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Signaling and Takeover Deterrence with Stock Repurchases: Dutch Auctions versus Fixed Price Tender Offers

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ABSTRACT

This article presents a model of repurchase tender offers in which firms choose between the Dutch auction method and the fixed price method. Dutch auction repurchases are more effective takeover deterrents, while fixed price repurchases are more effective signals of undervaluation. The model yields empirical implications regarding price effects of repurchases, likelihood of takeover, managerial compensation, and cross-sectional differences in the elasticity of the supply curve for shares.

FIRMS THAT WISH TO repurchase a large number of their outstanding shares in a short period of time do so by making a tender offer. Two motivations for these tender offers have received the most attention in the literature: signaling that the firm is undervalued, and defending the firm against a takeover.[1] The traditional type of repurchase tender offer is a fixed price tender offer, whereby the firm offers to repurchase shares at a stated price per share, and shareholders who wish to sell their shares tender them to the firm. A different tender offer mechanism, the "Dutch auction," gained popularity in the 1980s.[2] In a Dutch auction repurchase, the firm announces the number of shares it wishes to repurchase, and shareholders specify the price at which they are willing to sell their shares to the firm. The firm aggregates these asking prices into a supply schedule and calculates the price necessary to purchase the stated number of shares. It then pays the cutoff price to shareholders who tendered at this price or less, while shareholders who tendered at higher prices keep their shares. In a traditional tender offer, the repurchase price is set by the firm, but the number of shares repurchased

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[1]Regarding takeover deterrence through repurchases, see Bagnoli, Gordon, and Lipman (1989), Bagwell (1991b), Dann and Deangelo (1988), and Denis (1990). Empirical evidence of signaling with repurchases can be found in Dann (1981), Vermaelen (1981, 1984), Masulis (1980), Lakonishok and Vermaelen (1990), Dann, Masulis, and Mayers (1991), and Comment and Jarrell (1991). Models of signaling with repurchases include Vermaelen (1984), Ofer and Thakor (1987), Bagnoli, Gordon, and Lipman (1989), Hausch and Seward (1991), and Persons (1993).

[2]Table I lists the number of fixed price and Dutch auction tender offers by year.

depends on how shareholders respond to the offer. In a Dutch auction, the repurchase price varies depending on how shareholders respond to the offer.

This article analyzes the choice between these two tender offer mechanisms, and concludes that fixed price repurchases are better suited to signaling undervaluation and Dutch auctions are better suited to deterring takeovers. In the model, shareholders demand a premium in order to sell their shares, perhaps due to capital gains tax frictions. This required premium varies across shareholders, so the firm faces an upward-sloping supply curve when repurchasing shares. Because the firm must pay a premium price to repurchase any shares, a repurchase is costly for the shareholders who don't participate—wealth is transferred from them to the participating shareholders. There is uncertainty about shareholder tendering—the slope of the supply curve is unknown. This uncertainty is crucial; if the supply curve were known, fixed price and Dutch auction tender offers would be equivalent in this model. The risk-neutral manager of the firm decides whether to repurchase shares and chooses the terms of the tender offer. In the signaling model of Section II, the firm's true value is known only by the manager, and repurchasing shares at a premium may raise the stock price by convincing investors that firm value is high. The manager maximizes a weighted average of the expected intrinsic value per share and the expected market value per share. In the corporate control model of Section III, there is no asymmetric information to motivate a repurchase, but there is a potential bidder for the firm who will be deterred if the firm repurchases enough shares. If the bidder is not deterred, a control contest ensues, and the manager expects to suffer a private cost. The manager maximizes the expected share value adjusted for this private cost.

To develop some basic intuition about the results, suppose a firm is worth 10 and has one share outstanding, divided among many shareholders. Index the shareholders by $\alpha \in [0,1]$, and suppose that shareholder α demands a price of $10 + \tilde{s}\alpha$ to sell his or her shares to the firm, where $\tilde{s}$ is the random slope of the firm's supply curve.[3] If the firm repurchases α shares for a price P per share, the value of the remaining shares will be $(10 - P\alpha)/(1 - \alpha)$ per share. Consider two types of repurchase tender offers: a Dutch auction offer to buy 0.2 shares at whatever price is required, and a fixed price offer to repurchase all tendered shares at a price of 12 per share.[4]

Figure 1 illustrates three possible realizations of the supply curve—$s = 5$, 10, and 15. For the intermediate case, $s = 10$, the two offers have the same outcome: 0.2 shares are bought for 12 per share, producing a postrepurchase

[3]The model assumes a linear supply curve, but this assumption can be relaxed without altering the results—see Appendix A.

[4]Tender offers in the model are "unconditional" offers in which the firm names the purchase price (for a fixed price offer) or the number of shares (for a Dutch auction), and shareholder response to the offer determines the other price/quantity variable without restriction. In practice, fixed price tender offers usually specify a maximum quantity and Dutch auction tender offers specify maximum and minimum tender prices. Appendix D of the working paper version discusses how the results generalize to conditional tender offers.

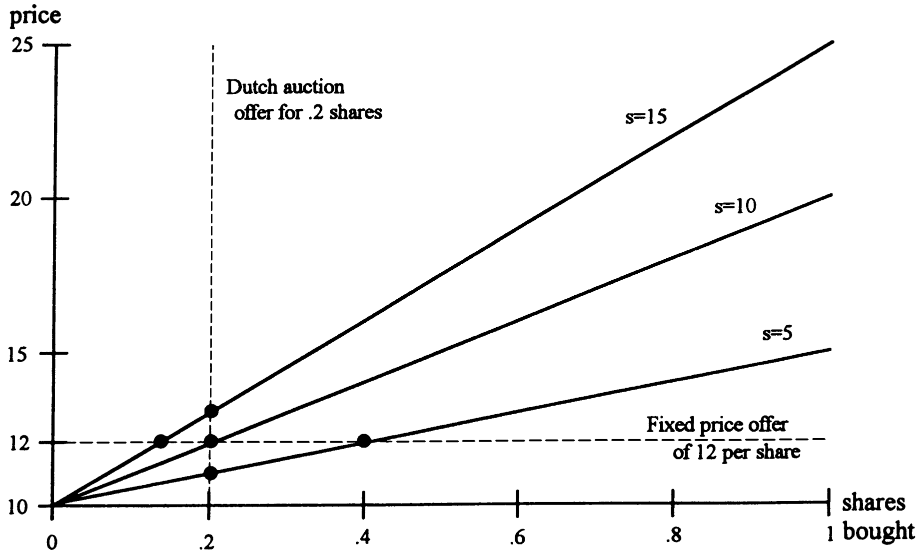

Figure 1. Example of Dutch auction and fixed price tender offer. The graph illustrates three possible outcomes of a Dutch auction offer to purchase 0.2 shares and a fixed price offer of 12 per share. The *slanted lines* are three realizations of the supply curve for the firm's shares. The firm's initial share value is 10.

value of 9.50 per share. For the Dutch auction offer, the repurchase prices for the realizations $s = 5$ and $s = 15$ are 11 and 13, as shown in the figure, and the resulting share values are 9.75 and 9.25, respectively. As one can see in Figure 2, a Dutch auction repurchase responds *linearly* to random shifts in the supply curve; as the supply curve gets steeper, the number of shares purchased remains fixed but the purchase price increases, and this reduces the value of the remaining shares in a linear fashion.

A fixed price tender offer responds quite differently to random shifts in the supply curve. As the supply curve gets steeper, the number of shares repurchased in a fixed price tender offer falls, and the value of the remaining shares increases. For the realizations $s = 5$ and $s = 15$, the firm repurchases 0.4 shares and 0.133 shares, respectively, as shown in Figure 1. The resulting share values are 8.67 and 9.69; an increase in the slope from 10 to 15 increases share value only 0.19, while a decrease from 10 to 5 decreases share value 0.83. As shown in Figure 2, the resulting share value is a *concave* function of the supply slope. Appendix A shows that these properties do not depend on the assumption that the supply curve is linear—they obtain for quite general concave supply curves.

The contrast between the linear behavior of Dutch auctions and the concave behavior of fixed price repurchases is crucial in what follows. In the signaling setting of Section II, the concavity of fixed price tender offers makes it more costly to send a false signal when the signaling mechanism is a fixed price tender offer. Because of this, fixed price repurchases prove to be more

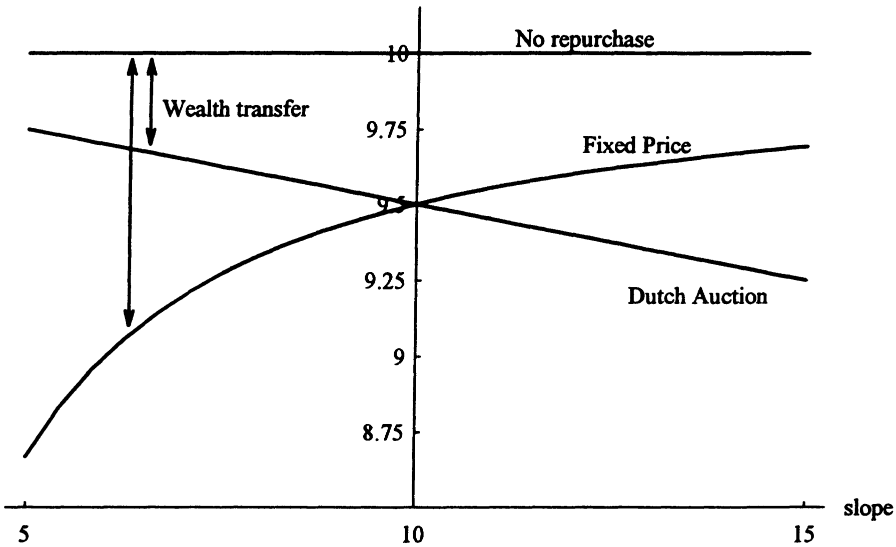

Figure 2. Postrepurchase stock price as a function of the realized supply slope. The graph plots the stock price that results from a fixed price offer at price 12 and a Dutch auction offer for 0.2 shares for the example from the text. The *horizontal line* is the stock price if there is no repurchase. This example has an initial share value of 10 and shareholder reservation values between 10 and 10 plus the slope. Random shocks to the supply curve affect a Dutch auction linearly, but a fixed price repurchase is concave in the supply slope.

effective signals than Dutch auction repurchases. In the corporate control setting of Section III, the bidder is deterred if the firm repurchases enough shares. This gives Dutch auction tender offers a natural advantage as a takeover defense, because the Dutch auction method eliminates the uncertainty about how many shares will be repurchased. This advantage is compounded by the linearity of the Dutch auction method. Consider two random functions that are equal when evaluated at the mean, but one function (the Dutch auction) is linear and the other function (the fixed price repurchase) is concave. By Jensen's inequality, the expected value of the linear function is higher than the expected value of the concave function. Because of this, a Dutch auction repurchase yields a higher expected stock value than a "comparable" fixed price repurchase.

