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Free Cash Flow, Signaling and the Dividend Puzzle

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by

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Abstract

The work in this paper contributes to two of the most topical issues in the study of corporate financial policy: Free Cash Flow theory and the Dividend providing a new explanation for the dividend puzzle. It is argued that two types of asymmetric information problems are inherent in the relationship between shareholders (as principles) and managers (as the shareholders' agents), and therefore the payment scheme between them will be designed to mitigate these problems. The conflict of interest between shareholders and managers (such as the free cash flow problem) causes the board of directors (shareholders) to design managerial compensation schedules which are dependent upon a committed payment out of the firm. This paper argues that greater flexibility allowed by a compensation scheme based on dividends instead of debt leads to a preference for dividends in alleviating this agency problem. When management is also better informed as to the value of the firm (determined by the present value of future cash flows), and shareholders desire this value to be conveyed, then the committed payment can serve as a natural signal to alleviate this adverse selection problem. A major reason that no answer has been found to the dividend puzzle is that the objective function of the agents paying dividends has not been adequately modelled. It is shown here, however, that in many circumstances contracts based upon dividend payments can provide a simultaneous solution to both problems, whereas contracts based upon debt cannot. Thus, dividends may have an advantage over debt in alleviating the free cash flow type problems and that the legal force associated with debt may not be required. The contribution to the dividend puzzle literature is that an explanation is provided of why debt or retained earnings are not substituted for dividends.

Introduction:

The work in this paper contributes to two of the most topical issues in the financial theory of the firm: Free Cash Flow theory and the Dividend Puzzle[1]. The Free Cash Flow theories come from the arguments of Donaldson (1968) and more recently Jensen (1986), and stem from the assumption that management behave so as to maximize their power. In so doing they maximize the resources directly under their control (engage in empire building). This results in inefficient operating policy as managers desire to allocate excess cash to negative net present value investments instead of to alternatives which would increase shareholder wealth[2]. Essentially, the theory says that if management is left alone with excess cash they will play with it! Jensen (1986), and more recently Hart and Moore (1989, 1990) and Harris and Raviv (1990) argue that the legal force associated with debt render it an effective method of dealing with the inefficiencies associated with free cash flow type problems.

The Dividend Puzzle originated thirty years ago with the work of Modigliani and Miller (1958) and Miller and Modigliani (1961), who showed that the large tax disadvantage to shareholders associated with dividends as compared to capital gains implies that no dividends should be paid. The persistent widespread occurrence of dividends has caused the topic to remain a popular area of research ever since. In explaining why shareholders prefer to have cash used for dividends, one must explain why dividends are superior to alternative policies which allow capital gains. In general, capital gains will accrue if alternatives generate cash that can be used for share repurchases or retained earnings. If the same funds are distributed via a repurchase instead of a dividend, shareholders receive their cash in exchange for the shares they sell back to the firm. Shareholders then pay taxes only on the capital gains. The same amount of cash has been distributed but lower

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[1]For example, leading articles in the Journal of Finance by Harris and Raviv (1990) and Brennan and Thakor (1990) address Free Cash Flow and the Dividend Puzzle, respectively, as do recent working papers by Burnheim (1990) and Hart and Moore (1989, 1990).

[2]In this paper, such empire building or entrenching activities are considered perquisites, since management only has to undertake negative NPV projects if they *choose* to.

taxes have been incurred. Further, those shareholders who did not desire any liquidity at the time did not have to re-invest their dividends, and can defer their capital gains taxes[3]. If funds are retained instead of paid out as a dividend, the value of the firm should increase by the amount of the retention and thus the value of shares should also increase. Shareholders operating in competitive capital markets could then sell off some of their shares until they have received the same amount of cash as the dividend, but incur only the lower capital gains taxation.

In addition to the above methods of transforming dividends into capital gains, there are two more subtle methods. One method is through mergers and acquisitions, where the firm uses the dividends to buy other firms. In this case, the tendering shareholders face only capital gains taxation and the transaction is just like the investment of retained earnings for the shareholders of the acquiring firm. Another, more subtle method, involves the firm choosing a different capital structure. The new capital structure could involve increasing debt such that the interest payments increase by the amount of the dividend, and distributing the proceeds of the extra debt to shareholders (via a share repurchase). The value of this debt will be equal to the present value of the increased interest payments to investors, which will be the same as the present value of the dividend to investors, since both are subject to taxation at the full personal income tax rate. Thus, shareholders will have received the same distribution (in present value terms) but incurred only capital gains taxes. Additionally, this will leave the same amount of funds available for the operation of the firm, and therefore the ability for the firm to produce the same cash flows. However, instead of using these cash flows for dividends, the firm uses them for debt payments, and this produces a further tax saving. This is because interest is not subject to the same double taxation as dividends (because interest expenses are deductible in calculating corporate taxable income whereas dividends must be paid out of after-tax earnings). With the same amount of funds coming out of the firm, retained earnings are higher when the dividends have been converted to interest payments, and again the shareholders can sell

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[3]The work presented here does not address the repurchase alternative.

some of their shares for capital gains (if they so desire).

Despite the possibilities to transform dividends into capital gains, dividends have averaged about 45% of real after-tax profits over the last 20 years[4]. Estimates of *excess taxes* paid due to dividends range from 20 to 45 percent of the distributions[5]. This translates, for example, into $8 to $18 billion in the U.S. for 1985. These facts have caused many notable economists to call the payment of dividends the "premier puzzle" in corporate finance[6]. Although no completely satisfactory explanation of the dividend puzzle has yet evolved, recent research suggests that environments of asymmetric information are promising (e.g. Burnheim 1990, Brennan and Thakor, 1990).

This paper integrates the free cash flow and dividend puzzle literature, providing a new explanation for the dividend puzzle. It is argued that a major reason that no answer has been found to the dividend puzzle is that the objective function of the agents paying dividends has not been adequately modelled. Two types of asymmetric information problems are inherent in the relationship between shareholders (principles) and managers (the shareholders' agents). The conflict of interest between shareholders and managers (such as the free cash flow problem) causes the board of directors (shareholders) to design managerial compensation schedules which are dependent upon a committed payment out of the firm. This paper argues that greater flexibility allowed by a compensation scheme based on dividends instead of debt leads to a preference for dividends in alleviating this agency problem. When management is also better informed as to the value of the firm (determined by the present value of future cash flows), and shareholders desire this value to be conveyed, then the committed payment can serve as a natural signal to alleviate this adverse selection problem. It is shown here, however, that in many circumstances contracts based upon dividend

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[4]Feldstein and Green, AER 1983.

