibria for stochastic disbursements satisfying the Intuitive Criterion. There is an important difference between repurchases and $Z(f, \theta)$, though, which limits the Intuitive Criterion's ability to eliminate pooling equilibria for share repurchases. The difference is that, unlike $Z(f, \theta)$ and dividends, the eventual disbursement with repurchases is influenced by the market's belief Q, which may result in indifference curves that are not positively sloped. To understand this, consider first dividends and a pair (Q, D) in Figure 1. Increasing Q for a fixed D benefits the current value (because the price on the secondary market will be higher) and has no effect on future value, which together moves the manager to a higher indifference curve. Also, decreasing D for a fixed Q benefits both current and future value. Thus, indifference curves are positively sloped. Now consider repurchases where a potential pooling equilibrium is a pair (Q, f). As Q increases for a fixed f the price paid for the f shares will increase.

So, unlike dividends, the disbursement for repurchases increases as Q increases. An increase in Q accompanied by an increase in disbursements may or may not benefit the current value, but it is unambiguously bad for the future value. As a result, it may be that the overall effect is to move the manager to a lower indifference curve. Thus, indifference curves can be negatively sloped.

To consider pooling with repurchases, we need to establish some new notation. If the market perceives Q as the probability that the firm is X_H when the firm announces a repurchase offshares, then the equilibrium bidding strategy is a function $B(\alpha; f, Q)$, the solution to

$$\frac{QF(X_H - f\cdot B(\alpha; f, Q)) + (1 - Q)F(X_L - f\cdot B(\alpha; f, Q))}{1 - f}$$
$$= W(B(\alpha; f, Q), \alpha). \tag{12}$$

The proof follows that of Theorem 2; note the similarity to the bidding strategy in (8) where the Q term is suppressed because $Q = 1$ in the separating equilibrium. Recall we are focusing on share repurchases, so $D = 0$. Then, for a realization q, the repurchase price is

$$\hat{B}(f; \theta, Q) \equiv B(H^{-1}(f; \theta); f, Q). \tag{13}$$

Suppose a pooling equilibrium exists where the firm announces f and the market perceives it to be the X_H firm with probability Q. Then the X_I firm's expected value $(I = H, L)$ is

$$\begin{aligned} V_I(Q, f) \equiv E[k\cdot\{&QF(X_H - f\cdot\hat{B}(f; \theta, Q)) \\ &+ (1 - Q)F(X_L - f\cdot\hat{B}(f; \theta, Q))\} \\ &+ (1 - k)F(X_I - f\cdot\hat{B}(f; \theta, Q)) + f\cdot\hat{B}(f; \theta, Q)]. \end{aligned} \tag{14}$$

Figure 2 shows indifference curves in the (Q, f) space. For the X_L firm, consider the indifference curve through the point (0, 0), that is, where no repurchase takes place and the market perceives the firm to be X_H with probability zero. The heavy line in Figure 2 is an example of such an indifference curve. The curve is easily seen to be continuous. Also, higher indifference curves for the X_L firm are to the southeast of this curve since higher indifference curves pass through the points $(Q, 0)$ as Q increases. Let

$$Z = \{(Q, f) \mid V_L(Q, f) \geq V_L(0, 0)\}.$$

Then Z is the shaded region southeast of the X_L firm's indifference curve through (0, 0). We can eliminate pairs (Q, f) not in Z from consideration as potential equilibria since the X_L firm is better off with no repurchase regardless of the market's beliefs, in- or out-of-equilibrium, as to the likelihood it is the X_H firm.

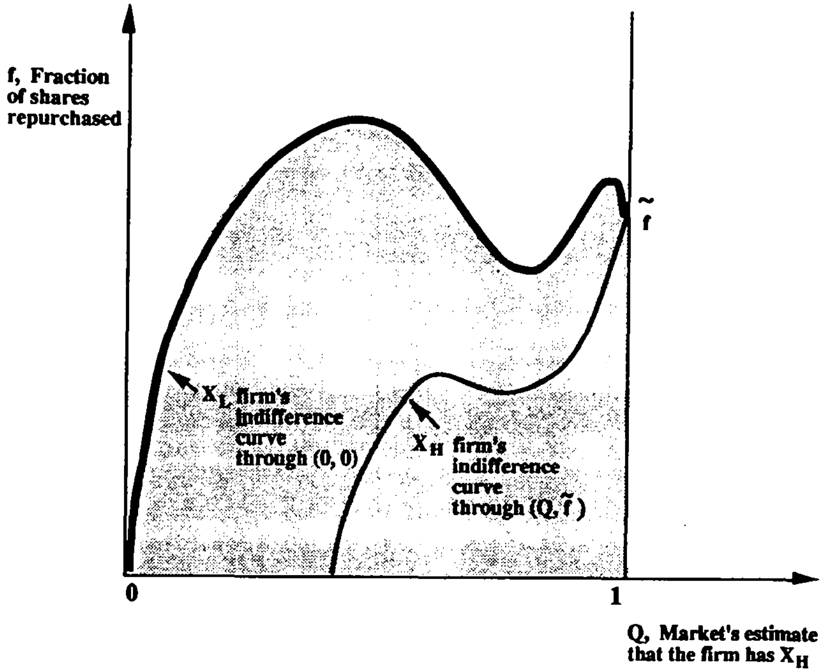

Figure 2
Separating equilibrium for share repurchases
The existence of a separating equilibrium for repurchases that satisfies the Intuitive Criterion is shown. The heavy line is the indifference curve for the X_L firm through (0, 0). $\tilde{f}$ is defined as the fraction of shares repurchased corresponding to a market belief of 1 that is on the same indifference curve for X_L. Also shown is the indifference curve for X_H through (1, $\tilde{f}$). While the slope of the indifference curve for X_H through any point (Q, f) exceeds that for the X_L firm, these curves need not be positively sloped. However, we do show that $\tilde{f}$ is the highest repurchase fraction on the X_H firm's indifference curve through (1, $\tilde{f}$). The separating equilibrium is supported by in-equilibrium beliefs that $f = 0$ means $Q = 0$ and $f = \tilde{f}$ means $Q = 1$, together with the out-of-equilibrium beliefs that $f \neq \tilde{f}$ means $Q = 0$, which satisfies the Intuitive Criterion.