Here is a brief summary of the model's empirical implications. Firms that wish to signal that their shares are undervalued are more likely to make a fixed price repurchase, while firms that wish to deter a takeover are more likely to choose the Dutch auction method. The probability that a control contest is avoided is very high when a Dutch auction is the optimal defense but is low when a fixed price offer is the optimal defense. The permanent change in firm value tends to be larger when fixed price repurchases are made than when Dutch auction repurchases are made. Dutch auctions are more likely when there is less dispersion in shareholder reservation values, i.e., when the supply curve for the firm's shares is more elastic. Dutch auctions are also more likely when there is less uncertainty about this elasticity. Finally, Dutch auction repurchases are more likely when the manager's fortunes are tied more closely to the long-term performance of the firm than to the short-term performance of the firm.

The only other article I know of that provides a theoretical comparison of fixed price tender offers and Dutch auctions is Gay, Kale, and Noe (1991). They report simulation results that demonstrate the advantages of Dutch auctions over fixed price tender offers in several dimensions: probability of acquiring a minimum number of shares, expected purchase price, expected proration, and expected reservation price of the median remaining shareholder. Since Dutch auctions dominate fixed price offers in their analysis, their model provides no motivation for choosing the fixed price method. In the present model, fixed price repurchases dominate Dutch auctions as signaling tools.

The rest of the article is organized as follows. Section I describes the model's assumptions about shareholder behavior and tender offer methods. Section II analyzes an asymmetric information model where repurchases signal firm value. Section III analyzes corporate control, with share repurchases serving as a method of deterring takeovers. Section IV discusses the model's empirical implications and existing evidence, and Section V concludes. All proofs are in Appendix B.

I. Modeling Repurchases with Heterogeneous Shareholders

I begin with an all-equity firm that is worth V, whose shares are held by a continuum of infinitesimally small investors. Normalize the number of shares outstanding to 1, so that V is also the value per share before any repurchase is made. I assume throughout that repurchases are financed by riskless borrowing, and they cause no change in the firm's investment policy. I also abstract from any valuation effects of capital structure such as tax advantages of debt or costs of financial distress. Thus a repurchase does not change the total (intrinsic) value of the firm V, but it replaces some of the firm's equity with debt.

If the firm repurchases α shares at a price of P per share, the value of the new debt must be $P\alpha$, so $V - P\alpha$ is the value of the remaining equity. Since the number of shares outstanding has been reduced from 1 to $1 - \alpha$, share value after the repurchase is

$$\frac{V - P\alpha}{1 - \alpha} = V - \frac{(P - V)\alpha}{1 - \alpha}. \tag{1}$$

When the firm repurchases shares at a premium over their value ($P > V$), the per-share value of the remaining shares decreases by $(P - V)\alpha/(1 - \alpha)$ because wealth is transferred to the departing shareholders. The numerator is the total premium paid to the departing shareholders (α shares at a premium of $P - V$ per share); this is divided by $1 - \alpha$ because the premium is borne by the remaining $1 - \alpha$ shares. I will often refer to this reduction in share value as the cost of the wealth transfer to departing shareholders.

Because shareholders have heterogeneous reservation values, the firm faces an upward-sloping supply curve when repurchasing its shares. Shareholders have heterogeneous reservation prices even though there are no differences of opinion about the fundamental value of the shares. The heterogeneity may arise from different tax rates, original purchase prices or expected holding periods (because these affect the incremental tax liability from selling immediately rather than later) or from different transaction costs, liquidity needs, or portfolio rebalancing needs.[5] While shareholders have different reservation prices (asking prices), I assume that all investors agree on the value of the shares in the sense that they are willing to pay the same amount to purchase additional shares—they have identical bid prices even though current shareholders have heterogeneous asking prices. The assumption of identical bid prices is natural if the stock has a close substitute available in the capital market. For ease of exposition, I follow Stulz (1988) in assuming that the supply curve is linear, but Appendix A shows that the results hold under much more general conditions.

To be precise about the assumed tendering behavior of shareholders, some notation is needed. Shareholder tendering is uncertain, and ω denotes an element of the state space. If the firm makes a fixed price tender offer to purchase shares at a price P per share, the number of shares tendered is denoted $\alpha_T(P, \omega)$, with $\alpha_T(\cdot, \omega)$ assumed continuous. If the firm makes a Dutch auction tender offer for α shares, the repurchase price is denoted $P_T(\alpha, \omega)$, with $P_T(\cdot, \omega)$ also assumed continuous.

Let $B(\omega)$ denote the lowest price at which shareholders will tender some shares, i.e., $B(\omega) = \inf\{P | \alpha_T(P, \omega) > 0\}$. This minimum price is the intercept of the share supply curve. The first assumption says that the uncertainty concerns the elasticity of the supply curve, not the intercept of the curve.

ASSUMPTION 1: *$B(\omega)$ is independent of ω.*

In the signaling setting of Section II, this base price B depends on what investors infer to be the true value of the firm; in the corporate control setting of Section III, it depends on the expected outcome of a control contest.

The second assumption about tendering behavior is that α_T and P_T are inverses. If shareholders respond to a fixed price tender offer of \$10 per share by tendering 25 percent of the shares, then they respond to a Dutch auction offer to buy 25 percent of the shares by requiring a purchase price of \$10 per share.

[5] Many articles discuss the potential causes and effects of inelastic share supply, for instance, Bagwell (1991a, 1992), Bradley, Desai, and Kim (1983), Brown (1988), Brown and Ryngaert (1992), Persons (1993), and Stulz (1988).

ASSUMPTION 2: *For any P with $0 < \alpha_T(P, \omega) < 1$, $P_T(\alpha_T(P, \omega), \omega) = P$.*

The third assumption is that the supply curve is linear. Suppose increasing the number of shares purchased in a Dutch auction from 10 to 15 percent increases the purchase price by \$1 per share. Then increasing the size of the repurchase to 20 percent increases the purchase price by an additional \$1 per share.

ASSUMPTION 3: *For any α between 0 and 1, $\partial P_T(\alpha, \omega)/\partial\alpha$ is a positive constant, say $s(\omega)$.*

I let $\bar{s} = E[s(\omega)]$ denote the expected slope, and assume that $\tilde{s}$ has a continuous distribution function F, density f, and support $[s_{\min}, s_{\max}]$ with $s_{\min} > 0$.

Assumptions 1 to 3 imply that the number of shares tendered into a fixed price tender offer is proportional to the premium offered above B: if the price offered is P per share, the number of shares tendered is $\tilde{\alpha} = (P - B)/\tilde{s}$.[6] Similarly, the premium required by shareholders in a Dutch auction tender offer is proportional to the number of shares repurchased: an offer to purchase α shares results in a purchase price (per share) of $\tilde{P} = B + \tilde{s}\alpha$.

As shown in equation (1), the postrepurchase share value is $(V - P\alpha)/(1 - \alpha)$, and either P or α is uncertain. In the case of a Dutch auction, the firm chooses α and the price $B + \tilde{s}\alpha$ is random. The resulting share value is

$$\frac{V - (B + \tilde{s}\alpha)\alpha}{1 - \alpha} = V - \frac{(B + \tilde{s}\alpha - V)\alpha}{1 - \alpha}, \tag{2}$$

where the last term is the cost of the wealth transfer to departing shareholders. Notice that this share value is a linear function of s, the slope of the supply curve. As the supply slope varies stochastically, the wealth transfer and share value respond linearly. In the case of a fixed price tender offer, the firm chooses P and the number of shares $(P - B)/\tilde{s}$ is random. The share value resulting from a fixed price offer is

$$\frac{V - P(P - B)/\tilde{s}}{1 - (P - B)/\tilde{s}} = V - \frac{(P - V)(P - B)/\tilde{s}}{1 - (P - B)/\tilde{s}}, \tag{3}$$

where again the last term is the cost of the wealth transfer to tendering shareholders. For a fixed price tender offer, this term is *convex* in s, so the share value is concave. This contrast between Dutch auctions and fixed price tender offers is illustrated in Figure 2 for the case $V = 10$.

Two factors contribute to make the cost of the wealth transfer convex (and the resulting share value concave) in s for fixed price repurchases. As the supply curve gets steeper, the number of shares repurchased (α) shrinks, so the per-share wealth transfer, $(P - V)\alpha/(1 - \alpha)$, shrinks. The first factor

[6] I disallow fixed price offers with $P > B + s_{\min}$; such offers result in *all* shares being tendered when s is small. I require that some shareholders remain after the repurchase, i.e., the firm must have some residual claimants.

causing convexity is that this wealth transfer is a convex function of α. The *gross* wealth transfer, $(P - V)\alpha$, is linear in α, but the *per-share* wealth transfer is not. When $\alpha = 0.9$, for instance, a decrease of 0.1 in shares purchased doubles the number of remaining shareholders from 0.1 to 0.2, dramatically reducing the per-share wealth transfer. But when $\alpha = 0.2$, a decrease of 0.1 in shares purchased increases the number of remaining shareholders by only 12.5 percent. As α decreases, the per-share wealth transfer shrinks, but at a slower and slower rate. The second factor is that the number of shares purchased decreases at an ever-slower rate—$\alpha'(s)$ is not constant—making α a convex function of s. For example, in Figure 1, increasing the slope from 5 to 10 reduces the number of shares purchased by 0.2 (from 0.4 to 0.2), but increasing the slope from 10 to 15 reduces the number of shares purchased by only 0.067 (from 0.2 to 0.133). If $\alpha(s)$ were linear, the per-share wealth transfer would be convex because of the first factor; the second factor adds "more convexity" to the wealth transfer (and more concavity to the postrepurchase stock price). Both effects are absent from a Dutch auction because the number of shares repurchased is fixed, and the purchase price responds linearly to supply curve shocks.