[5]Crockett and Friend, Review of Economics and Statistics, 1988.

[6]For example, F. Black (1976); B. D. Burnheim (1990); J. Crockett and I. Friend REStatistics 1988; M. Feldstein and J. Green AER 1983.

payments can provide a simultaneous solution to both problems, whereas contracts based upon debt cannot.

Thus, the work in this paper contributes to the free cash flow literature by endogenizing the objective function of managers, showing that dividends may have an advantage over debt in alleviating the free cash flow type problems and that the legal force associated with debt may not be required. The contribution to the dividend puzzle literature is that an explanation is provided of why debt or retained earnings are not substituted for dividends. Finally, it is argued that the most efficient method of dealing with the problems inherent to the firm will involve an explicit link between corporate financial policy and dividend policy[7].

Model:

The following definitions are used to model the relationship between managers, shareholders and the cash flows of the firm:

$F(I;\mu,\varepsilon) = F(I) + \mu + \varepsilon$ is the production function depending on investment, I, quality, $\mu \in [\underline{\mu}, \bar{\mu}]$ with density $h(\mu)$ (μ may represent characteristics innate to the firm and/or managerial ability), and random component, ε, with density function $f(\varepsilon)$,

D = Dividends policy undertaken by the firm,

Z = Zero NPV investments undertaken by the firm,

Q = cash spent on perQuisites which are consumed only by management: these include environment enhancing expenditures (management spend close to 1/2 of their awake lives at firm) such as dinners, parties, jet and limousine use, trips, top quality hotels, secretaries and office fixtures, contracts for friends, conducting business on the golf course, reduction in creative

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[7]In so doing, it is necessary to analyze a number of issues, such as the market for managerial labour, the legalities of labour contracts, the agency relationships between shareholders, managers and bondholders, the composition of the quality or value of a firm, etc.

entrepreneurial activities, reduced effort, enhancement of social status and/or career opportunities, empire building etc.

$x \equiv \tilde{F}(I;\mu,\varepsilon) + Z = \tilde{F}(I;\mu,\varepsilon) + Y - I - D - Q$ represents the end of period cash flow generated by the firm,

m = proportion of shares owned by management,

x^e = the exercise price on any stock options that may be included as managerial compensation,

B = debt undertaken by the firm,

$w(\delta)$ = wage compensation paid to managers conditional upon δ, where δ represents a vector of observables upon which the contracts can be contingent: here[8] $\delta = (D, B, m, x^e)$,

$EU^S(x, w(\delta))$ and $EU^M(w(\delta),Q)$ are the expected utilities of shareholders and management, respectively.

The optimal sharing rule (compensation contract) in this paper is that contract which maximizes the expected utility of shareholders subject to (i) a given level of expected utility of management, (ii) management acting to maximize their own expected utility, and (iv) revelation of the unknown quality parameter.

Before proceeding, a number of adjustments that will greatly simplify the subsequent analysis can be made. It is shown in related work[9] that so long as there is excess cash on hand and the opportunity to put this cash into Z, the optimal investment in positive NPV projects will always be undertaken (i.e. I will be increased until F'(I) is driven down to 1 since I will

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[8]More generally, this set could include warrants, convertibles, preferred stock, repurchases, etc., and these are discussed below. Also, each of the elements in this set could inter-depend upon each other. This also is not considered for now (e.g. I assume m and x^e do not change as the choice of D and B change).

[9]Douglas, A., Ph.D. Dissertation, Queen's University, in progress.

continue to dominate Z in the manager's expected utility function so long as $F'(I) > 1$). Thus, for the analysis here, "I" will be suppressed as a decision variable. It is also shown that the results are qualitatively unaltered whether dividends are "committed to" by paying dividends at the beginning of the period or by including the "commitment" in the contract. However, the analysis here can be illustrated more clearly if we simply assume that the commitment occurs via contracting[10], and thus only a final dividend will be modelled. These two simplifications allow us to consider x to depend only on μ and Q (and thus focusing directly on the quality and agency problems). For modelling purposes, this will enable us to follow the theory of contracts literature (Holmstrom 1979, Hart and Holmstrom 1987), and transform the variables so that x is modelled as the uncertain variable with the density function $f(x;\mu,Q,\varepsilon)$.

The analysis can be further simplified by assuming that capital markets are sufficiently complete so that $f(x;Q,\mu)$ represents an appropriate risk- and time-adjusted density function (such as the "equivalent martingale measure" of Harrison and Kreps (1979). This appropriate function can then be used to justify risk neutral shareholders and a zero rate of interest.

Thus, the problem here can be written as follows. Risk-neutral shareholders and management find a *set* of contracts $W(\delta)$ such that management selection of policy, δ^*, implies the selection of a *particular* $w^*(\delta^*)$ which simultaneously reveals firm type and aligns incentives. Thus, the following problem is solved:

$$\max_{\langle W(\delta),Q\rangle} \int_{-\infty}^{\infty} (x - w(x;\delta) - k(w(x;\delta))f(x;Q,\mu)dx$$

$$+ \lambda[E\mathcal{U}^M - \int_{-\infty}^{\infty} U(w(x;\delta))f(x;Q,\mu)dx - V(Q)]$$

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[10]However, as shown in another part of the thesis this is important in related work addressing multi-period dividend smoothing and the dividend versus repurchases question.

$$+ \xi[E\mathcal{U}(w(x;\delta)) + V(Q^*) \geq E\mathcal{U}(w(x;\delta)) + V(Q)]$$

$$+ \Phi[E\mathcal{U}(w(x;\delta^*)) + V(Q) \geq E\mathcal{U}(w(x;\delta)) + V(Q)]$$

and $w(\delta^*,\mu) \in W(\delta)$ provides a proper signal: $\delta \Rightarrow \mu \Rightarrow \delta(\mu)$ invertible $\Rightarrow f(x(\mu)) \Rightarrow Ew(\delta(\mu))$ and $E(x(\mu))$ and $E(k(\mu)) \Rightarrow E(x\text{-}w\text{-}k) \Rightarrow$ market value. Mathematically, monotonicity constraint which will imply invertibility can be written as:

$$+ \psi[d(\delta^*(\mu))/d\mu - h(\mu)].$$

Finally, we need the constraint that $w(x;\delta) \in [\underline{w}, \overline{w}]$, representing that legal restrictions, opportunity wages and wealth constraints will restrict the feasible values of the compensation paid to management.