While indifference curves for the X_H and X_L firms are not necessarily positively sloped in Figure 2, it can be shown that the slope of the indifference curve through any point (Q, f) for the X_H firm is greater than that for the X_L firm. This means that the single-crossing property holds. Lemma 2 further describes the indifference curves for the X_H firm.

Lemma 2. $Q < 1$ and $(Q, f) \in Z$, then $V_H(1, f) > V_H(Q, f)$.

Proof. See Appendix E.

Lemma 2 holds whether or not $(1, f) \in Z$. Choose $(Q, f) \in Z$ and let $\hat{f}(\hat{Q})$ solve $V_H(\hat{Q}, \hat{f}) = V_H(Q, f)$ for $0 \leq \hat{Q} \leq 1$. Lemma 2 implies that if $0 \leq \hat{Q} < 1$ and $(\hat{Q}, \hat{f}(\hat{Q})) \in Z$, then

$$\hat{f}(\hat{Q}) < \hat{f}(1).$$

Thus, while an indifference curve of the X_H firm need not be increasing in Q, the repurchase fraction corresponding to a market belief of 1 exceeds the fraction for all other points on the indifference curve that are in Z.

First, we show that the separating equilibrium satisfies the Intuitive Criterion. Figure 2 illustrates the separating equilibrium with the indifference curve for X_L through (0, 0) and the indifference curve for X_H that intersects with X_L's indifference curve at Q = 1. Let f be the repurchase fraction at that intersection. Again, Lemma 2 implies that f is the highest repurchase fraction on the X_H firm's indifference curve through $(1, f)$. Consider the in-equilibrium beliefs that $f = 0$ means $Q = 0$ and $f = f$ means $Q = 1$. These together with the out-of-equilibrium belief that $f \neq f$ means $Q = 0$ satisfy the Intuitive Criterion.

Before showing that share repurchase pooling equilibria may exist that satisfy the Intuitive Criterion, we consider Figure 3 where a potential pooling equilibrium does not survive the Intuitive Criterion. The potential pooling equilibrium is $(Q', f') \in Z$ and f is the highest share repurchase fraction on X_L's indifference curve through (Q', f'). In Figure 3, the market belief corresponding to f is to the right of Q'. Since the X_L indifference curve is below the X_H indifference curve for market beliefs exceeding Q', there exist pairs $(1, f)$ that are preferred by X_H to (Q', f') but are less preferred by X_L. This region is depicted in Figure 3 by the heavy line and its existence allows the Intuitive Criterion to eliminate (Q', f') as a pooling equilibrium just as was done for the case of dividends.

Now we show a pooling possibility in Figure 4 that cannot be eliminated by the Intuitive Criterion. The pooling equilibrium considered has the market's belief probability equal to μ, where μ is the prior probability that a firm is X_H. What distinguishes Figures 3 and 4 is that f the maximum share repurchase fraction on the X_L indifference curve through the candidate equilibrium (μ, f'), is to the left of μ. Further, Figure 4 has $f > f$. For all share repurchase fractions $f \in (f', \tilde{f})$, there are market beliefs that raise the X_H firm to a higher indifference curve and mutually exclusive market beliefs that put the X_L firm on a higher indifference curve. Only for $f \in (\dot{f}, \bar{f})$ does the Intuitive Criterion require market beliefs of zero. So, beliefs that support this pooling equilibrium are a market belief of μ for $f \in [f', f]$ and a belief of zero otherwise.

2. Numerical Example

In this section, we provide an example to illustrate numerically the role of the model's parameters in determining the relative efficiency

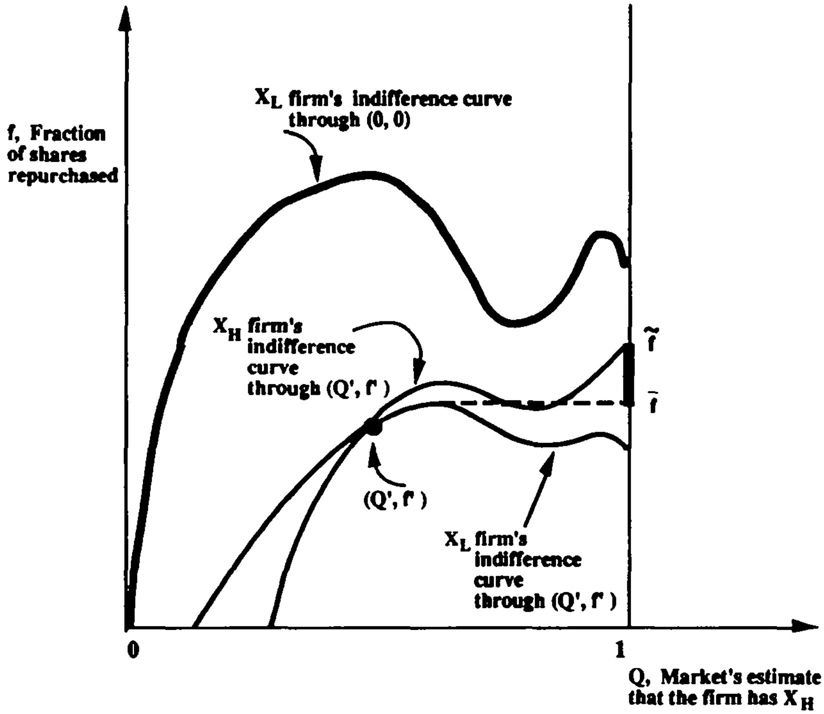

Figure 3
Pooling equilibrium candidate that does not satisfy the Intuitive Criterion
An example of a pooling equilibrium (Q', f') that does not survive the Intuitive Criterion is shown. $\tilde{f}$ and $\bar{f}$ are the highest fractions on X_H's and X_L's indifference curves through (Q', f'). In this case, since $\tilde{f} > \bar{f}$, there exists a pair $(1, f)$ that is preferred by X_H to (Q', f') but is less preferred by X_L. Therefore, the pooling equilibrium violates the Intuitive Criterion.

of dividends and auction-based share repurchases as signaling mechanisms in the separating equilibrium. We consider a square root production technology, so that $F(X) = \sqrt{X}$. In order to maintain our assumption that $F'(X) \geq$: we require that $X \leq 0.25$. For this production function, $R_A(X) = 0.5(X - 2X^{3/2})^{-1}$, which is increasing for $X > \frac{1}{9}$ and decreasing for $X < \frac{1}{9}$. This means that if $X_L < X_H < \frac{1}{9}$, the high-quality firm prefers the stochastic disbursement. If $\frac{1}{9} < X_L < X_H$ and the required disbursement is small, then a deterministic disbursement is preferred. Other cases, such as $X_L < \frac{1}{9} < X_H$ and $\frac{1}{9} < X_L < X_H$) with a large disbursement, are less obvious but will be numerically illustrated in this section.