II. Signaling with Repurchases

This section examines repurchases as signals of undervaluation. The manager knows the value V of the firm (which I call the "true" or "intrinsic" value), but investors are uncertain about this value. V takes one of two values, H (high) or L (low). A manager who learns that his or her firm is a high-value firm might choose to signal to the market that the value is high by repurchasing shares. A repurchase is a credible signal if it is large enough that a low-value firm would not be willing to mimic the strategy.

Recall that investors are unanimous in their estimate of value, i.e., they are all willing to pay the same price for a share; let V_M denote the market's estimate of the value of the firm. Then the intrinsic value per share after a repurchase is $(V - P\alpha)/(1 - \alpha)$, while the market value per share is $(V_M - P\alpha)/(1 - \alpha)$. These two values are identical in a signaling equilibrium, because the manager's actions reveal V to investors. Nevertheless, it is important to distinguish between them, because the minimum repurchase that provides a credible signal is determined by considering *out-of-equilibrium* actions.

Following Miller and Rock (1985) and many others, I assume that the manager maximizes a weighted average of expected market value and expected intrinsic value. The uncertainty arises from uncertain shareholder tendering. The manager's objective is to maximize

$$(1 - \tau)E\left[\frac{V_M - \tilde{P}\tilde{\alpha}}{1 - \tilde{\alpha}}\right] + \tau E\left[\frac{V - \tilde{P}\tilde{\alpha}}{1 - \tilde{\alpha}}\right], \tag{4}$$

where τ is the weight the manager places on the true or intrinsic share value.[7] One can view τ as a measure of the manager's patience—the manager's current information will eventually be reflected in the stock price, and a patient manager (τ close to 1) is more willing to wait for this to happen. An impatient manager (τ close to 0) has a stronger urge to correct the market's mispricing when the firm's shares are undervalued. He or she is therefore more willing to pay a premium to tendering shareholders to signal this favorable information.

When responding to a tender offer, shareholder reservation prices depend on the value V_M they impute to the firm. A fixed price tender offer must carry a purchase price higher than V_M to attract any shares; no one will sell their shares to the firm for less than this, because other investors are willing to pay V_M for the shares. I assume that offering a small premium above V_M will induce *some* shareholders to sell. This being so, the inferred value of the firm V_M plays the role of B from Section I—it is the intercept of the supply curve. If the firm makes a fixed price tender offer P, shareholders tender $(P - V_M)/\tilde{s}$ shares; if the firm makes a Dutch auction tender offer α, the repurchase price is V_M plus a premium $\tilde{s}\alpha$.[8]

Let P^* denote the smallest fixed price offer that convinces investors the firm has high value (so $V_M = H$), and let α^* be the smallest credible Dutch auction signal. (The values P^* and α^* will be determined subsequently.) If a high-value firm signals by making the fixed price tender offer P^*, the "signaling payoff" is

$$E\left[\frac{H - P^*(P^* - H)/\tilde{s}}{1 - (P^* - H)/\tilde{s}}\right] = H - E\left[\frac{(P^* - H)^2/\tilde{s}}{1 - (P^* - H)/\tilde{s}}\right] \equiv H - C_F, \tag{5}$$

where C_F can be considered the cost of signaling with a fixed price repurchase—it is the expected loss in share value that results from asymmetric information. Similarly, if a high-value firm signals by making the Dutch auction offer α^*, the signaling payoff is

$$E\left[\frac{H - (H + \tilde{s}\alpha^*)\alpha^*}{1 - \alpha^*}\right] = H - E\left[\frac{\tilde{s}\alpha^{*2}}{1 - \alpha^*}\right]$$

$$= H - \frac{\bar{s}\alpha^{*2}}{1 - \alpha^*} \equiv H - C_D, \tag{6}$$

[7]The manager is concerned with the welfare of the shareholders who remain, not those who sell out in a tender offer. This can be motivated either by assuming the manager owns some shares and doesn't participate in the repurchase, or by recognizing that it is the remaining shareholders that the manager must satisfy in the future, so that their welfare is paramount.

[8]Although the current notation does not recognize the possibility, the premium demanded by shareholders might depend on how valuable they think the firm is. This would not affect the results of the article. One could allow supply elasticity to depend on V_M by introducing a different distribution of $\tilde{s}$ for each V_M. The relevant distribution for the following analysis would then be the one that applies when $V_M = H$, i.e., when investors believe the firm is a high-value firm.

where C_D is the cost of signaling with a Dutch auction. To prove that signaling with a fixed price repurchase is preferred, one must show that C_F is less than C_D.

The credible signals P^* and α^* are determined by the payoffs to the manager of a low-value firm if he or she were to send a *false* signal. If a low-value firm offered to repurchase shares at price P^*, investors would be fooled into thinking the firm is worth H, and the market price of the stock would be $[H - P^*(P^* - H)/\tilde{s}]/[1 - (P^* - H)/\tilde{s}]$. The *intrinsic* share value, known to the manager, would be $[L - P^*(P^* - H)/\tilde{s}]/[1 - (P^* - H)/\tilde{s}]$, and the imposter's expected payoff would be

$$(1 - \tau)E\left[\frac{H - P^*(P^* - H)/\tilde{s}}{1 - (P^* - H)/\tilde{s}}\right] + \tau E\left[\frac{L - P^*(P^* - H)/\tilde{s}}{1 - (P^* - H)/\tilde{s}}\right].$$

If the low-value firm makes no repurchase, the manager's payoff is just L. The credible signaling price must be high enough to prevent a low-value firm from imitating, so P^* is given implicitly by

$$(1 - \tau)E\left[\frac{H - P^*(P^* - H)/\tilde{s}}{1 - (P^* - H)/\tilde{s}}\right] + \tau E\left[\frac{L - P^*(P^* - H)/\tilde{s}}{1 - (P^* - H)/\tilde{s}}\right] = L.^9 \quad (7)$$

Similarly, the smallest credible Dutch auction signal is determined by

$$(1 - \tau)E\left[\frac{H - (H + \tilde{s}\alpha^*)\alpha^*}{1 - \alpha^*}\right] + \tau E\left[\frac{L - (H + \tilde{s}\alpha^*)\alpha^*}{1 - \alpha^*}\right] = L. \quad (8)$$

Here is where the concavity of fixed price repurchases and the linearity of Dutch auctions come into play. They ensure that the fixed price signal, P^*, is less than the expected purchase price, $E[H + \tilde{s}\alpha^*] = H + \bar{s}\alpha^*$, under the Dutch auction signal. For suppose that $P^* \geq H + \bar{s}\alpha^*$, which also means $(P^* - H)/\bar{s} \geq \alpha^*$. Applying Jensen's inequality to equation (7) yields

$$\begin{aligned} L &= (1 - \tau)E\left[\frac{H - P^*(P^* - H)/\tilde{s}}{1 - (P^* - H)/\tilde{s}}\right] + \tau E\left[\frac{L - P^*(P^* - H)/\tilde{s}}{1 - (P^* - H)/\tilde{s}}\right] \\ &< (1 - \tau)\left(\frac{H - P^*(P^* - H)/\bar{s}}{1 - (P^* - H)/\bar{s}}\right) + \tau\left(\frac{L - P^*(P^* - H)/\bar{s}}{1 - (P^* - H)/\bar{s}}\right) \\ &\leq (1 - \tau)\left(\frac{H - (H + \bar{s}\alpha^*)\alpha^*}{1 - \alpha^*}\right) + \tau\left(\frac{L - (H + \bar{s}\alpha^*)\alpha^*)}{1 - \alpha^*}\right), \end{aligned}$$

and this contradicts equation (8). Thus, we must have $P^* < H + \bar{s}\alpha^*$.

[9] Recall (footnote 6) that fixed price offers with $P \geq V_M + s_{\min}$ are disallowed because they might result in all shares being tendered. I assume in the text that there is an offer with price less than $H + s_{\min}$ that satisfies equation (7), so P^* is well-defined. Appendix C of the working paper version shows that this assumption is justified under weak conditions. While equation (7) defines P^* implicitly, one cannot solve for P^* in closed form.

Unfortunately, one cannot conclude that fixed price signals dominate just because the purchase price is less than the expected purchase price resulting from a Dutch auction signal—$P^* < H + \bar{s}\alpha^*$ does not guarantee $C_F < C_D$. To illustrate, suppose $H = 10$, $L = 8$, $\tau = 1/2$, and $\tilde{s}$ is uniformly distributed on [5, 15]. Then the three supply curves in Figure 1 are the mean $\bar{s} = 10$ and the two extreme values $s_{\min} = 5$ and $s_{\max} = 15$. Using equation (8), the required Dutch auction signal is $\alpha^* \approx 0.23166$, which produces an expected purchase price of $H + \bar{s}\alpha^* \approx 12.32$. From equation (6), the Dutch auction signaling payoff is then 9.30. Suppose for a moment that the fixed price signal for this example is $P^* = 12.30$, which is less than the expected 12.32 purchase price under the Dutch auction.[10] Then the fixed price signaling payoff would be $E[(H - P^*(P^* - H)/\tilde{s})/(1 - (P^* - H)/\tilde{s})] \approx 9.18$, worse than the Dutch auction signaling payoff; $P^* < H + \bar{s}\alpha^*$ does not guarantee $C_F < C_D$. So more work is required to prove that the fixed price repurchase is a better signaling device.