The major differences from the original contracting problem are (i) there is simultaneous signalling and therefore a set of contracts must be offered so that quality can be revealed via self-selection, and (ii) shareholders cannot observe the internal workings of the firm, and in particular x is directly observable only to the agent and not the principle. This assumption is often made in the literature[11], with the main justification being that management can use aggregation of information etc. in such a way that accounting information does not have the same information as real cash flows, and that managers have a number of ways to divert cash into perquisites etc[12]. This implies that the compensation scheme must be based on observables such as dividends, debt, share-options etc.

The problem is still very complex, and in order to obtain results in particular areas of interest, certain simplifications can be made to this general structure. The next section shows that with no bankruptcy costs or taxes, dividends can dominate debt in solving this problem.

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[11]See Diamond (1984), Gale and Hellwig (1985), Harris and Raviv (1990), Hart and Moore (1989), Williams (1988) for example.

[12]See White (1984).

An Illustration of The Advantage of Dividends Over Debt.

The papers on free cash flow have argued that debt is a natural way to control free cash flow, as debt payments also are not subject to manipulation by management. Committing to future interest payments may align incentives in just the same way as a commitment to dividends[13]. Furthermore, the deductibility of interest expenses as opposed to the high rates of taxation on dividends would seem to suggest an advantage to debt. However, other concerns may make the use of dividends optimal even in light of the tax disadvantages. For example, an important concern may be reduced legal costs and the ability to maintain control of the firm when a committed payment is missed. Additionally, shareholders' ability to control management's compensation may be greater in the case of a missed dividend payment than in the case of bankruptcy (since they still have ownership rights in the former case). A greater set of equilibrium compensation schemes with the use of dividend policies may enable a more efficient solution when there are costs of making committed payments. These concerns may make the flexibility of dividends (relative to legally stringent debt contracts) desirable.

In order to find the most efficient way of aligning management's incentives, we must consider the costs of using each policy as well as the implications of any restrictions associated with each policy. The cost of using dividends is higher taxation. The cost of using debt could include legal costs of underwriting an issue, potential bankruptcy costs, "extra" sub-optimal investment incentives[14], foregone substitute tax shields such as investment

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[13]It is always in the interest of shareholders to align managerial incentives because the presence of rational investors in the debt market and the existence of competitive managerial labour markets (so that managers must attain a given level of expected utility) imply that shareholders bear all of the agency costs. A possible exception is if managers have firm specific human capital.

[14]The sub optimal investment decisions from the second reason has been recognized in the literature since Myers (1977) and Jensen and Meckling (1976). In the usual analysis some positive NPV projects are ignored, whereas here it is zero NPV projects that are passed up (with the sufficient funds assumption, the reduction is in Z). However, there is still a deadweight loss since the funds are instead used for over-consumption of perks. Also, with a strictly convex investment opportunity set (e.g. if

tax credits (D'Angelo and Masulis (1980)), etc. The arguments in this paper, however, will be made based only upon differences in the managerial compensation schedules.

The advantage of dividends over debt is most simply illustrated in the case where the uncertainty in the production is uniformly distributed: $\varepsilon \sim \text{unif}[\underline{\varepsilon}, \bar{\varepsilon}]$, so the proofs of propositions one and two will made under this assumption. When there is a bounded distribution on x and no bounds on the sharing rule the first best solution can be obtained via a step function. This is invoked via a huge penalty if an outcome below the lower bound associated with optimal action is observed. If such a penalty were possible, either debt or dividends could induce the first; however, it is assumed that (due to legal restrictions on the penalty that can be imposed) such a penalty is not possible. In this case, the adverse selection and agency problems must be alleviated via the incentives incorporated in the *uncertain* compensation of management.

Proposition 1: Any set of contracts based only on debt cannot simultaneously solve the signalling and perquisite problem. (Proof is given in the appendix).

The intuition for proposition 1 is as follows. The only information shareholders have is whether of not the debt payment has been met, so they can only offer a bonus contingent upon the payment being met. If the payment is not met the firm goes bankrupt (shareholders have lost control of the firm) and the bonus component of management compensation must be zero[15].

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costs of free cash flow become proportionally higher as free cash flow increases or if Z were to be modelled to include risk), there could be real costs of funds coming out of Z as well. In general, it should also be recognized that management may want a less risky firm than shareholders due to their human capital being tied to this firm. This is often cited as a reason for management taking too little risk (management are relatively more risk averse than shareholders). In this case, giving management shares offsets this because they then have incentive to expropriate bondholders, as above. Thus, the overall conflict of interest should be considered.

[15]Under bankruptcy law, executives are entitled to commissions and bonuses

The compensation contracts have the form depicted in figure 1. In order to change incentives, $\bar{w}$ must be raised above the first best level so that the gap between $\bar{w}$ and $\underline{w}$ increases. That $B > \underline{x}$ follows due to the assumption that $\underline{w}$ cannot set low enough to use the first best step function. Thus, to keep the manager's expected utility at $\overline{E\mathcal{U}}$, there must be some probability that $w = \underline{w}$. The possible outcomes of x are between the limits of the uniform distribution: $\underline{x}(\mu,Q)$ and $\bar{x}(\mu,Q)$. The distribution shifts right as μ increases or Q decreases (e.g. from the solid line distribution to the dotted line).