Dividends are represented by D. To characterize the share repurchase decision for the high-quality firm, we will assume the following:

$$H(\alpha; \theta) = (\alpha/\bar{\alpha})^{\theta}, \qquad \text{for } 0 \leq \alpha \leq \bar{\alpha}. \tag{15}$$

The parameter $\bar{\alpha}$ is the maximum possible α value and, from (15),

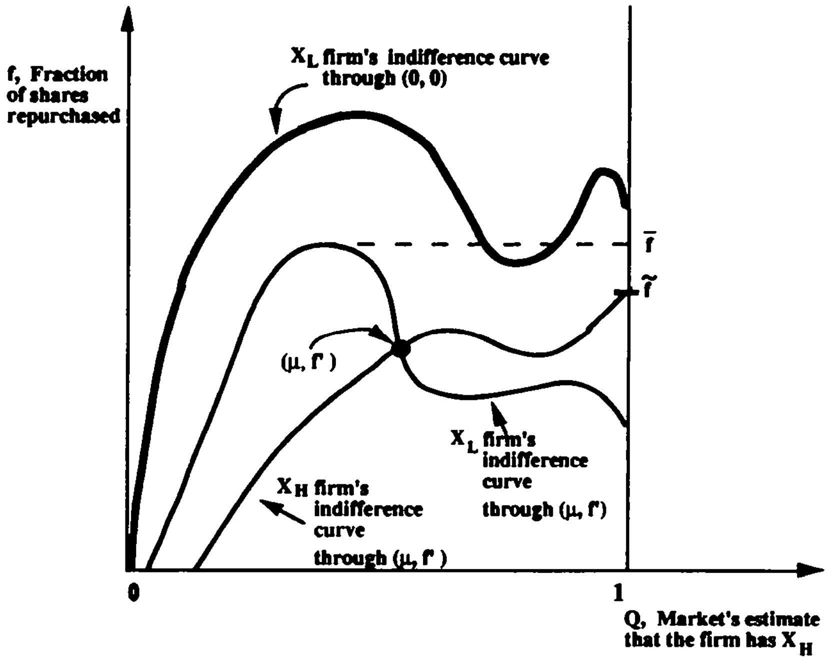

Figure 4
Pooling equilibrium satisfying the Intuitive Criterion
This example shows that the Intuitive Criterion may allow pooling equilibria. This is accomplished with a market belief of μ for $f \in [f', \tilde{f}]$ and a belief of zero otherwise.

the proportion of shareholders with a premium less than or equal to a is decreasing in q. Equivalently, $H(\alpha;\ \theta_1)$ stochastically dominates $H(\alpha;\ \theta_2)$ for $\theta_1 > \theta_2$. We will also suppose that q is exponentially distributed:

$$\theta \sim f(\theta) = \lambda e^{-\lambda\theta}, \qquad \text{for } \theta \in [0, \infty). \tag{16}$$

(Note, for $q = 0$, all shareholders have $\alpha = 0$, and, for $\theta = \infty$ all shareholders have $\alpha = \bar{\alpha}$.) In the auction-based share repurchase, shareholders submit their bids, the lowest fare accepted, and the repurchase price is set at the highest of those f bids. Recall that the equilibrium bidding strategy in the auction-based share repurchase is the schedule $B(\alpha; f)$, which solves (8), and the repurchase price is $B(f; \theta) \equiv B(H^{-1}(f; \theta); f)$ Finally, we assume that $W(R, \alpha) = R - \alpha$.

In this example, the repurchase price $\ddot{B}(f; \theta)$ can be shown to be

$$\hat{B}(f;\ \theta) = \bar{\alpha} f^{1/\theta} - \frac{f}{2(1-f)^2} + \frac{1}{2(1-f)}\sqrt{4(X_H - D) + \left(\frac{f}{1-f}\right)^2 - 4\bar{\alpha} f^{(1+\theta)/\theta}}. \tag{17}$$

Table 2
Numerical illustration of the model in the case of a square root production function