Using equation (5), one can write the fixed price no-mimicry condition (7) as

$$(1 - \tau)(H - C_F) + \tau(L - [(P^* - L)/(P^* - H)]C_F) = L. \tag{9}$$

$H - C_F$ is the market price if the firm sends the signal P^*, while $L - [(P^* - L)/(P^* - H)]C_F$ is the intrinsic share value of a low-value firm that sends a false signal. One can think of $[(P^* - L)/(P^* - H)]C_F$ as the cost of *false* signaling, and equation (9) makes the important point that the cost of false signaling with a fixed price repurchase is proportional to the cost of truthful signaling C_F. The constant of proportionality is $(P^* - L)/(P^* - H)$; the numerator is the true premium paid by an imposter, and the denominator is the premium paid by a truthful signaler. Notice that this ratio gets larger as P^* gets smaller—the lower is P^*, the greater is the cost of false signaling relative to the cost of truthful signaling. Rearranging equation (9) produces the following expression for the cost of signaling with a fixed price tender offer:

$$C_F = \frac{(1 - \tau)(H - L)}{1 + \tau(H - L)/(P^* - H)}. \tag{10}$$

Using equation (6), one can write the Dutch auction no-mimicry condition (8) as

$$(1 - \tau)(H - C_D) + \tau(L - [(H + \bar{s}\alpha^* - L)/(\bar{s}\alpha^*)]C_D) = L, \tag{11}$$

which has the same interpretation as equation (9). Since the expected purchase price under a Dutch auction signal is $H + \bar{s}\alpha^*$, the constant of propor-

[10] In reality, this example has $P^* = 12.13$.

tionality is the ratio of expected premiums paid by an imposter and a truthful signaler. Rearranging equation (11) yields

$$C_D = \frac{(1 - \tau)(H - L)}{1 + \tau(H - L)/(\bar{s}\alpha^*)}. \tag{12}$$

Comparing equations (10) and (12), we see that the problem has now been reduced to comparing $P^* - H$ with $\bar{s}\alpha^*$, and we have already seen that $P^* < H + \bar{s}\alpha^*$ (the fixed price signal is less than the expected price from a Dutch auction). This proves that C_F is less than C_D, so fixed price signals are better than Dutch auction signals. The fact $P^* < H + \bar{s}\alpha^*$ was insufficient, in itself, to conclude that fixed price signals dominate. However, once the no-mimicry conditions (7) and (8) are analyzed, $P^* < H + \bar{s}\alpha^*$ guarantees that fixed price signals dominate after all.

Fixed price signals are better because they deter imitation more efficiently —concavity makes imitation more costly. The cost of false signaling relative to the cost of truthful signaling is captured by the ratio of (expected) premiums: $(P^* - L)/(P^* - H)$ for fixed price offers and $(H + \bar{s}\alpha^* - L)/(\bar{s}\alpha^*)$ for Dutch auctions. The concavity of fixed price offers implies $P^* < H + \bar{s}\alpha^*$, and this guarantees that the cost ratio is higher for fixed price offers than for Dutch auctions.

PROPOSITION 1: *The signaling payoff is higher for a fixed price tender offer than for a Dutch auction tender offer.*

What happens to the signaling advantage of fixed price tender offers when the amount of uncertainty about shareholder tendering increases? Because the payoff from a Dutch auction is linear in s, changing the distribution of $\tilde{s}$ (without changing its mean) has no effect on α^*. But because of the concavity of fixed price repurchases, an increase in the risk of $\tilde{s}$ (in the sense of Rothschild and Stiglitz (1970)), reduces the expected share value from a given tender offer. The signaling price P^*, defined by equation (7), decreases—because of the increased risk, a smaller repurchase is sufficient to prevent imitation. Since P^* falls and α^* is unchanged, equations (10) and (12) immediately imply that the signaling advantage of fixed price offers increases when the amount of uncertainty increases.

PROPOSITION 2: *The difference between the signaling payoffs for a fixed price tender offer and a Dutch auction tender offer increases when the risk of $\tilde{s}$ increases (in the sense of Rothschild and Stiglitz* (1970)).

Fixed price repurchases are always more effective signals than Dutch auction repurchases in this model, but as the supply curve gets very elastic, this advantage dwindles. Consider what happens when the supply curve gets very flat. A signaling firm can buy a lot of shares at a price barely higher than H; because the premium $P^* - H$ is tiny, the cost of signaling becomes negligible. Nevertheless, a low-value firm is unwilling to imitate the offer—the cost of *false* signaling is nonnegligible because an imposter would be paying a nonnegligible premium over true value, namely $P^* - L$. Signaling with either method becomes almost costless as supply elasticity increases; the fixed price signaling payoff is always higher, but the difference in signaling payoffs between the two methods gets squeezed toward 0.

The signaling advantage of a fixed price offer also vanishes as the manager becomes very patient (τ approaches 1). A patient manager places great weight on intrinsic share value rather than market value, and so is very reluctant to take steps that reduce true share value but increase market value. If a low-value firm imitates a high-value firm, this action increases its market value because the market is fooled into thinking the firm is worth H, but decreases its intrinsic share value because of the premium paid to the departing shareholders. The larger is τ, the smaller are the benefits of imitation and the greater are the costs of imitation. Therefore, when τ is close to 1, a relatively small signal is enough to convince investors the firm is worth H. Since the required signal is small, the cost of signaling is small for either method, and the advantage of a fixed price signal over a Dutch auction signal cannot be very great; as τ goes to 1, the fixed price signaling advantage goes to 0.

PROPOSITION 3: *The difference between the signaling payoffs for a fixed price tender offer and a Dutch auction tender offer approaches* 0 *as the expected slope of the supply curve* $\bar{s}$ *approaches* 0, *and as the manager's patience* τ *increases to* 1.

The proposition is proved easily using equation (12), which implies $0 < C_D \leq [(1 - \tau)(H - L)]/[1 + \tau(H - L)/\bar{s}]$. Since this upper bound approaches 0 as $\bar{s} \to 0$ and as $\tau \to 1$, C_D must approach 0 also. Because $C_D > C_F$ by Proposition 1, this implies $C_D - C_F \to 0$.

A fixed price repurchase is always preferred when signaling is the only consideration, but suppose the manager has other concerns as well (such as maintaining corporate control, discussed in the next section). Propositions 2 and 3 suggest that Dutch auctions are more likely when there is little uncertainty about shareholder reservation values, when the supply curve is elastic, and when the manager is patient, because other considerations that favor a Dutch auction could easily outweigh the signaling advantages of a fixed price repurchase.

III. Takeover Deterrence with Repurchases

In this section, I assume there is a potential bidder for the firm, and the manager may choose to repurchase some shares to prevent the bidder from attempting a takeover. Repurchasing shares may concentrate ownership in hands friendly to management and reduce the probability that the bidder would prevail in a fight for control.[11] Under current management, the firm is

[11] Harris and Raviv (1988) and Stulz (1988) present models of corporate control based on the control of voting rights by management.

worth V per share, and this is common knowledge. A control battle is good news for shareholders, since it is expected to increase the value of their shares by $g \geq 0$ per share. This increase in value could come from increased efficiency forced upon the current management team, from increased efficiency achieved by replacing management, or from a premium received by shareholders in a merger or acquisition. If no shares are repurchased, a control battle will ensue, and the expected share value that results is $V + g$. I therefore assume the firm must offer a premium above $V + g$ in order to purchase any shares; $V + g$ plays the role of B in equations (2) and (3). If there were no bidder, shareholders would be willing to sell at prices above V, but the bidder's presence shifts the supply curve upward by g. For convenience, I will refer to g as the expected takeover premium.[12]

Suppose the manager attempts to preempt a control contest by repurchasing some shares. If the firm makes a fixed price tender offer of $P \geq V + g$ per share, the number of shares tendered is proportional to the premium offered: $\tilde{\alpha} = (P - V - g)/\tilde{s}$. If instead the firm makes a Dutch auction tender offer for α shares, the repurchase premium is proportional to the number of shares purchased: $\tilde{P} = V + g + \tilde{s}\alpha$. I assume the bidder will desist if the firm repurchases enough shares—at least π shares, with $0 < \pi < 1$. In this case, incumbent management retains control; otherwise, a control contest ensues. The higher is π, the more shares the firm must purchase to deter the bidder, so I call π the bidder's "persistence."[13]

The manager's expected utility depends on the expected value of the firm's shares, but also depends directly on whether there is a battle for control of the firm. In a control contest, the manager bears a personal cost that is not reflected in the share price. The expected cost, expressed on a per-share basis, is denoted c. This can be thought of as the expected cost of finding new employment plus the expected loss of future income (because some of the manager's human capital is specific to his or her current firm) if the manager is fired, or the expected loss of perquisite consumption if the manager is forced to manage the firm more efficiently. I refer to c as the manager's private benefits of control or control rents.[14]

If the firm succeeds in purchasing at least π shares, the bidder desists and the firm's equity is worth $(V - P\alpha)/(1 - \alpha)$ per share. If the firm purchases fewer than π shares, a battle ensues and shareholders expect an additional g

[12] Related to the discussion in footnote 8, it is not important that the distribution of $\tilde{s}$ be independent of g. The basic results are unaffected if the premiums that shareholders demand from the firm (above $V + g$) depend on the expected takeover premium. However, the results of Proposition 5 (concerning the optimal defensive strategy when g is large or small) take the distribution of $\tilde{s}$ as fixed.

[13] I have assumed that the probability of a control battle is a step function: the probability is 1 if $\alpha < \pi$ and 0 if $\alpha \geq \pi$. Nothing substantive would change if this probability were continuous but approximately a step function. The probability of a control battle could fall slowly when α is small, fall rapidly around the threshold π, and then fall slowly again for larger α.