The marginal benefit of taking perks is $V'(Q)$, and the marginal cost is that there will be one more state of nature in which $w = \underline{w}$ instead of $\bar{w}$; this marginal cost is constant. Since the marginal benefit is decreasing, $V'' < 0$, management can be induced to take any level of Q by changing the marginal cost. To induce optimal perks requires that $\underline{w}$ and $\bar{w}$ be "fixed" where Q is chosen such that $V' = 1$ (since a dollar spent on perks costs a dollar).

The marginal benefit of increasing B will come from the increase in $\underline{w}(B)$ and $\bar{w}(B)$ (stipulated in the contract) and the marginal cost will again be that there will be one more state of nature in which $w = \underline{w}$ instead of $\bar{w}$. For a credible signalling equilibrium, it must be the case that it is easier for the higher quality firm to pay the higher B, or that $dB^*(\mu)/d\mu > 0$. However, this condition and optimal perks will be simultaneously impossible. The set of contracts must be offered to all managers, and therefore the MB of increasing B must be the same for all. Also, optimal perks requires that $V' = 1$ for all firms, which requires that $U(\bar{w}) - U(\underline{w})$ must be the same for all, which implies that the MC of increasing B must also be the same for all. This implies that all firms will choose the same B, and signalling is simultaneously impossible.

In the special case where management is risk neutral (figure 1): $U(w) = w$

$$\Rightarrow \bar{w}_B = \underline{w}_B = w_B \text{ for } Q^* \ \forall\ \mu \Rightarrow \partial\int w_B f dx/\partial\mu = 0 \text{ and } \partial\{[\bar{w} - \underline{w}]f\}/\partial\mu = 0\ \forall\ \mu$$

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only after all other creditors have been satisfied (see Kryzanowski, Gandhi and Gitman, 1982, p831).

$$\Rightarrow \partial^2 E\mathcal{U}/\partial B\partial\mu = \partial\int w_B f dx/\partial\mu - \partial\{[\overline{w} - \underline{w}]f\}/\partial\mu = 0 \ \forall \ \mu$$

$$\Rightarrow \text{no signalling equilibrium can exist.}$$

It is often argued that agency problems can be mitigated by having managers hold some of the firm's stock, since this will give managers similar incentives to other shareholders. While this will partially alleviate the free cash flow type problem here, it cannot fully solve it since management will still only bear a proportion of the cost of funds spent on perquisites. Additionally, when adverse selection is simultaneously present, extending the contracts to include share ownership programs cannot reverse the result of proposition 1. This is proven as a corroallary to proposition 1.

Corollary 1: With a set of contracts based only on debt and stock options, simultaneous signalling and optimal perks are not possible. (See appendix for proof).

These contracts will look as in figure 3, where x^e represents the exercise price on the stock options (if $x^e = 0$, then the stock option is equivalent to giving managers stock). To induce optimal perks, the difference in utility from the best outcome and the worse outcome, $U(\overline{w}) - U(\underline{w})$, must again be constant. Signalling will again require that the MC of increasing debt be higher for lower quality firms, since the set of contracts must be offered to all managers, and therefore the MB of increasing B must be the same for all. However, because a change in μ implies a shift right in the distribution of x, the difference in MC for each μ will just be the difference in $U(\overline{w}) - U(\underline{w})$, which must be zero for optimal perks. This implies that all firms will choose the same B, and signalling is simultaneously impossible.

Proposition 1 and corollary 1 show that it is not possible to simultaneously alleviate the adverse selection and agency problems that may be present when shareholders hire managers to work their capital. The next proposition states that contracts conditioned upon dividends can solve both problems simultaneously, implying a potential advantage of D over B. The proof of this next proposition uses similar methodology to the proofs above.

Figure 1

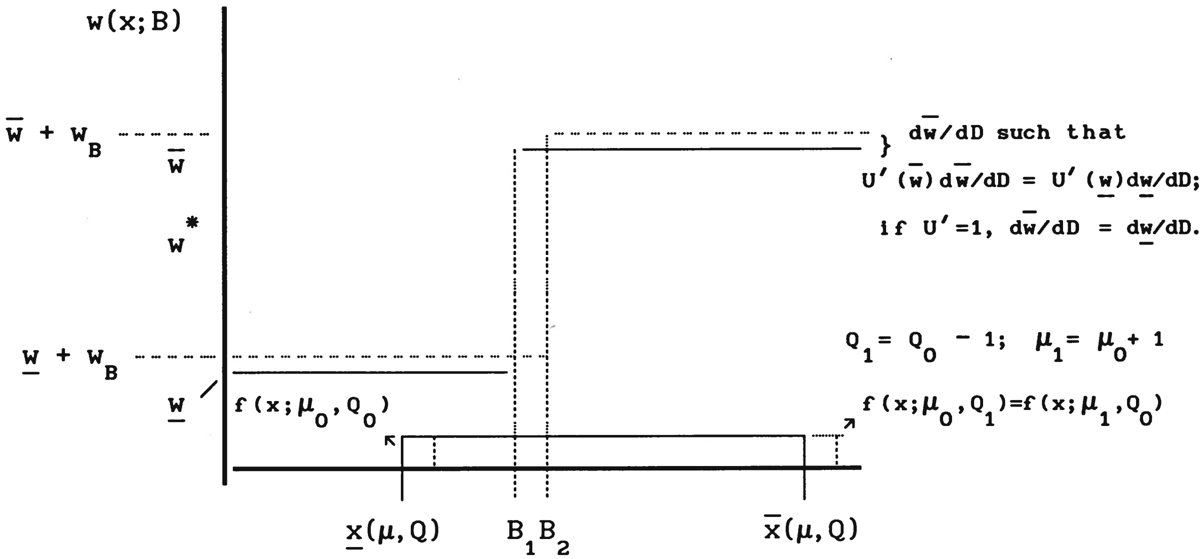
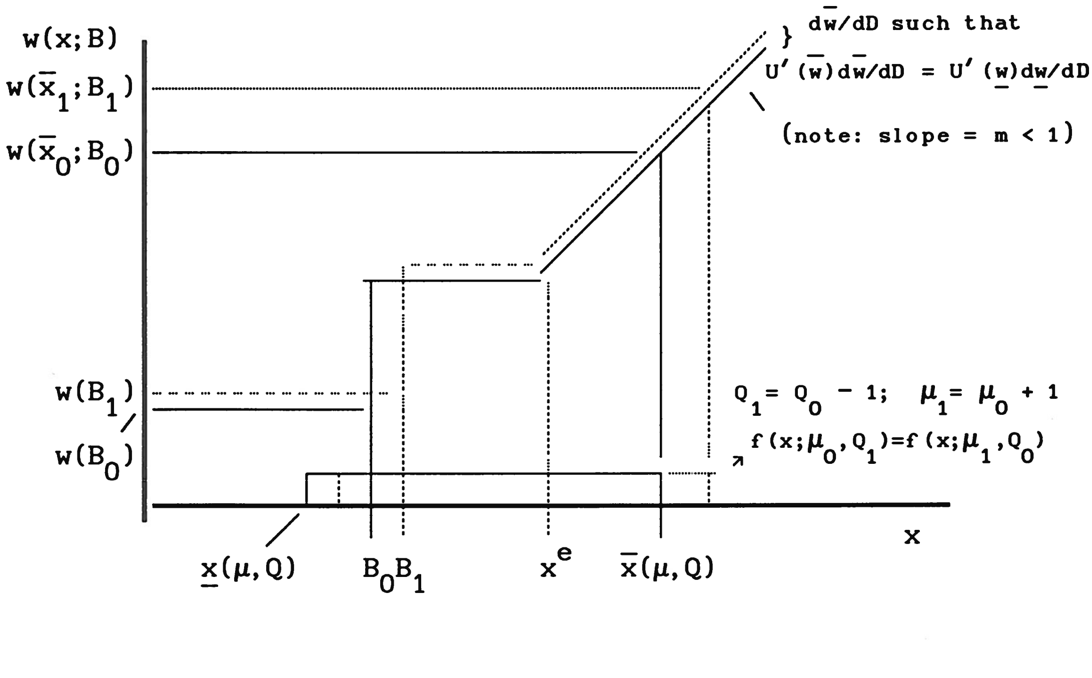