X_H	f	D	Expected value of the high-quality firm	Expected repurchase price	Expected signaling costs
Case 1 parameter values: $X_L = 0.10$, $k = 0.1$, $\lambda = 0.5$, $\bar{\alpha} = 0.1$					
.11	.00775	0	.33029735	.34108911	.00136513
.12	.01439	0	.34405206	.35685799	.00235810
.16	0	.01387	.39613935	—	.00386065
.20	0	.02106	.44407303	—	.00314057
.25	0	.02849	.49913855	—	.00086145
Case 2 parameter values: $X_L = 0.10$, $k = 0.1$, $\lambda = 0.5$, $\bar{\alpha} = 0.5$					
.11	.00690	0	.33029735	.38259976	.00136513
.12	.01264	0	.34405211	.40579384	.00235805
.16	0	.01387	.39613935	—	.00386065
.20	0	.02106	.44407303	—	.00314057
.25	0	.02849	.49913855	—	.00086145
Case 3 parameter values: $X_L = 0.10$, $k = 0.5$, $\lambda = 0.5$, $\bar{\alpha} = 0.1$					
.11	.03796	0	.32447138	.34139487	.00719110
.12	.06993	0	.33338158	.35358832	.01302858
.16	.15417	0	.37519542	.40016344	.02480458
.20	.18756	0	.42431994	.45040218	.02289366
.25	.17817	0	.48951436	.51531442	.01048564
Case 4 parameter values: $X_L = 0.10$, $k = 0.5$, $\lambda = 0.5$, $\bar{\alpha} = 0.5$					
.11	.03187	0	.32447187	.40488758	.00719061
.12	.05718	0	.33338740	.42872732	.01302276
.16	.12209	0	.37548926	.49328707	.02451074
.20	.12377	0	.43090258	.54912095	.01631102
.25	.11395	0	.49411957	.60980604	.00588043
Case 5 parameter values: $X_L = 0.15$, $k = 0.1$, $\lambda = 0.5$, $\bar{\alpha} = 0.1$					
.16	0	.00429	.39889143	—	.00110857
.18	0	.01207	.42186178	—	.00240229
.20	0	.01898	.44444529	—	.00276831
.25	0	.03310	.49880957	—	.00119043
Case 6 parameter values: $X_L = 0.15$, $k = 0.1$, $\lambda = 0.5$, $\bar{\alpha} = 0.5$					
.16	0	.00429	.39889143	—	.00110857
.18	0	.01207	.42186178	—	.00240229
.20	0	.01898	.44444529	—	.00276831
.25	0	.03310	.49880957	—	.00119043
Case 7 parameter values: $X_L = 0.15$, $k = 0.5$, $\lambda = 0.5$, $\bar{\alpha} = 0.1$					
.16	0	.02017	.39410797	—	.00589203
.18	0	.05222	.40968147	—	.01458260
.20	.17025	0	.42761507	.45315922	.01959853
.25	.23506	0	.48073513	.50792381	.01926487
Case 8 parameter values: $X_L = 0.15$, $k = 0.5$, $\lambda = 0.5$, $\bar{\alpha} = 0.5$					
.16	0	.02017	.39410797	—	.00589203
.18	.09887	0	.40968180	.52102755	.01458227
.20	.13798	0	.42765829	.54918047	.01955531
.25	.17769	0	.48377139	.61269647	.01622861

increasing absolute risk aversion area that dividends become the preferred signal. This switch to dividends does not happen when k = 0.5, though, because the expected disbursement must be larger as k increases (because the reward to the X_L firm of mimicking increases as k increases). This larger disbursement moves the actual investment by X_H much closer to than when $k = 0.1$, and it forces the investment level of a mimicking X_L firm into a region of high local absolute risk aversion.

Next, consider the case when the low-quality firm generates $X_L = 0.15$, a higher level of internally generated cash. Now both X_L and X_H are in the increasing absolute risk-averse region, even with a disbursement as large as 0.039 $(=0.15 - \frac{1}{9})$, so dividends tend to be the preferred choice. Only when the required average disbursement is large (i.e., when k is large and $X_H - X_L$ is large) do repurchases become the more efficient signal. This is again because the large disbursement forces a mimicking X_L firm's investment level well into the locally decreasing absolute risk-averse region while it moves the X_H firm's investment level into a locally less risk-averse region.

Table 2 shows the expected signaling costs of the two methods of cash disbursement. This cost is the difference between $F(X_H)$, the full information value of the X_H firm, and the expected value of the X_H firm in the separating equilibrium. Note that as X_H increases then, if dividends are the efficient signal, D increases. This is easily seen to be a general result by requiring $f = 0$ in the signaling optimization problem, letting $D(X_H, X_L, k)$ solve (19) with $f = 0$, and showing that $D(X_H, X_L, k)$ is increasing in X_H. Hence, as the ability of the high-quality firm to generate cash internally increases, aggregate corporate cash distributions will increase. A general result that as corporate managers increase the weight that they attach to current share prices (i.e., k increases) corporate cash distributions increase is illustrated in Table 2. This can be observed for dividends by comparing dividends in cases 5 and 6 with those in cases 7 and 8. Thus, our model suggests that one explanation for the recent increase in cash distributions is that corporate managers have become relatively more concerned about the current market values of their firms over the future values.

Also, observe that the optimal dividend can be increasing or decreasing in X_L. Cases 1 and 5 with $X_H = 0.25$ show it increasing in X_L, while the same cases with $X_H = 0.20$ show it decreasing. This nonmonotonicity arises from two opposing effects. First, as X_L decreases, the difference between X_H and X_L increases, thereby increasing the incentive for the X_L firm to mimic the X_H firm. At the same time, though, this mimicry becomes costlier for the X_L firm because the concave production function means that marginal return on investment increases as X_L decreases. This suggests that aggregate corporate dividends will increase more rapidly when high-quality and low-quality firms benefit from increased economic activity. However, if increased economic activity benefits only low-quality firms, then aggregate corporate dividends can actually decrease. Interestingly, aggregate corporate distributions are quite sensitive to, as well as nonmonotonic in, the relative rate of improvement in corporate cash flows for lower-quality firms.

For the cases in Table 2 when it is optimal to signal with share repurchases exclusively, observe that the fraction of shares repurchased, f, can decrease as X_H decreases for fixed X_L. However, in all cases, the expected disbursement (f times the expected repurchase price) increases as X_H increases.

Note also that the parameter $\bar{\alpha}$ which describes the distribution of the heterogeneous shareholders' private information, influences the expected repurchase price (but, of course, does not affect the dividend payment). Our example suggests that an increase in $\bar{\alpha}$ has a twofold effect on the share repurchase decision: (a) it decreases the fraction of shares that the firm seeks; and (b) it increases the expected share repurchase price. To understand the effect on the value of the firm as $\bar{\alpha}$ increases, note that $\bar{\alpha}$ is positively related to the risk that the firm faces in repurchasing a specified fraction of its shares. If the X_H firm's production function displays less absolute risk aversion, then an increase in $\bar{\alpha}$ is advantageous because the expected disbursement can be reduced while the inherent risk continues to be great enough to prevent mimicking. On the other hand, an increase in $\bar{\alpha}$ is disadvantageous for an X_H firm with a production function displaying more absolute risk aversion because, while it can still reduce its expected disbursement as $\bar{\alpha}$ increases, the firm cannot reduce it enough to maintain firm value because the X_L firm is more tolerant of risk. Note, however, that in this latter case, a dividend is the preferred signal regardless of the magnitude of $\bar{\alpha}$. These results suggest that when the production function has strictly decreasing absolute risk aversion, then the X_H firm would prefer the riskiest available disbursement mechanism. The X_H firm would utilize this form of cash distribution at a low level, but the risk would nonetheless be sufficient to deter the X_L firm from mimicking.