[14] Assuming the manager derives private benefits from controlling the firm is quite common. Grossman and Hart (1988) and Harris and Raviv (1988) are two prominent examples.

per share above the value under current management; in addition, the manager bears the private cost c. Since the manager is risk neutral, his or her objective is to maximize

$$\Pr[\tilde{\alpha} \geq \pi] E\left[\frac{V - \tilde{P}\tilde{\alpha}}{1 - \tilde{\alpha}} \middle| \tilde{\alpha} \geq \pi\right] + \Pr[\tilde{\alpha} < \pi] E\left[\frac{V - \tilde{P}\tilde{\alpha}}{1 - \tilde{\alpha}} + g - c \middle| \tilde{\alpha} < \pi\right],$$

which can be written as

$$V - E\left[\frac{(\tilde{P} - V)\tilde{\alpha}}{1 - \tilde{\alpha}}\right] - \Pr[\tilde{\alpha} < \pi](c - g). \tag{13}$$

The first term is firm value under current management, the second term is the (expected) cost of the wealth transfer to departing shareholders, and the third term is the (expected) net cost to the *manager* of a control battle. Here is one interpretation of this objective function. Suppose the manager owns β shares and, in the event of a control contest, the manager is fired and loses firm-specific human capital of K or must forego perquisites worth K. Then the manager's private benefits of control would be $c = K/\beta$, and the manager would maximize expression (13). I restrict attention to the interesting case where $c > g$; if the control rents were smaller than the takeover premium, the manager would never repurchase shares to prevent a control battle.

If the manager makes no repurchase ("does nothing"), his or her utility is simply $V + g - c$: the control contest yields shareholders an expected takeover premium, g, but the manager loses the control rents, c. Suppose instead that the firm makes a Dutch auction tender offer for α shares. Using expression (13), the manager's utility is

$$\begin{aligned} U_D(\alpha) &= V - E\left[\frac{(g + \tilde{s}\alpha)\alpha}{1 - \alpha}\right] - \Pr[\alpha < \pi](c - g) \\ &= V - \frac{(g + \bar{s}\alpha)\alpha}{1 - \alpha} - I(\alpha < \pi)(c - g), \end{aligned} \tag{14}$$

where $I(\cdot)$ is the indicator function. The only Dutch auction offer that could possibly be an optimal strategy is $\alpha = \pi$. Any offer $\alpha < \pi$ does not deter the bidder, but merely transfers wealth to departing shareholders, and any offer $\alpha > \pi$ transfers more wealth to departing shareholders with no marginal benefit, since $\alpha = \pi$ is enough to deter the bidder.

The Dutch auction offer $\alpha = \pi$ yields utility $V - (g + \bar{s}\pi)\pi/(1 - \pi)$, while doing nothing yields $V + g - c$. A Dutch auction is preferred to taking no action if the first payoff is larger, i.e., if

$$c > \frac{g + \bar{s}\pi^2}{1 - \pi}. \tag{15}$$

The left-hand side is the control rents preserved by the repurchase, while the right-hand side combines the foregone takeover premium and the wealth transfer to shareholders bought out in the repurchase.

The manager's third option is to make a fixed price tender offer. Using expression (13), a fixed price offer at a price $P \geq V + g$ per share yields utility

$$U_F(P) = V - E\left[\frac{(P - V)(P - V - g)/\tilde{s}}{1 - (P - V - g)/\tilde{s}}\right] - \Pr\left[\frac{P - V - g}{\tilde{s}} < \pi\right](c - g).^{15} \tag{16}$$

Letting $m = P - V - g$ denote the premium offered, this can be written more simply as

$$U_F(V + g + m) = V - (m + g)mE\left[\frac{1}{\tilde{s} - m}\right] - \Pr\left[\tilde{s} > \frac{m}{\pi}\right](c - g). \tag{17}$$

As one increases the repurchase premium, m, the second term increases in magnitude because more wealth is transferred to tendering shareholders, and the third term decreases in magnitude because a control contest becomes less likely. The net penalty $c - g$ is incurred when s turns out to be larger than m/π, i.e., when the supply curve is steep enough that fewer than π shares are repurchased.

The lemma below delimits the set of potentially optimal fixed price tender offers to those with premiums between $s_{\min}\pi$ and $\bar{s}\pi$. The manager never makes a fixed price offer with premium $m \leq s_{\min}\pi$ because it has zero probability of deterring the bidder, and the manager never makes an offer with premium $m \geq \bar{s}\pi$ because the Dutch auction offer $\alpha = \pi$ is always better (this is explained below). We therefore know that, in any cases where a fixed price tender offer is chosen, the firm will "probably" fail to deter the bidder. The bidder leaves only when $s \leq m/\pi < (\bar{s}\pi)/\pi = \bar{s}$, so a successful defense requires that the supply curve be flatter than expected. A control battle ensues whenever the supply curve is steeper than expected, and in some cases when it is flatter than expected. The probability that the bidder is deterred is less than $\Pr[\tilde{s} < \bar{s}]$; if the distribution of $\tilde{s}$ is approximately symmetric, the repurchase successfully deters the bidder less than half the time.

LEMMA 1: *If a fixed price tender offer is an optimal defense, the repurchase price P satisfies* $s_{\min}\pi < P - V - g < \bar{s}\pi$.

[15]As mentioned in footnote 6, tender offers with $P \geq V + g + s_{\min}$ are disallowed because they would result in all outstanding shares being tendered when s is small. The formula applies to offers with $V + g \leq P < V + g + s_{\min}$.

COROLLARY: *If a fixed price tender offer is an optimal defense, the probability that the bidder is deterred is less than* $Pr[\tilde{s} < \bar{s}]$.

The manager never makes a fixed price tender offer at a price of $P = V + g + \bar{s}\pi$ (or higher) because the Dutch auction offer $\alpha = \pi$ is better. One reason the Dutch auction is better is that it guarantees the bidder is deterred and the manager's control rents are preserved. The second reason the Dutch auction is better is that the expected wealth transfer is less burdensome. This second point deserves explanation. The Dutch auction offer $\alpha = \pi$ produces an expected repurchase price of $E[V + g + \tilde{s}\pi] = V + g + \bar{s}\pi$; why is the wealth transfer less onerous than for a fixed price repurchase at this very price? The reason once again is that the cost of the wealth transfer is linear for the Dutch auction but convex for the fixed price offer.[16] Linearity gives Dutch auctions a second advantage in matters of corporate control.

To summarize, the only strategies the manager will ever choose when facing a potential bidder are: (i) do nothing and allow a control battle to ensue; (ii) make the Dutch auction offer $\alpha = \pi$ and guarantee control; or (iii) make a fixed price offer with a premium between $s_{\min}\pi$ and $\bar{s}\pi$ and run some risk of a control battle. The following proposition shows that the choice among these three alternatives depends on how important control is to the manager. We know from inequality (15) that a Dutch auction is preferred to standing pat when c is large and standing pat is preferred to a Dutch auction when c is small. But it is not obvious how a fixed price tender offer interacts with the other two possibilities. The proposition shows that when control is relatively unimportant to the manager (c is small), it is optimal to make no repurchase, even though $c > g$. When control is very important (c is large), it is optimal to guarantee control through the Dutch auction $\alpha = \pi$. For intermediate values of c, the manager may choose to bear some risk of a control contest by making a fixed price offer. However, this intermediate interval may be empty—for some parameterizations $(V, g, \pi, F(\cdot))$, a fixed price offer is *never* used to deter a takeover, regardless of c.

[16] The cost of the wealth transfer is $(\tilde{P} - V)\tilde{\alpha}/(1 - \tilde{\alpha})$, as in equation (1). For the Dutch auction $\alpha = \pi$, the expected cost is

$$E\left[\frac{(V + g + \tilde{s}\pi - V)\pi}{1 - \pi}\right] = \frac{(g + \bar{s}\pi)\pi}{1 - \pi}.$$

For the fixed price offer $P = V + g + \bar{s}\pi$, the cost is

$$E\left[\frac{(V + g + \bar{s}\pi - V)(V + g + \bar{s}\pi - (V + g))/\tilde{s}}{1 - (V + g + \bar{s}\pi - (V + g))/\tilde{s}}\right]$$

$$= E\left[\frac{(g + \bar{s}\pi)\pi\bar{s}/\tilde{s}}{1 - \pi\bar{s}/\tilde{s}}\right] > \frac{(g + \bar{s}\pi)\pi\bar{s}/\bar{s}}{1 - \pi\bar{s}/\bar{s}} = \frac{(g + \bar{s}\pi)\pi}{1 - \pi},$$

the inequality from Jensen.

PROPOSITION 4: *There exist critical values c_1 and c_2 with $g < c_1 \leq c_2 < \infty$ such that: the Dutch auction tender offer $\alpha = \pi$ is the optimal defense when $c > c_2$, a fixed price tender offer is optimal when $c_1 < c < c_2$, and it is optimal to make no repurchase when $c < c_1$.*

Whereas fixed price repurchases are better for signaling, Dutch auctions are more effective takeover deterrents (corollary to Lemma 1), and are optimal takeover deterrents when control is important to the manager (Proposition 4). The model thus points toward different motives for the two types of repurchases.

Proposition 4 deals with the benefit side of the manager's calculus, since c is the benefit the manager derives from deterring the bidder. The next proposition deals with the *cost* of deterring the bidder, which depends on π, g, and s. Contemplating variations in π and g is straightfoward, but variations in the supply slope are less straightforward because $\tilde{s}$ is random. I therefore write $\tilde{s}$ as $\bar{s}\tilde{\eta}$, where $\tilde{\eta}$ has unit mean, and consider variations in the expected slope $\bar{s}$.