Figure 2



Proposition 2: Any set of contracts based only on dividends can simultaneously solve the signalling and perquisite problem. (Proof is given in the appendix).

The reason that dividends can solve both problems is that when a dividend is missed (or reduced), the firm does not go bankrupt and shareholders retain their ability to affect management's compensation. This extra flexibility (as compared to the debt case) allows contracts more control over the behavior and information dissemination of management. In particular, a contract which is dependent upon the magnitude of shortfall will enable shareholders to induce both optimal perquisite consumption and the revelation of firm quality.

These compensation contracts look as in figure 3, where $\omega(x\text{-}D)$ is the bonus based upon how close the manager comes to his committed dividend, with x^d given by $\omega(x^d\text{-}D) \equiv 0$ and $\bar{w}$ given[16] by $\underline{w} + \omega(0)$. As above, $D > \underline{x}$ follows in order to meet $\overline{E\mathcal{U}}$. In contrast to above, in the case where $x^d < \underline{x}$, the marginal cost of increasing dividends will decrease as μ increases since $w(\underline{x};D)$ increases but $w(\bar{x};D)$ does not. With the MB of D the same for all, this implies $dD^*/d\mu > 0$. As illustrated in figure 3, this will also enable the optimal perks condition (via the optimal distance between $\bar{w}$ and $\underline{w}$) for all μ to be simultaneously met. Thus, each μ is choosing a higher D^* and the D^* is such that $U(\bar{w}) - U(\underline{w})$ is the same for all.

It may seem that this result is due to the uniform distribution of x. However, this is not the case. Propositon 3 below shows that the result also goes through with a general distribution, so long as the contract is designed such that the range over which $\omega(\cdot)$ changes is the same range for which the density function has positive slope.

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[16]In general there could also be a jump when D is met, just as with B. However, $\omega(\cdot)$ can be designed to closely imitate a contract with such a jump, and I am assuming there is no extra jump. Also, in general the *functional form* for $\omega(\cdot)$ could depend upon the level of D committed to, but I am assuming it does not. Thus, there is potentially more flexibility with compensation dependent on dividends than I am considering.