Table 2 also shows that firms will rely on share repurchases, even when the expected repurchase price *exceeds* the firm's true value. This can be seen by comparing the "Expected repurchase price" column with the "Expected value of the high-quality firm" column in Table 2. The payment of this premium above the actual market value by the nontendering shareholders to the tendering shareholders creates a distinct (relative to dividends) signaling cost function. Nevertheless, Table 2 shows that nontendering shareholders do, under certain circumstances, prefer to bear this incremental cost because firm value is higher than the case where the firm would distribute an incentive compatible cash dividend. Thus, our model provides a rational explanation for the repurchase of shares by firms at prices other than their true value. It also makes clear why, even in a fully revealing equilibrium, shareholders may retain their shares despite the fact that they are offered a price that exceeds the actual market value of their claim.[14]

3. Summary and Conclusions

In this article, we have examined the choice between deterministic and stochastic cash disbursements to signal information efficiently. We do not explain why firms utilize different forms of stochastic distributions, though. Suppose management can observe with certainty its actual shareholder reservation price schedule. Then an auction-based share repurchase program can always be designed that exactly mimics the shareholder tendering behavior in a fixed-price share repurchase. This suggests that management's uncertainty about the schedule of shareholder reservation prices plays a nontrivial role in the optimal design aspect of share repurchase mechanisms.

Our results also provide insights regarding abnormal share price reactions upon the expiration of a self-tender offer.[15] Corporate managers select optimal cash disbursement mechanisms conditional upon their expectations about the distribution of their heterogeneous shareholder base. Consequently, managers design their repurchase programs uncertain about the exact amount of cash that they must ultimately distribute. Assuming that the results of the self-tender are announced near the expiration date, abnormal share price responses on that date will reflect the incremental information disseminated about the actual outcome of the repurchase program. In particular, since firms underinvest in our model, actual cash distributions that are greater (less) than expected will lead to a decrease (increase) in the share price upon completion. The intuition is straightforward.

For example, if the firm elects an auction-based share repurchase and finds that it actually has a larger mass of low reservation price shareholders than expected, it will be able to repurchase the fraction f of the outstanding shares at an aggregate cost less than its initial expectation. In our model, the "incremental" cash flow generated by this outcome will then be reinvested in the firm's productive opportunities, and the actual cost of signaling will be lower than expected. Clearly, then, the magnitude of the "second-order" announcement

[14] An earlier version of this article contained numerical and analytical results for the case of the exponential production function. Since $R_A(X)$ is everywhere increasing, the high-quality firm will always find that dividends are a more efficient signal.

[15] See. for example, Aharony and Swary (1980) and Asquith and Mullins (1983) on dividend announcement effects, Dann (1981) and Vermaelen (1981) on fixed-price share repurchase announcements, and gamma, Kanatas, and Raymar (1990) on auction-based share repurchase announcements.

effect depends on two attributes of the firm: the concavity of its production function, and the size and direction of the deviation of the actual cash disbursement from the expected level. This observation suggests that, in conducting empirical tests for announcement effects, it is important to investigate the share price response over the entire time period that the repurchase offer is outstanding.

The main empirical implication of this article relates the properties of the firm's production function to the form of its shareholder cash distribution mechanism. Thus, in order to empirically investigate the predictions of our model, it would be necessary to estimate the firm's production function. Our results suggest that there is a relationship between the type of production possibilities, the form of cash distribution, and the magnitude of the announcement effect observed. For example, share repurchases are not unambiguously more consistent with larger deviations between market and true value as in Ofer and Thakor (1987). Rather, the magnitude of the announcement effect for a given cash distribution decision depends on a firm's investment opportunities. Our numerical results do support a positive relationship between the size of the distribution and the magnitude of the announcement effect. This result has been documented already in the literature.

There is, perhaps, an alternative way in which to test our model that circumvents production function estimation problems. In this article, we have restricted our analysis to firms with very simple financial structures-all equity finance. By allowing more complex capital structures, we can examine the choice of deterministic and stochastic cash disbursements across distinct claimant classes. For example, would firms that we characterize as preferring stochastic distributions utilize this same payout feature in other classes of securities? (That is, is the corporate preference for stochastic disbursements independent of the types of financial securities in its capital structure?) Is there a "pecking order" in that firms prefer to first create stochastic disbursements for higher priority claims? The benefit of establishing results on stochastic and deterministic disbursements for senior corporate financial securities is that empirical tests can be designed without having to estimate production functions. Since financial securities are easily observed, this approach may provide a better method for examining the empirical properties of our model.

Appendix A: Proof of Lemma 1

Let (f, D) solve (1) with equality. Clearly such pairs (f, D) exist and, since $X_H > X_L$ at least one off and D is strictly positive. To show that this (f, D) satisfies (2) with strict inequality, observe that

$$E[F(X_H - D - Z(f, \tilde{\Theta})) + D + Z(f, \tilde{\Theta})]$$
$$= F(X_L) + (1-k)E[F(X_H - D - Z(f, \tilde{\Theta})) - F(X_L - D - Z(f, \tilde{\Theta}))]$$
$$= kF(X_L) + (1-k)\{F(X_H) + E[F(X_H - D - Z(f, \tilde{\Theta})) - F(X_H)$$
$$- F(X_L - D - Z(f, \tilde{\Theta})) + F(X_L)]\}$$
$$> kF(X_L) + (1-k)F(X_H),$$

as was to be shown. The first equality holds by definition of (f, D) and the strict inequality holds because $(X - D - Z(f, \theta)) - F(X)$ is decreasing in X by the strict concavity of $F(\cdot)$. Q.E.D

Appendix B: Proof of Theorem 1

In order to prove Theorem 1, we will make use of the following lemma.

Lemma Al. *Suppose that $g(\theta)$ and $h(\theta)$ are probability density functions with $g(\theta) > 0$ and $h(\theta) > 0$ for $\theta \in [\underline{\theta}, \bar{\theta}]$ and $g(\theta) = h(\theta) = 0$ for $\theta \notin [\underline{\theta}, \bar{\theta}]$. If $g(\theta)/h(\theta)$ is increasing in θ for $\theta \in [\underline{\theta}, \bar{\theta}]$, then $g(\theta)$ first-order stochastically dominates $h(\theta)$.*

Proof. See Milgrom (1981, Proposition 1).