If the bidder is very persistent (π is large), the firm must purchase many shares to deter the bidder, and this transfers a lot of wealth to the departing shareholders. The larger the expected takeover premium g and the steeper the supply curve (expected slope $\bar{s}$), the higher the price the firm must pay to purchase a given number of shares. Again, this transfers more wealth to the shareholders who sell out. Proposition 5 gives results for these parameters that are similar to, but weaker than, the results for c in Proposition 4. A Dutch auction is optimal when the bidder is not very persistent, i.e., when π is small, because the cost of guaranteeing control through a Dutch auction is small. Similarly, a Dutch auction is optimal when g and $\bar{s}$ are both small because it is not very costly to guarantee control when the takeover premium is small and the supply curve is flat. Furthermore, standing pat is optimal when either g or $\bar{s}$ is large—any probability of deterring the bidder is too costly when these parameters are large enough.[17]

PROPOSITION 5: *There exist critical values $\hat{\pi} > 0$, $\hat{k} > 0$, $\hat{g} < c$, and $\hat{s} < \infty$ such that:*

1. *If $\pi < \hat{\pi}$ or $\max[g, \bar{s}] < \hat{k}$, the Dutch auction tender offer $\alpha = \pi$ is optimal.*
2. *If $g > \hat{g}$ or $\bar{s} > \hat{s}$, it is optimal to make no repurchase.*

Part 1 of the proposition suggests that a fixed price tender offer is unlikely when supply is very elastic: when g and $\bar{s}$ are below some cutoff, the Dutch auction repurchase is optimal. We had a similar implication regarding signal-

[17] One is tempted to conclude that standing pat must be optimal when the bidder is very persistent, because large π makes it costly to deter the bidder. However, one cannot rule out fixed price tender offers just because π is large. When $s_{\min}$ is small, a fixed price tender offer at even a small premium will produce some probability of deterring the bidder, and the expected benefits of retaining control may exceed the cost of purchasing shares at a premium.

ing in Proposition 3. A fixed price repurchase is always an optimal signal, but the advantage of signaling with the fixed price method vanishes as $\bar{s}$ gets small. Both signaling and control considerations suggest that more elastic share supply tilts matters toward the Dutch auction method.

The final result about takeover deterrence concerns the degree of uncertainty about shareholder heterogeneity. As in Proposition 2 in the signaling setting, we find that greater uncertainty about the supply curve favors the fixed price method. In particular, a fixed price repurchase cannot be an optimal takeover defense unless there is "enough" uncertainty about the supply curve. Consider expanding or contracting the distribution of $\tilde{s}$ around its mean, as illustrated in Figure 3. Specifically, let $\delta = s - \bar{s}$ denote the deviation from the mean, and define F_γ by

$$F_\gamma(s) = F_\gamma(\bar{s} + \delta) = F\left(\bar{s} + \frac{\delta}{\gamma}\right) \quad \text{for} \quad 0 < \gamma < \frac{1}{1 - s_{\min}/\bar{s}}, \tag{18}$$

where F is the distribution function of $\tilde{s}$. F_γ is a probability distribution that still has mean $\bar{s}$. Setting $\gamma = 1$ gives the original distribution; $\gamma < 1$ contracts the distribution toward its mean, and $\gamma > 1$ expands the distribution away from its mean. (The upper bound on γ ensures that the slope of the supply curve is never negative, which would be nonsensical.) Increasing γ increases the risk of $\tilde{s}$ in the sense of Rothschild and Stiglitz (1970).

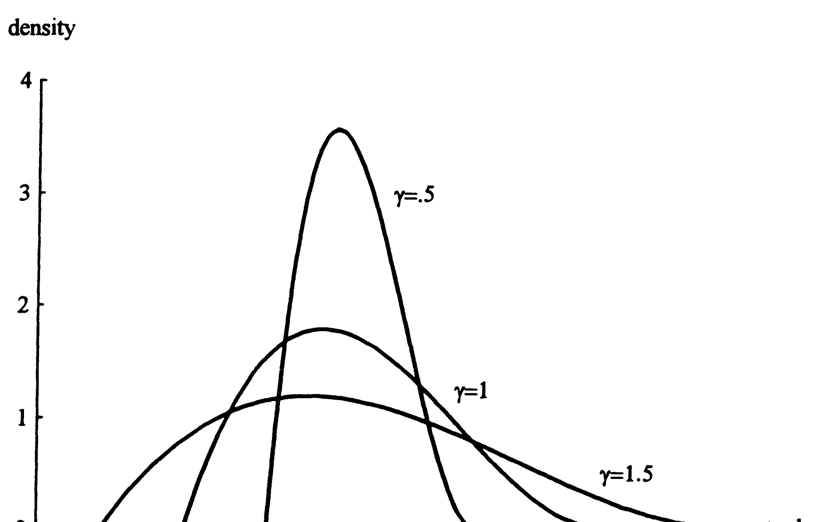

Figure 3. Example of changing the uncertainty about the supply curve. Proposition 6 shows that there must be a relatively large amount of uncertainty about the supply curve (γ must be large enough) in order for a fixed price tender offer to be an optimal takeover deterrent. For $\gamma = 1$ in this particular example, slope/10 has a translated beta distribution with parameters 2 and 3.

Proposition 6 shows that a fixed price tender offer requires a relatively large amount of uncertainty about shareholder tendering—γ must be above some (positive) cutoff. When γ is below this cutoff value, a fixed price tender offer is suboptimal; the manager either makes a Dutch auction offer or does nothing, depending on the direction of the inequality in condition (15).

PROPOSITION 6: *Consider any class $\{F_\gamma\}$ of probability distributions for $\tilde{s}$, as in (18). Then there exists a critical value $\hat{\gamma} > 0$ such that a fixed price tender offer is never an optimal defense when $\gamma < \hat{\gamma}$.*

Note that the proposition provides only a necessary condition for a fixed price tender offer to be optimal, i.e., $\gamma \geq \hat{\gamma}$. Depending on the other parameters, it may be that a fixed price offer is never chosen, even when γ is large.

IV. Empirical Implications

The model predicts that fixed price repurchases are better signaling devices than Dutch auction repurchases. Comment and Jarrell (1991) analyze fixed price and Dutch auction tender offers (as well as open market repurchases) and conclude, consistent with the model, that fixed price offers are more effective signals. The evidence in Lee, Mikkelson, and Partch (1992) is also supportive. They find unusually heavy buying and unusually light selling by insiders in the six months preceding fixed price repurchases but no such evidence preceding Dutch auction repurchases. Their conclusion is that only fixed price repurchases are information motivated.

The model predicts that Dutch auction repurchases are better takeover deterrents than fixed price repurchases, although fixed price offers may be chosen when it is too costly to guarantee control through a Dutch auction offer for π shares. This is broadly consistent with the relative frequency of Dutch auction repurchases in Table I. While the first Dutch auction repurchase was made in 1981, the Dutch auction method was very rare until the takeover market heated up in the mid-1980s. The popularity of Dutch auctions relative to fixed price repurchases reached its peak (to date) in 1989, the same year takeover activity reached its peak.[18]

In the model, Dutch auctions always succeed in deterring the bidder. In those cases where the manager chooses a fixed price tender offer as a takeover deterrent, there is a large probability that the repurchase fails to deter the bidder. The model thus predicts a higher probability of a control contest following a defensive fixed price repurchase than following a defensive Dutch auction.

The model implies that fixed price offers increase the market value of the firm (adjusted for any cash payout) because they signal high firm value.

[18] For 1980 to 1992, the correlation between number of repurchases and merger activity is 0.91 for Dutch auctions and 0.18 for fixed price repurchases. If one excludes 1980 to 1983 (Dutch auctions were a recent innovation), the difference is somewhat less stark: 0.91 for Dutch auctions and 0.47 for fixed price repurchases.

Table I

Historical Data—Tender Offer Repurchases and Merger Activity

Repurchase frequencies for 1984 through 1989 are from Comment and Jarrell (1991). Dutch auction frequencies prior to 1984 are from Gay, Kale, and Noe (1990). Fixed price repurchase frequencies prior to 1984 were provided by Josef Lakonishok from the database used in Lakonishok and Vermaelen (1990). Repurchase frequencies beyond 1989 were collected by searching University Microfilms' *Wall Street Journal Ondisc*. Data on merger activity for 1983 through 1992 are from the *Mergers & Acquisitions M & A Almanac* for 1992; data for 1980 through 1982 are from the *M & A Almanac* for 1989. These data are adjusted for the price level using the GNP implicit price deflator.

Year	No. of Fixed Price Offers	No. of Dutch Auction Offers	Dutch Auctions ÷ Total Offers	Merger Activity ($Billion 1992)
1980	19	0	0.00	56.9
1981	27	1	0.04	103.7
1982	26	3	0.10	85.5
1983	11	2	0.15	98.8
1984	21	2	0.09	200.0
1985	11	6	0.35	189.5
1986	12	10	0.45	275.4
1987	21	9	0.30	238.5
1988	16	21	0.57	327.2
1989	13	24	0.65	353.3
1990	8	10	0.56	220.2
1991	4	3	0.43	145.2
1992	5	5	0.50	125.3

There is substantial empirical evidence consistent with this hypothesis.[19] The predicted price effects of control-oriented repurchases are more complex. There is a temporary positive effect because the repurchase offer gives shareholders the opportunity to sell their shares at an above-market price. There is a permanent negative effect on firm value because the repurchase reduces the probability of a value-increasing takeover. There is a further permanent negative effect on *share* value (but not firm value) because wealth is being transferred to the departing shareholders. Finally, there is a positive effect on firm value if the repurchase offer reveals the presence of a bidder or increases the public's estimated probability that a bidder will appear.[20] Even if the firm successfully deters the bidder, this last effect will persist—to some degree—until investors conclude that no other bidder is forthcoming. Because of these complications, predicting price reactions to defensive offers is somewhat precarious. The model certainly predicts a negative *permanent* price

[19] See the studies listed in footnote 1.

[20] For example, Denis (1990) reports a positive average announcement effect for defensive repurchases, but the average announcement effect is negative for those firms (33 of 40) where hostile activity was already publicly known. These repurchases include open market repurchases and exchange offers, as well as repurchase tender offers.

effect for repurchases that succeed in deterring the bidder. In estimating this price effect, care must be taken to account for any expectation that a new bid or bidder will appear. For defensive payouts, Denis (1990) reports a negative average return from announcement through contest outcome when management retains control, but a positive average return when the bidder or a third party acquires control. This is consistent with the current model, but the sample is not limited to repurchase tender offers—it includes open market repurchases, exchange offers, and special dividends.