Figure 3

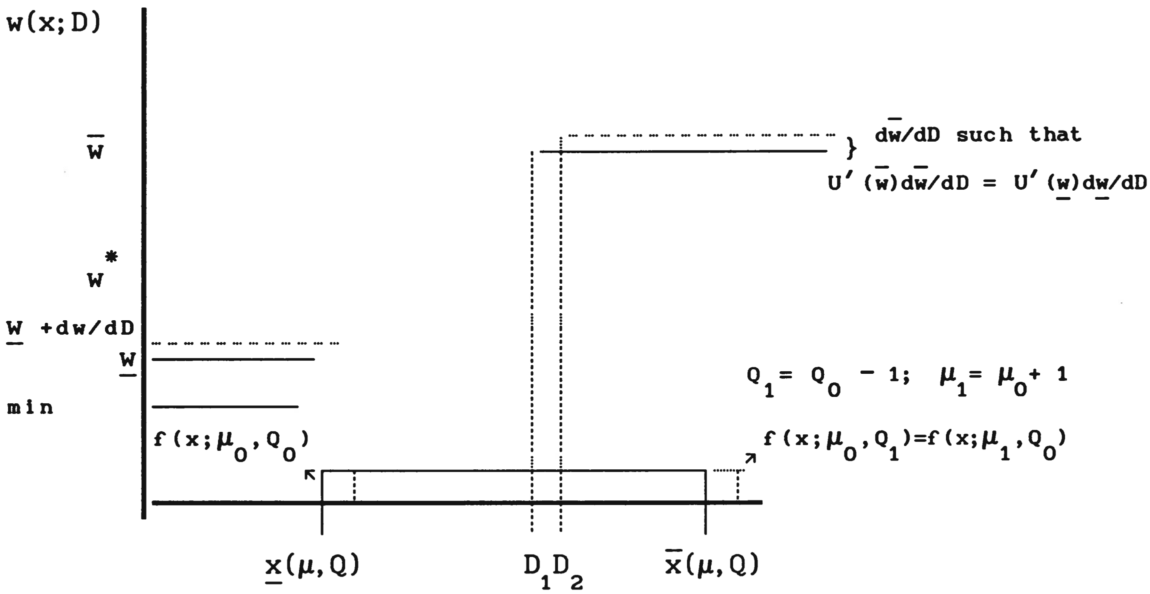
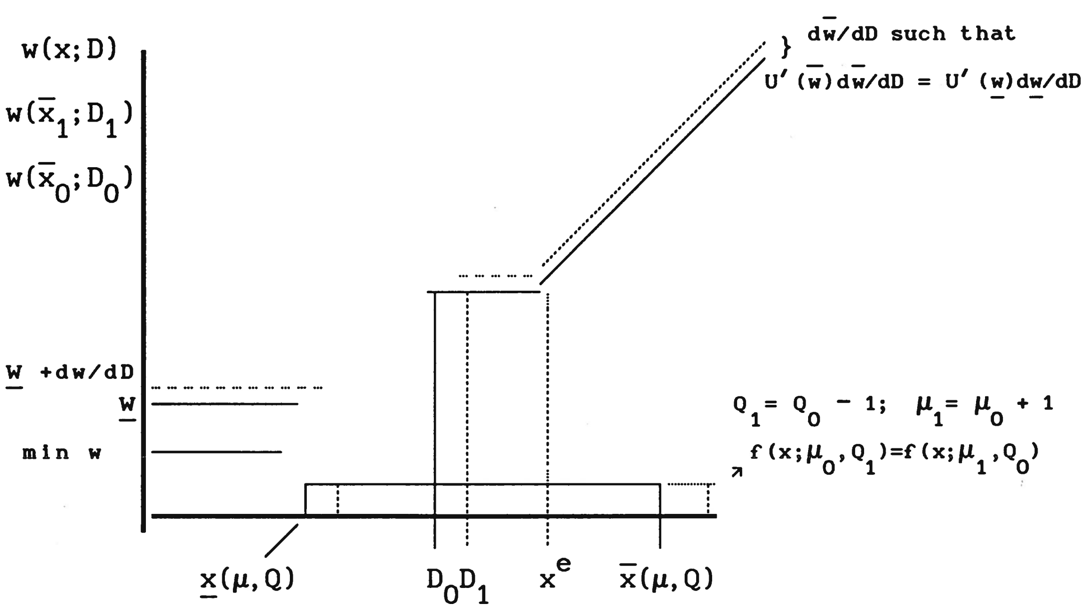


Figure 4.



The following example shows how a dividend commitment can alleviate the asymmetric information problems.

Example: Illustration of proposition 2 when we have quadratic w(x;D), risk neutral management and ε~unif.

In this case

$$w(D_i) = \begin{cases} \bar{w}(D_i) - (x-D_i)^2 & \text{if } \underline{x} \le x \le D_i \\ \bar{w}(D_i) & \text{if } D_i \le x \le \bar{x} \end{cases} \qquad \text{(E.1)}$$

where D_i is chosen such that $x^d \le \underline{x}$.

Shareholders offer two contracts:

$$W(D) = \{w(D_1),\ w(D_2) \mid \bar{w}(D_1) < \bar{w}(D_2)\}$$

Risk neutral management choose D, Q to max:

$$E\mathcal{U}(w(D),Q;\mu) = \int_0^X w(x,D)f(x;Q,\mu)dx + V(Q)$$

$$= \int_{\underline{x}(\mu,Q)}^{D} [\bar{w} - (x-D)^2]f(x)dx + \int_D^{\bar{x}(\mu,Q)} [\bar{w}]f(x)dx + \ln(Q) \qquad \text{(E4.2)}$$

The first order condition for Q is:

$$Q:\ [\bar{w} - (\underline{x}(\mu,Q)-D)^2]f - \bar{w}f + V' = 0$$

$$\Rightarrow V'(Q) = f[\underline{x}(\mu,Q)-D)]^2. \qquad \text{(E4.3)}$$

The second order condition is satisfied because V′ starts at a large value and decreases with Q and the right hand side starts at a low value and increases (the term to be squared is negative). Thus, for an equilibrium with optimal optimal perks, w(D) must be designed such that $f[\underline{x}(\mu_i,Q^*)-D(\mu_i)]^2 = 1$, since for optimal perks we need $V' = 1$ ($\Rightarrow Q^* = 1$ here) for all μ. This implies that we must have

$$\bar{w}(D_1)-(\underline{x}(\mu_1,Q_1^*)-D_1)^2 = \bar{w}(D_2)-(\underline{x}(\mu_2,Q_2^*)-D_2)^2 = 1/f.$$

For a signalling equilibrium, it must be that for all i, j = 1,2

$E\mathcal{U}(w(D_i),\ Q_i^*;\mu_i) \ge E\mathcal{U}(w(D_j),\ Q_i;\mu_i)$. Now, $E\mathcal{U}(w(D),Q;\mu)$

$$= \int_{\underline{x}(\mu,Q)}^{D} [\bar{w}(D) - (x-D)^2] f(x)dx + \int_{D}^{\bar{x}(\mu,Q)} [\bar{w}(D)] f(x)dx + \ln(Q).$$

Integrating gives $E\mathcal{U}(w(D),Q;\mu)$

$$= [\bar{w}(D)xf - (1/3)(x-D)^3 f]_{\underline{x}(\mu,Q)}^{D} + [\bar{w}(D)xf]_{D}^{\bar{x}(\mu,Q)} + \ln(Q)$$

$$= f\bar{w}(D)(\bar{x}-\underline{x}) + f(1/3)(\underline{x}(\mu,Q)-D)^3 + \ln(Q)$$

$$= \bar{w}(D) + f(1/3)(\underline{x}(\mu,Q)-D)^3 + \ln(Q),$$

where the last equality follows because a uniform distribution implies $f(\underline{x} \le x \le \bar{x}) = 1/(\bar{x}-\underline{x})$. Thus, the requirement is that

$$\bar{w}(D_i) + f(1/3)(\underline{x}(\mu_i,Q_i^*)-D_i)^3 + \ln(Q_i^*)$$

$$\ge \bar{w}(D_j) + f(1/3)(\underline{x}(\mu_j,Q_i)-D_j)^3 + \ln(Q_i), \qquad \text{(E4.4)}$$

where Q_i will only be optimal (from an overall point of view) if D_i is chosen.