Proof of Theorem 1

Since the objective function (5) and the right-hand side of the nonmimicry constraint (6) are decreasing in f and D, the signaling problem can be written with the nonmimicry constraint as an equality. With the multiplier λ on this constraint, the first-order conditions for the Lagrangian are

$$E[-F'(X_H - D - Z(f, \tilde{\Theta})) + 1]$$
$$- \lambda \cdot E[-kF'(X_H - D - Z(f, \tilde{\Theta}))$$
$$- (1-k)F'(X_L - D - Z(f, \tilde{\Theta})) + 1] \leq 0,$$
$$E[Z_1(f, \tilde{\Theta})\{-F'(X_H - D - Z(f, \tilde{\Theta})) + 1\}]$$
$$- \lambda \cdot E[Z_1(f, \tilde{\Theta})\{-kF'(X_H - D - Z(f, \tilde{\Theta}))$$
$$- (1-k)F'(X_L - D - Z(f, \tilde{\Theta})) + 1\}] \leq 0.$$

Rearranging terms yields the following ratio conditions:

$$\frac{E[F'(X_H - D - Z(f, \tilde{\Theta})) - 1]}{E[F'(X_L - D - Z(f, \tilde{\Theta})) - 1]} \geq \frac{\lambda(1-k)}{1 - \lambda k} \tag{B1}$$

and

$$\frac{E[Z_1(f,\tilde{\Theta})\{F'(X_H - D - Z(f,\tilde{\Theta})) - 1\}]}{E[Z_1(f,\tilde{\Theta})\{F'(X_L - D - Z(f,\tilde{\Theta})) - 1\}]} \geq \frac{\lambda(1-k)}{1-\lambda k}. \qquad \text{(B2)}$$

For a given f and 0, the numerator on the left-hand side of (B1) is the marginal cost to the X_H firm of increasing D, and the denominator is the marginal cost for the X_L firm. The numerator (denominator) of the left-hand side of (B2) is the marginal cost to the X_H (X_L) firm of increasing f Therefore, the marginally efficient signal is the one with the lower ratio in (B1) and (B2). If one ratio is lower for all f and D, it is the efficient signal. Thus,

$$\frac{\partial}{\partial X}\frac{E[Z_1(f,\tilde{\Theta})\{F'(X - D - Z(f,\tilde{\Theta})) - 1\}]}{E[F'(X - D - Z(f,\tilde{\Theta})) - 1]} > (<)\ 0, \qquad \text{(B3)}$$

for all $f \geq 0$, $D \geq 0$, is sufficient for the X_H firm to prefer to signal using only the deterministic (stochastic) disbursement. Note that (B3) can be rewritten as

$$\frac{-E[Z_1(f,\tilde{\Theta})\{F''(X - D - Z(f,\tilde{\Theta}))]}{E[Z_1(f,\tilde{\Theta})\{F'(X - D - Z(f,\tilde{\Theta})) - 1\}]}$$

$$< (>)\ \frac{-E[F''(X - D - Z(f,\tilde{\Theta}))]}{E[F'(X - D - Z(f,\tilde{\Theta})) - 1]}. \qquad \text{(B4)}$$

Fix X, D, and f, and define

$$g(\theta) = -F''(X - D - Z(f,\theta))/E[-F''(X - D - Z(f,\tilde{\Theta}))]$$

and

$$h(\theta) = (F'(X - D - Z(f,\theta)) - 1)/E[F'(X - D - Z(f,\tilde{\Theta})) - 1].$$

Then (B4) can be written as

$$E[Z_1(f,\tilde{\Theta})g(\tilde{\Theta})] < (>)\ E[Z_1(f,\tilde{\Theta})\ h(\tilde{\Theta})].$$

Since $Z_{12}(f,\theta) \geq 0$ by assumption, our result follows from Lemma A1 by noting: (i) if $g(\theta)/h(\theta)$ is increasing in q, then $(g(\theta)\cdot f(\theta))/(h(\theta)\cdot f(\theta))$ is also increasing in q for any density function $f(\theta)$; (ii) $g(\theta)\cdot f(\theta)$ and $h(\theta)\cdot f(\theta)$ are well-defined density functions; and (iii) the derivatives of $R_A(X)$ and $g(\theta)/h(\theta)$ have the opposite signs since $Z_2 > 0$. Q.E.D.

Appendix C: Proof of Theorem 2

Suppose other shareholders use the bid function $B(\alpha, f)$ (assumed monotone in α, which is later shown to be true of the equilibrium function) and this shareholder bids b. Given f and θ, $H(\alpha,\theta) = f$ yields the marginal shareholder whose share is repurchased as $H^{-1}(f, \theta)$. Thus, the repurchase price is$B(H^{-1}(f;\theta);f)$.. If the shareholder under consideration bids b, his or her share is repurchased if and only if $b < B(H^{-1}(f;\theta);f)$.. This can be rewritten as $^{-1}(b;f) < H^{-1}(f;\theta)$ $H(B^{-1}(b;f);\theta) < f$. Define $\hat{\theta}(B^{-1}(b;f);f)$

$$H(B^{-1}(b;f), \hat{\theta}(B^{-1}(b;f);f) = f.$$

Then the previous condition simplifies to

$$H(B^{-1}(b,f);\theta) < H(B^{-1}(b,f), \hat{\theta}(B^{-1}(b,f);f)).$$

Since $H(\alpha, \theta)$ is monotone decreasing in q for given α, we obtain

$$\theta > \hat{\theta}(B^{-1}(b,f);f).$$

Hence, our shareholder solves the following optimization problem:

$$\underset{b}{\text{Maximize}} \int_{\underline{\theta}}^{\hat{\theta}(B^{-1}(b;f);f)} \frac{F(X_H - f \cdot B(H^{-1}(f;\theta);f))}{(1-f)} g(\theta \mid \alpha)\, d\theta$$

$$+ \int_{\hat{\theta}(B^{-1}(b;f);f)}^{\bar{\theta}} W(B(H^{-1}(f;\theta);f), \alpha) g(\theta \mid \alpha)\, d\theta.$$