Because fixed price offers are better signals (with positive price implications), and Dutch auctions are better takeover deterrents (with mixed or negative price implications), the model suggests larger increases in value from fixed price repurchases than from Dutch auction repurchases. Comment and Jarrell (1991) report larger announcement returns for fixed price offers, but these should be interpreted carefully because of the first temporary price effect described in the previous paragraph. Kamma, Kanatas, and Raymar (1992) calculate the weighted average return to tendering and nontendering shareholders from offer announcement to offer outcome; this measure avoids the temporary price effect. They find a marginally higher average return for fixed price offers (8.6 versus 7.9 percent).

If one accepts the notion that small firms are more inclined to signal than large firms—because information asymmetries are more substantial or because insiders hold a greater fraction of the firm—then this prediction is also consistent with the empirical facts about the size of repurchasing firms. The evidence indicates that firms that choose the fixed price method are dramatically smaller than firms that use the Dutch auction method. In Comment and Jarrell's (1991) sample, the median size of fixed price repurchasers is $96 million and the median size of Dutch auction repurchasers is $1035 million.

The model has interesting implications about the amount of dispersion in shareholder reservation prices. Recall that $\bar{s}$ is the expected range of reservation prices, i.e., the expected slope of the supply curve. In the signaling setting of Section II, the signaling advantage of fixed price offers goes to 0 as $\bar{s}$ gets small. In the control setting of Section III, Dutch auctions are always optimal when g and $\bar{s}$ are small. One would therefore expect to observe Dutch auction repurchases when the supply curve is relatively flat; fixed price repurchases are more likely when the supply curve is relatively steep. Bagwell (1993) presents evidence consistent with this prediction. Using a sample of fixed price tender offers and Dutch auctions, she estimates a simultaneous equation model. One equation estimates supply elasticity as a function of: (i) fraction of shares held by officers and directors; (ii) fraction of shares held by institutions; (iii) a dummy variable for inclusion in the S&P 500; (iv) a dummy variable for New York Stock Exchange listing; and (v) firm size. The second equation estimates the choice of repurchase method as a function of these same variables plus the fraction of shares sought in the offer. Consistent with this model, she finds that greater supply elasticity favors the Dutch auction method. Furthermore, she cannot reject the hypothesis that variables (i) through (v) affect the choice of repurchase method only through their effect on supply elasticity. Her findings suggest that the choice of repurchase method exhibits an "elasticity effect" rather than a "size effect" or "institutional investor effect" (for instance).

There are similar implications regarding the degree of uncertainty about shareholder reservation prices. In the signaling setting, the advantage of fixed price offers increases as one increases the risk of $\tilde{s}$. In the corporate control setting, fixed price offers can be optimal only when the distribution of $\tilde{s}$ is "spread out" (γ is large in equation (18)). In both cases, more uncertainty about shareholder reservation prices pushes the manager toward a fixed price offer. Since large firms have many more shareholders than small firms, the law of large numbers may hold more sway with large firms, thus reducing the uncertainty about the supply curve. This would tend to make Dutch auctions more attractive for large firms.

The model also predicts that the signaling advantage of fixed price repurchases shrinks as the manager becomes very patient. This suggests that managers whose compensation is tied more closely to long-term performance than to short-term performance are more likely to choose the Dutch auction method for repurchasing shares. For example, managers with shares/options that cannot be sold/exercised for a long time should be inclined toward Dutch auctions. Managers in industries where executives are less mobile would also be more inclined toward Dutch auctions, because this reduces the manager's ability to exploit good short-term performance in the external labor market.

V. Conclusion

This article has presented a model of managerial choice between Dutch auction repurchases and fixed price repurchases. Fixed price repurchases are more effective signals of undervaluation, and Dutch auction repurchases are more effective takeover deterrents. The model yields empirical implications regarding price effects, likelihood of control changes, supply elasticity, supply uncertainty, and management compensation. The model's predictions are consistent with much existing evidence, and the model suggests additional factors that may help us understand the empirical evidence regarding tender offer repurchases.

Appendix A

Generalized Supply Curves

This appendix introduces more general conditions on the share supply curve that sustain the article's results. In the text, the supply curve had the linear form $P_T(\alpha, \omega) = B + s(\omega)\alpha$, which can be inverted to give $\alpha_T(P, \omega) = (P - B)/s(\omega)$. It was assumed that $\tilde{s} = s(\omega)$ was continuously distributed on $[s_{\min}, s_{\max}]$. The results of the article do not depend on a linear supply curve, however—they can be sustained with fairly general concavity. If the supply curve is "too convex," the results will fail.

Shareholder α is willing to sell at some price above B, but the manager is uncertain about the shareholder's reservation price. Denote the minimum possible price $B + \underline{m}(\alpha)$ and the maximum possible price $B + M(\alpha)$, and let $r(\alpha) = M(\alpha) - \underline{m}(\alpha)$ denote the range of possible reservation prices for shareholder α. Make the following assumptions:

ASSUMPTION A1: *The "lowest" shareholder is willing to sell at B: $\underline{m}(0) = M(0) = 0$.*

ASSUMPTION A2: *There is uncertainty: $M(\alpha) > \underline{m}(\alpha)$ for all $\alpha > 0$.*

ASSUMPTION A3: *The upper bound and lower bound supply curves are increasing and concave: $\underline{m}'(\alpha) > 0$, $\underline{m}''(\alpha) \leq 0$, $M'(\alpha) > 0$ and $M''(\alpha) \leq 0$.*

ASSUMPTION A4: *The realized supply curve is a weighted average of these two extremes:*

$$P_T(\alpha, \omega) = B + (1 - \theta(\omega))\underline{m}(\alpha) + \theta(\omega)M(\alpha) = B + \underline{m}(\alpha) + \theta(\omega)r(\alpha), \tag{19}$$

where $\tilde{\theta} = \theta(\omega)$ is a random variable distributed (continuously) on $[0,1]$.

ASSUMPTION A5: *There is more uncertainty about shareholders with higher reservation prices, so $r(\alpha)$ is increasing.*

These assumptions permit the supply curve to be any concave function with intercept B, plus some noise that enters through the random variable $\tilde{\theta}$. The variable $\tilde{\theta}$ captures the uncertain supply elasticity: θ close to 1 means the supply curve is "steep" (close to $B + M(\alpha)$), and θ close to 0 means the supply curve is "flat" (close to $B + \underline{m}(\alpha)$). The special case treated in the text has $\underline{m}(\alpha) = s_{\min}\alpha$, $M(\alpha) = s_{\max}\alpha$, and $r(\alpha) = (s_{\max} - s_{\min})\alpha$. I henceforth omit reference to the underlying state ω and write $P_T(\alpha, \theta)$.

Since the supply curve might not be linear, it doesn't necessarily have a single slope. We can, however, define the average slope

$$\begin{aligned} s(\theta) &= \int_0^1 \frac{\partial}{\partial \alpha} P_T(\alpha, \theta)\, d\alpha \\ &= \int_0^1 \underline{m}'(\alpha) + \theta r'(\alpha)\, d\alpha = \underline{m}(1) + \theta r(1). \end{aligned}$$

By analogy with the linear case, denote the expectation of this random variable $\bar{s} = E[s(\tilde{\theta})] = \underline{m}(1) + E[\tilde{\theta}]r(1)$.

Given this more general formulation, one cannot write a closed-form expression for the inverse function $\alpha_T(P, \theta)$, but this inverse function is described implicitly by

$$P \equiv B + \underline{m}(\alpha_T(P, \theta)) + \theta r(\alpha_T(P, \theta)).$$

Differentiating with respect to θ shows that α_T is decreasing and convex in θ, just as α_T is decreasing and convex in s for the linear case. Specifically,

$$\frac{\partial}{\partial\theta}\alpha_T(P,\theta) = \frac{-r(\alpha_T)}{\underline{m}'(\alpha_T) + \theta r'(\alpha_T)} < 0$$

and

$$\frac{\partial^2}{\partial\theta^2}\alpha_T(P,\theta) = \frac{r(\alpha_T)}{[\underline{m}'(\alpha_T) + \theta r'(\alpha_T)]^2} \times \left\{2r'(\alpha_T) - r(\alpha_T)\frac{\underline{m}''(\alpha_T) + \theta r''(\alpha_T)}{\underline{m}'(\alpha_T) + \theta r'(\alpha_T)}\right\} > 0,$$

where α_T on the right-hand side is shorthand for $\alpha_T(P,\theta)$. (Signing the second derivative uses the fact that $\underline{m}'' + \theta r'' \leq 0$, which follows from $\underline{m}'' + r'' = (\underline{m} + r)'' = M'' \leq 0$, the last inequality by Assumption A3 above.

The analogue of equation (2) for a Dutch auction repurchase is then

$$\frac{V - P_T(\alpha,\theta)\alpha}{1-\alpha} = V - \frac{(P_T(\alpha,\theta) - V)\alpha}{1-\alpha}. \tag{20}$$

Note that this share value resulting from a Dutch auction is linear in P_T. Furthermore, one can see from equation (19) that P_T is linear in θ. Therefore, the share value resulting from a Dutch auction repurchase is linear in θ *regardless of the shape of the supply curve*. A linear supply curve is unimportant because the share value resulting from a Dutch auction responds linearly to shocks θ even when the supply curve is nonlinear. The analogue of equation (3) for a fixed price repurchase is

$$\frac{V - P\alpha_T(P,\theta)}{1-\alpha_T(P,\theta)} = V - \frac{(P - V)\alpha_T(P,\theta)}{1-\alpha_T(P,\theta)}. \tag{21}$$

One can show that this share value is a concave function of θ, using the fact that α_T is decreasing and convex. This is where the (weak) concavity of the supply curve is important. If the supply curve were convex enough, the share value resulting from a fixed price tender offer would not be concave in θ. Thus the more general formulation preserves the essential characteristics of the special case treated in the text: a Dutch auction responds linearly to supply curve shocks, while a fixed price repurchase is concave.