Now we must use some numerical values for a numerical solution:
Let $\tilde{x} = \tilde{F} + Z = 2I^{1/2} + \mu + \tilde{\varepsilon} + Y - I - Q = 2I^{1/2} + \mu + \tilde{\varepsilon} + 10 - I - Q$. Also, let $\mu_1 = 1$, $\mu_2 = 2$; $\tilde{\varepsilon} \sim$ unif$[-1, 1]$ so that $f = 1/2$. With sufficient funds, management will always choose $I^* = 1$. Thus, we have $x \sim$ unif$[10+\mu-Q, 12+\mu-Q]$.

Now for (E4.3), we need $(\underline{x}_i-D_i)^2 = 1/f = 2 \Rightarrow -(\underline{x}_i-D_i) = 2^{1/2}$ or $D_i = \underline{x}_i + 2^{1/2}$. Thus, we need

$D_1 = 10 + 2^{1/2} = 11.4$ and $D_2 = 11 + 2^{1/2} = 12.4$.

For (E4.4) we need

$$\bar{w}(D_1)+f(1/3)(\underline{x}(\mu_1,1)-D_1)^3 = \bar{w}(D_1) + (1/6)(-1)(2^{1/2})^3 = \bar{w}(D_1)- 0.47$$

$$\ge \bar{w}(D_2) + f(1/3)(\underline{x}(\mu_1,Q_1)-D_2)^3 - \ln(Q_1),$$

and

$$\bar{w}(D_2)+f(1/3)(\underline{x}(\mu_2,1)-D_2)^3 = \bar{w}(D_2) - 0.47$$

$$\geq \bar{w}(D_1) + f(1/3)(\underline{x}(\mu_2,Q_2)-D_1)^3 + \ln(Q_2).$$

Thus, we must compute what Q_1 and Q_2 will be if management "cheat". From (E4.3), if firm 1 cheats by choosing D_2, they will choose Q_1 such that

$$V'(Q_1) = 1/Q_1 = f[\underline{x}(\mu_1,Q_1)-D_2)]^2 = 1/2[(11-Q_1)-(11+2^{1/2})]^2$$

$$1/Q_1 = 1/2[-2^{1/2}- Q_1]^2$$

$$\Rightarrow 2 = 2Q_1 + 2(2^{1/2})Q_1^2 + Q_1^3$$

This can be solved using a standard formula[17] for $Q_1 = 0.37$.
Similarly, if firm 2 cheats by choosing D_1, they will choose Q_2 such that

$$V'(Q_2) = 1/Q_2 = f[\underline{x}(\mu_2,Q_2)-D_1)]^2 = 1/2[(12-Q_2)-(10+2^{1/2})]^2$$

$$= 1/2[2 - 2^{1/2}- Q_2]^2$$

$$\Rightarrow 2 = Q_2[(2 - Q_2) - 2^{1/2}]^2$$

which, again using a standard formula, gives $Q_2 = 1.68$.

Thus, conditions (E4.4) are that

$$\bar{w}(D_1) - 0.47 \geq \bar{w}(D_2) + (1/6)[(11-0.38)-12.4)^3 + \ln(.38)$$

$$= \bar{w}(D_2) - 1.91$$

and that

$$\bar{w}(D_2) - 0.47 \geq \bar{w}(D_1) + (1/6)[(12-1.68)-11.4)^3 + \ln(Q_2).$$

$$= \bar{w}(D_1) + 0.31.$$

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[17] I obtained the formula from W. Beyer (1987).

Together, these imply that the correct D will be chosen if

$$0.78 \le \bar{w}(D_2) - \bar{w}(D_1) \le 1.44$$

or if $\bar{w}(D_2) \in [\bar{w}(D_1) + .78,\ \bar{w}(D_1) + 1.44]$. In these cases, we will get a signalling equilibrium where management are also induced to consume the optimal amount of perks, and thus proposition 2 holds.

As above, proposition 2 can also be extended to allow for stock ownership plans in managerial compensation. This is presented as corollary 2.

Corollary 2: A signalling equilibrium with simultaneous optimal perks also exists with contracts based on debt and stock options. (See appendix for proof).

Such a contract looks as in figure 4. The same logic applies; the difference here is that while stock ownership helps alleviate the agency problem (since it increases the gap between the lowest and highest w which determines the MC of perks to management) it imposes more stringent conditions on $\omega(\cdot)$ for the existence of a simultaneous signalling equilibrium (since it must again be that the MC of increasing D decreases as μ increases). Thus, we have a potential advantage of dividends over debt payments.

Extensions:

The main directions for extensions involve relaxing the simplifying assumptions made above, and considering the robustness of the results here. In particular, I wish to examine the implications or a more general form for the production function and the uncertainty. Preliminary work on this combined with the costs of debt and dividends suggests strong links between debt and dividend policy. As shown below, the above results are not dependent upon the assumption of uniformly distributed uncertainty. The extension that I am currently studying is the choice between repurchases and dividends in alleviating these problems.

General Distribution of Uncertainty:

In the next proposition, the implications of relaxing the uniform uncertainty assumption for the above results are considered. In order to show this, we need to show that there exists a set of contracts (given any distribution of uncertainty) such that D^* and Q^* are interior solutions to the manager's problem, Q^* satisfies $V'(Q^*) = 1$, and D^* reveals the true value of the firm.

Proposition 3: For a general distribution of uncertainty, a set of contracts based only upon dividends can create an equilibrium with simultaneous signalling and optimal perks whereas a set of contracts based only upon debt cannot. (Proof in appendix).