Since $H(\alpha;\theta)$ stochastically dominates $H(\alpha;\theta')$ for $\theta > \theta'$, then $H^{-1}(f;\theta)$is increasing in q. Since the first integrand, $F(X_H - f \cdot B(H^{-1}(f;\theta);f))/(1-f)$is, decreasing in q while the second integrand, $W(B(H^{-1}(f;\theta);f), \alpha)$, is increasing in q, the objective function is maximized with b as the solution to

$$\frac{F(X_H - f \cdot B(H^{-1}(f;\hat{\theta}(B^{-1}(b;f);f));f))}{(1-f)}$$

$$- W(B(H^{-1}(f;\hat{\theta}(B^{-1}(b;f);f));f), \alpha) = 0.$$

Setting $b = B(\alpha;f)$ for a symmetric equilibrium gives the equilibrium bidding strategy as the solution to

$$\frac{F(X_H - f \cdot B(\alpha;f))}{(1-f)} - W(B(\alpha;f), \alpha) = 0. \tag{C1}$$

Next, differentiating (Cl) with respect to a and rearranging gives

$$B_1(\alpha;f) = \frac{-W_2(B(\alpha;f), \alpha)}{W_1(B(\alpha;f), \alpha) + [f \cdot F'(X_H - f \cdot B(\alpha;f))]/(1-f)} > 0,$$

where the latter inequality follows since $W_2 < 0$ and $W_1 > 0$. Differentiating (Cl) with respect to f and rearranging gives

$$B_2(\alpha;f)\left[W_1(B(\alpha;f), \alpha) + \frac{f \cdot F'(X_H - f \cdot B(\alpha;f))}{(1-f)}\right]$$

$$= \frac{F(X_H - f \cdot B(\alpha; f)) - (1 - f)B(\alpha; f)F'(X_H - f \cdot B(\alpha; f))}{(1 - f)^2}$$

$$= \frac{W(B(\alpha; f), \alpha) - B(\alpha; f)F'(X_H - f \cdot B(\alpha; f))}{(1 - f)}$$

$$\leq \frac{B(\alpha; f)(1 - F'(X_H - f \cdot B(\alpha; f)))}{(1 - f)},$$

$$\text{since } W(B(\alpha; f), \alpha) \leq B(\alpha; f)$$

$$< 0. \qquad \text{Q.E.D.}$$

Appendix D: Proof of Theorem 3

We have

$$\frac{\partial(D + f \cdot \hat{B}(f; \theta))}{\partial f}$$

$$= \hat{B}(f; \theta) + f \cdot \frac{\partial \hat{B}(f; \theta)}{\partial f}$$

$$= B(H^{-1}(f; \theta); f) + f[B_1(H^{-1}(f; \theta); f) \cdot H_1^{-1}(f; \theta) + B_2(H^{-1}(f; \theta); f)]$$

$$\geq B(H^{-1}(f; \theta); f) + f \cdot B_2(H^{-1}(f; \theta); f)$$

$$= B(H^{-1}(f; \theta); f) - [f \cdot B(H^{-1}(f; \theta); f)F'(X_H - f \cdot B(H^{-1}(f; \theta); f)) - f \cdot W(B(H^{-1}(f; \theta); f), H^{-1}(f; \theta))] \cdot [(1 - f)W_1(B(H^{-1}(f; \theta); f), H^{-1}(f; \theta)) + f \cdot F'(X_H - fB(H^{-1}(f; \theta); f))]^{-1}$$

$$= [f \cdot W(B(H^{-1}(f; \theta); f), H^{-1}(f; \theta)) + (1 - f)W_1(B(H^{-1}(f; \theta); f), H^{-1}(f; \theta))] \cdot [(1 - f)W_1(B(H^{-1}(f; \theta); f), H^{-1}(f; \theta)) + f \cdot F'(X_H - f \cdot B(H^{-1}(f; \theta); f))]^{-1}$$

$$> 0, \qquad \text{since } W_1 > 0.$$

Then,

$$
\begin{aligned}
&\frac{\partial(D + f\cdot \hat{B}(f;\theta))}{\partial D} \\
&\quad = 1 + f\cdot \frac{\partial \hat{B}(f;\theta)}{\partial D} \\
&\quad = 1 + f\cdot \frac{\partial B(H^{-1}(f;\theta);f)}{\partial D} \\
&\quad = 1 - [f\cdot F'(X_H - D - f\cdot B(H^{-1}(f;\theta);f)) \\
&\qquad\qquad \cdot[f\cdot F'(X_H - D - f\cdot B(H^{-1}(f;\theta);f)) \\
&\qquad\qquad\quad + W_1(B(H^{-1}(f;\theta);f), H^{-1}(f;\theta))]^{-1}] \\
&\quad > 0.
\end{aligned}
$$

The last equality follows from (8) and the last inequality follows since $W_1 > 0$. Q.E.D.

Appendix E: Proof of Lemma 2

Since $(Q, f) \in Z$, then $V_L(0, 0) \le V_L(Q, f)$ or, equivalently,

$$
\begin{aligned}
F(X_L) \le E[&k\{QF(X_H - f\hat{B}(f;\theta, Q)) \\
&\quad + (1 - Q)F(X_L - f\hat{B}(f;\theta, Q))\} \\
&+ (1 - k)F(X_L - f\hat{B}(f;\theta, Q)) + f\hat{B}(f;\theta, Q)].
\end{aligned}
$$

Rearranging gives

$$
k \ge \frac{E[F(X_L) - F(X_L - f\hat{B}(f;\theta, Q)) - f\hat{B}(f;\theta, Q)]}{QE[F(X_H - f\hat{B}(f;\theta, Q)) - F(X_L - f\hat{B}(f;\theta, Q))]}. \tag{E1}
$$