Propositions 1, 3, 4, and 5 remain true in this more general setting, and the proofs follow the pattern of the proofs in the text or in Appendix B. Propositions 2 and 6 remain correct if we consider altering the distribution of $\tilde{\theta}$ rather than the distribution of $\tilde{s}$.

Appendix B

Proof of Proposition 2: I must show that $C_D - C_F$ increases when the risk of $\tilde{s}$ increases. It is clear from equation (8) that mean-preserving changes in the distribution of $\tilde{s}$ do not change α^*; therefore, C_D is also unaffected. From Rothschild and Stiglitz (1970) and the fact that the functions in equation (7) are concave in s, an increase in the risk of $\tilde{s}$ reduces the left-hand side of equation (7) for any given repurchase price. Therefore, P^* must decrease with such a change in risk to maintain equality in equation (7). From (10), this decrease in P^* decreases C_F.

Proof of Lemma 1: Using (17), a fixed price offer gives a payoff of

$$U_F(V + g + m) = V - (m + g)mE\left[\frac{1}{\tilde{s} - m}\right] - \Pr\left[\tilde{s} > \frac{m}{\pi}\right](c - g)$$
$$< V - \Pr\left[\tilde{s} > \frac{m}{\pi}\right](c - g).$$

If $m \leq s_{\min}\pi$, the probability is 1, so $U_F < V - (c - g)$, which is the payoff from standing pat. Thus, a fixed price offer can be optimal only if $m > s_{\min}\pi$, or $P - V - g > s_{\min}\pi$.

Recall that offers with premiums of $s_{\min}$ or more are disallowed because all shares might be repurchased. If $\bar{s}\pi \geq s_{\min}$, the conclusion $P - V - g < \bar{s}\pi$ is vacuous because $P - V - g < s_{\min} \leq \bar{s}\pi$ by assumption. So assume $\bar{s}\pi < s_{\min}$. Since $1/(s - m)$ is convex in s, applying Jensen's inequality to equation (17) shows that

$$U_F(V + g + m) < V - (m + g)m\frac{1}{\bar{s} - m} - \Pr\left[\tilde{s} > \frac{m}{\pi}\right](c - g)$$
$$< V - \frac{(g + m)m}{\bar{s} - m}. \tag{22}$$

From equation (14), the Dutch auction offer $\alpha = \pi$ yields

$$U_D(\pi) = V - \frac{(g + \bar{s}\pi)\pi}{1 - \pi} = V - \frac{(g + \bar{s}\pi)\bar{s}\pi}{\bar{s} - \bar{s}\pi}. \tag{23}$$

Comparing inequality (22) and equation (23), a fixed price offer can be optimal only if $m < \bar{s}\pi$, i.e., if $P - V - g < \bar{s}\pi$, and the lemma is proved.

Proof of Proposition 4: Doing nothing gives the manager a payoff $V + g - c$; this is decreasing in c at rate -1. The payoff from the Dutch auction $\alpha = \pi$ is $V - (g + \bar{s}\pi)\pi/(1 - \pi)$, independent of c (see equation (14)). Reproducing equation (17), a fixed price offer with premium $P - V - g = m$ yields

$$U_F(V + g + m) = V - (m + g)mE\left[\frac{1}{\tilde{s} - m}\right] - \Pr\left[\tilde{s} > \frac{m}{\pi}\right](c - g). \tag{24}$$

This payoff is decreasing in c at rate

$$-\Pr[\tilde{s} > m/\pi] > -\Pr[\tilde{s} > s_{\min}] = -1,$$

using Lemma 1. If a Dutch auction is optimal for some c, it is optimal for all larger c because the payoffs from the other two strategies decrease in c. If standing pat is optimal for some c, it is optimal for all smaller c because the payoff from standing pat increases at the fastest rate as c shrinks. Thus, the set on which a particular type of strategy is optimal is connected, as claimed in the proposition.

It remains to show that the Dutch auction is optimal for some finite c, and that doing nothing is optimal for some $c > g$. It is clear that a Dutch auction must be optimal for some c, because the Dutch auction payoff is independent of c and the other two payoffs decrease without bound as c grows large. To see that it is optimal to make no repurchase when c is close to g, first notice that as $c \downarrow g$, the payoff from doing nothing approaches V. The payoff from the Dutch auction $\alpha = \pi$ is less than V and is independent of c, so standing pat is preferred to a Dutch auction when c is small. All that is left is to consider fixed price offers with $s_{\min}\pi < m < \bar{s}\pi$ (Lemma 1). Using the first line of inequality (22), we have the following upper bound for all such offers:

$$\begin{aligned} U_F(V+g+m) &< V - (m+g)m\frac{1}{\bar{s}-m} - \Pr\left[\tilde{s} > \frac{m}{\pi}\right](c-g) \\ &< V - (s_{\min}\pi + g)s_{\min}\pi/(\bar{s} - s_{\min}\pi) - \Pr[\tilde{s} > \bar{s}](c-g). \end{aligned} \tag{25}$$

Because this is strictly less than V, standing pat is optimal when c is close enough to g, and the proof is complete.

Proof of Proposition 5: Consider the payoffs from the three potentially optimal strategies (do nothing; Dutch auction $\alpha = \pi$; fixed price offer with $s_{\min}\pi < m < \bar{s}\pi$) as $\pi \to 0$. The payoff from standing pat is $V + g - c$, independent of π. Using equation (14), the payoff from the Dutch auction approaches V as π approaches 0, so a Dutch auction is better than standing pat when π is small. Using inequality (25), the payoff from any fixed price offer is less than $V - \Pr[\tilde{s} > \bar{s}](c-g)$. Since this is strictly less than V, a Dutch auction is preferred to any fixed price offer when π is small enough. This establishes the existence of $\hat{\pi}$.

Now consider changes in $\max[g, \bar{s}]$. The payoff from the Dutch auction $\alpha = \pi$ is $V - (g + \bar{s}\pi)\pi/(1-\pi)$. Since $g + \bar{s}\pi \to 0$ as $\max[g, \bar{s}] \to 0$, this payoff approaches V as $\max[g, \bar{s}]$ gets small. The payoff from standing pat is $V + g - c$, which approaches $V - c < V$ as $\max[g, \bar{s}] \to 0$. Thus the Dutch auction is better than standing pat when $\max[g, \bar{s}]$ is small. Using inequality (25), a fixed price offer has a payoff less than $V - \Pr[\tilde{s} > \bar{s}](c-g) = V -$

$\Pr[\tilde{\eta} > 1](c - g)$. As $\max[g, \bar{s}] \to 0$, $g \to 0$ and this upper bound approaches $V - \Pr[\tilde{s} > \bar{s}]c < V$. Thus, for $\max[g, \bar{s}]$ close to 0, the Dutch auction is also better than any fixed price offer, and this establishes the existence of $\hat{k}$.

As $\bar{s}$ gets large, the payoff from the Dutch auction $\alpha = \pi$ decreases unboundedly, while the payoff from making no repurchase is unchanged, so doing nothing is better than a Dutch auction when $\bar{s}$ is large. Doing nothing is also better than any fixed price repurchase for $\bar{s}$ large. To see this, rewrite inequality (25) as

$$U_F(V + g + m) < V - \frac{(\bar{s}\eta_{\min}\pi + g)\bar{s}\eta_{\min}\pi}{\bar{s} - \bar{s}\eta_{\min}\pi} - \Pr[\tilde{s} > \bar{s}](c - g)$$

$$= V - \frac{(\bar{s}\eta_{\min}\pi + g)\eta_{\min}\pi}{1 - \eta_{\min}\pi} - \Pr[\tilde{\eta} > 1](c - g).$$

This upper bound on the fixed price offer goes toward $-\infty$ as $\bar{s}$ grows. This establishes $\hat{s}$.

As $g \uparrow c$, the payoff from standing pat approaches V; the Dutch auction and fixed price payoffs are both less than V and decreasing in g. Thus, making no repurchase is optimal when g is close to c, which proves that $\hat{g}$ exists.

Proof of Proposition 6: Let $s_{\gamma\min}$ be the lower bound of the support of $\tilde{s}_\gamma$, i.e., $s_{\gamma\min} = \inf\{s | F_\gamma(s) > 0\}$. From the definition in equation (18) of F_γ, $\bar{s} - s_{\gamma\min} = \gamma(\bar{s} - s_{\min})$, so $s_{\gamma\min} \to \bar{s}$ as $\gamma \to 0$. By Lemma 1, an optimal fixed price tender offer must have a premium m between $s_{\gamma\min}\pi$ and $\bar{s}\pi$. Using inequality (25), the payoff from any such offer is less than

$$V - \frac{(s_{\gamma\min}\pi + g)s_{\gamma\min}\pi}{\bar{s} - s_{\gamma\min}\pi} - \Pr\left[\tilde{s}_\gamma > \bar{s}\right](c - g)$$

$$= V - \frac{(s_{\gamma\min}\pi + g)s_{\gamma\min}\pi}{\bar{s} - s_{\gamma\min}\pi} - \Pr[\tilde{s} > \bar{s}](c - g),$$

since the probability $\Pr[\tilde{s}_\gamma > \bar{s}]$ is independent of γ. As $s_{\gamma\min}$ approaches $\bar{s}$, this upper bound approaches

$$V - (\bar{s}\pi + g)\pi/(1 - \pi) - \Pr[\tilde{s} > \bar{s}](c - g) < V - (\bar{s}\pi + g)\pi/(1 - \pi),$$

which is the payoff from the Dutch auction offer $\alpha = \pi$. Since $s_{\gamma\min} \to \bar{s}$ as $\gamma \to 0$, there is some positive $\hat{\gamma}$ below which a fixed price tender offer cannot be optimal.

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