Then,

$$
\begin{aligned}
&V_H(1, f) - V_H(Q, f) \\
&\quad = E[F(X_H - f\hat{B}(f;\theta, 1)) + f\hat{B}(f;\theta, 1)] \\
&\qquad - E[k\{QF(X_H - f\hat{B}(f;\theta, Q)) \\
&\qquad\qquad + (1 - Q)F(X_L - f\hat{B}(f;\theta, Q))\} \\
&\qquad\quad + (1 - k)F(X_H - f\hat{B}(f;\theta, Q)) + f\hat{B}(f;\theta, Q)] \\
&\quad = E[F(X_H - f\hat{B}(f;\theta, 1)) + f\hat{B}(f;\theta, 1) \\
&\qquad\quad - F(X_H - f\hat{B}(f;\theta, Q)) - f\hat{B}(f;\theta, Q)] \\
&\qquad + k(1 - Q)E[F(X_H - f\hat{B}(f;\theta, Q))
\end{aligned}
$$

$$
\begin{aligned}
&- F(X_L - f\hat{B}(f;\theta, Q))] \\
\geq\ & E[F(X_H - f\hat{B}(f;\theta, 1) + f\hat{B}(f;\theta, 1) \\
&\quad - F(X_H - f\hat{B}(f;\theta, Q)) - f\hat{B}(f;\theta, Q)] \\
&+ Q^{-1}(1 - Q)E[F(X_L) - F(X_L - f\hat{B}(f;\theta, Q)) - f\hat{B}(f;\theta, Q)] \\
&\hfill \text{[by (E1)]} \\
=\ & Q^{-1}(1 - Q)F(X_L) \\
&- Q^{-1}E[QF(X_H - f\hat{B}(f;\theta, Q)) \\
&\qquad + (1 - Q)F(X_L - f\hat{B}(f;\theta, Q))] \\
&+ E[F(X_H - f\hat{B}(f;\theta, 1)) + f\hat{B}(f;\theta, 1) - Q^{-1}f\hat{B}(f;\theta, Q)] \\
=\ & Q^{-1}(1 - Q)F(X_L) - (1 - f)Q^{-1}[W(\hat{B}(f;\theta, Q), H^{-1}(f;\theta))] \\
&+ E[F(X_H - f\hat{B}(f;\theta, 1)) + f\hat{B}(f;\theta, 1) - Q^{-1}f\hat{B}(f;\theta, Q)] \\
&\hfill \text{[by (12) and (13)]} \\
\geq\ & Q^{-1}(1 - Q)E[F(X_L - f\hat{B}(f;\theta, 1)) + f\hat{B}(f;\theta, 1)] \\
&- (1 - f)Q^{-1}E[W(\hat{B}(f;\theta, Q), H^{-1}(f;\theta))] \\
&+ E[F(X_H - f\hat{B}(f;\theta, 1)) + f\hat{B}(f;\theta, 1) - Q^{-1}f\hat{B}(f;\theta, Q)] \\
&\hfill \text{[by concavity of } F(\cdot) \text{ and since } \hat{B} \geq 0] \\
=\ & (1 - f)Q^{-1}E[W(\hat{B}(f;\theta, 1), H^{-1}(f;\theta)) \\
&\qquad - W(\hat{B}(f;\theta, Q), H^{-1}(f;\theta))] \\
&+ fQ^{-1}E[\hat{B}(f;\theta, 1) - \hat{B}(f;\theta, Q)] \\
>\ & 0
\end{aligned}
$$

since $W_1 > 0$ and $\hat{B}(f;\theta, Q)$ is easily shown to be increasing in Q from (12) and (13). Q.E.D.

References

Aharony, J., and I. Swary, 1980, "Quarterly Dividend and Earnings Announcement and Stockholders' Returns: An Empirical Analysis," *Journal of Finance*, 35, 1-12.

Ambarish, R., K. John, and J. Williams, 1987, "Efficient Signalling with Dividends and Investments." *Journal of Finance*, 42, 321-343.

Asquith, P., and D. Mullins, 1983, "The Impact of Initiating Dividend Payments on Shareholders' Wealth," *Journal of Business*, 56, 77-96.

Bagwell, L., 1992, "Dutch Auction Repurchases: An Analysis of Shareholder Heterogeneity," *Journal of Finance*, 47, 71-105.

Cho. I., and D. Kreps, 1987, "Signaling Games and Stable Equilibria," *Quarterly Journal of Economics,* 52, 179-221.

Dann, L., 1981, "Common Stock Repurchases: An Analysis of Returns to Bondholders and Stockholders," *Journal of Financial Economics,* 9, 113-138.

Finnerty, J.. 1988, "Financial Engineering in Corporate Finance: An Overview," *Financial Management,* 17, 14-33.

Gay, G., J. Kale, and T. Noe, 1990. "Shareholder Heterogeneity and Bidding Strategies in a Dutch Auction Share Repurchase," working paper, Georgia State University.

Harris. M., and A. Raviv, 1981a. "A Theory of Monopoly Pricing Schemes with Demand Uncertainty," *American Economic Review,* 71. 347-365.

Harris, M., and A. Raviv, 1981 b. "Allocation Mechanismsand the Design of Auctions," Econometrica, 49, 1477-1499.

John, K., and J. Williams. 1985, "Dividends, Dilution, and Taxes: A Signalling Equilibrium," *Journal of Finance,* 40, 1053-1070.

Kamma, S., G. Kanatas, and S. Raymar. 1990, "Dutch Auction Vs. Fixed-Price Self-Tender Offers for Common Stock: An Empirical Examination," working paper, Indiana University.

Milgrom, P., 1981. "Good News and Bad News: Representation Theorems and Applications," *Bell Journal of Economics,* 12, 380-391.

Milgrom. P.. and J. Roberts, 1986, "Price and Advertising Signals of Product Quality," *Journal of Political Economy,* 94, 796-821.

Miller, M., and K. Rock, 1985, "Dividend Policy Under Asymmetric Information." *Journal of Finance,* 40, 1031-1051.

Myerson, R., 1981, "Optimal Auction Design," *Mathematics of Operations Research,* 6, 58-73.

Ofer, A.. and A. Thakor, 1987, "A Theory of Stock Price Responses to Alternative Corporate Cash Disbursement Methods: Stock Repurchases and Dividends," *Journal of Finance,* 42, 365-394.

Ross, S., 1977, "The Determination of Financial Structure: The Incentive Signalling Approach," *Bell Journal of Economics,* 8, 23-40.

Vermaelen, T., 1981, "Common Stock Repurchases and Market Signalling: An Empirical Study," *Journal of Financial Economics,* 9, 138-184.

Vermaelen, T., 1984. "Repurchase Tender Offers, Signalling. and Managerial Incentives," *Journal of Financial and Quantitative Analysts,* 19, 163-181.