Dividends as opposed to Repurchases

The above has compared dividends to debt. It remains to be argued that dividends are a better form of commitment than repurchases. Since these are both payments to shareholders, a different approach to the argument must be taken. This is the subject of continuing research, but is proceeding along the following lines. There are four potential arguments for D as opposed to R in the model. They are as follows:

1. A repurchase will usually imply an increase in management's fractional ownership of the firm: in a tender to repurchase shares, management does not participate and therefore their share of the remaining value of the firm increases. This presents two problems for shareholders: (i) management may be able to use their superior information as to the value of the firm to manipulate the price they pay for the shares (specifically, management may try to decrease P) expropriating wealth from tendering shareholders (as in chapter 1). Also, the change in m will have implications for the set of parameter values for which the above type of equilibrium can exist below, since meeting or not meeting the commitment will imply a different m. (ii) Management's relative control over the firm increases as they hold proportionately more votes , and this may make it harder for shareholders to

control management.

2. Regular repurchases can be taxed as dividends anyway. This is actually linked to (1) because (as I want to show in my second paper) a multi-pd analysis will reduce the incentive problems in (1) due to reputation effects. This would again make R preferred to D, except that R must be regular, and therefore the tax advantage is likely eliminated anyway.

3. If management is more risk-averse than shareholders, then the increase in holdings of the firm associated with a repurchase will not be worth as much to management as to shareholders, and may conflict to the optimal risk-sharing rule (related to (2)).

4. When both dividends and repurchases are simultaneously used, more funds may have to be committed as R is substituted for D (the implications of this will also depend upon the relative value solving the agency versus signalling problem).

Preliminary results show that the additional separation of incentives associated with (1) above implies that an equilibrium solving the problems in this model is harder to obtain. The construction of the contract not only becomes much more complicated, but the range of parameter values under which both problems can be simultaneously alleviated is greatly reduced.

Conclusion.

The main idea here is that having a dividend level which management is committed to can ensure that a sufficient amount of funds is being allocated to profitable investment, since the dividends will only be able to be met if enough funds are invested (instead of being used for perks). Also, since only better quality firms can expect to maintain a high level of dividends, the level of dividends also act as a signal. The simultaneous alleviation of the moral hazard and adverse selection by dividends provides a potential advantage of a payout policy based on dividends instead of debt, and helps refute the reasonable observation that dividends seem to be a very expensive way of signaling.

So far, dividends have been shown to possess certain advantages over debt in solving the agency and information dissemination problems inherent to firms. This is due to the extra flexibility allowed in the event of a missed commitment when there is uncertainty. A full explanation of the dividend puzzle requires showing not only that dividends are preferable to retained earnings and debt payments, but also that dividends are preferable to repurchases. This is currently being incorporating into this analysis.

Appendix

Proof of Proposition 1: Any such contracts must the form

$$w(x;B) = \begin{cases} \underline{w} & \text{if } x < B \\ \overline{w} & \text{if } x \geq B \end{cases} \qquad \text{(P1.1)}$$

Thus, management will now choose perks and debt to maximize:

$$E\mathcal{U}^M = \int_0^B U(\underline{w}(B))f(x;\mu,Q)dx + \int_B^X U(\overline{w}(B))f(x;\mu,Q)dx + V(Q),$$

where $x \in [0, X]$ is assumed since μ is distributed on a bounded interval and uncertainty is uniformly distributed: $f(x;\mu,Q) = f$ if $x \in [\underline{x}(\mu,Q), \overline{x}(\mu,Q)]$ and zero otherwise.

The first order condition for Q is

$$\int_0^B U(\underline{w}(B))f_Q(x;\mu,Q)dx + \int_B^X U(\overline{w}(B))f_Q(x;\mu,Q)dx + dV(Q)/dQ$$

$$= U(\underline{w}))f + U(\overline{w})(-f) + V' = [U(\overline{w}) - U(\underline{w})]f + V' = 0, \qquad \text{(P1.2)}$$

where the second equality follows due to the uniform distribution. The second order condition for a maximum[18] is $V'' < 0$.

The first order condition for B (incentive compatibility) requires

$$(\partial B/\partial B)[(U(\underline{w}(B)) - U(\overline{w}(B))]f(B)$$

$$+ \int_0^B (U'(\underline{w})(d\underline{w}/dB)f(x;\mu,Q)dx + \int_B^X (U'(\overline{w})(d\overline{w}/dB))f(x;\mu,Q)dx = 0. \qquad \text{(P1.3)}$$

The second order condition for a maximum is

$$+ \int_0^B(U''(d\underline{w}/dB) + U'(d^2\underline{w}(B)/dB^2)f(x;\mu,Q)dx$$

$$+ \int_B^X (U''(d\overline{w}/dB) + U'(d^2\overline{w}(B)/dB^2))f(x;\mu,Q)dx < 0,$$

which will be satisfied for $d^2\overline{w}(B)/dB^2$, $d^2\underline{w}(B)/dB^2 < 0$.

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[18]Sufficient conditions for a maximum are $\partial^2 E\mathcal{U}/\partial Q^2$, $\partial^2 E\mathcal{U}/\partial Q^2 < 0$ since this is sufficient for concavity of the (additively separable) objective function.

Next, we can show that a signalling equilibrium and optimal perks are simultaneously impossible. For a credible signalling equilibrium, it must be the case that it is easier for the higher quality firm to pay the higher B, or that $\partial^2 E\mathcal{U} / \partial B \partial \mu > 0 \Rightarrow dB^*(\mu)/d\mu > 0$. Now, from (P1.3) we need

$$\partial^2 E\mathcal{U} / \partial B \partial \mu = U'(\underline{w})(d\underline{w}/dB) f_\mu(\underline{x};\mu,Q) + U'(\bar{w})(d\bar{w}/dB)) f_\mu(\bar{x};\mu,Q)$$

$$= [U'(\bar{w})(d\bar{w}/dB)) - U'(\underline{w})(d\underline{w}/dB)] f > 0. \qquad \text{(P1.5)}$$

However, for optimal perks, we need $V'(Q^*) = 1$ for all μ. Thus, from (P1.2) we need $[U(\bar{w}(B^*(\mu)) - U(\underline{w}(B^*(\mu))] f = 1$ for all μ, or that

$$d[U(\bar{w}(B^*(\mu))) - U(\underline{w}(B^*(\mu)))] f / d\mu = 0$$

$$\Rightarrow [\, U'(\bar{w})(d\bar{w}/dB)(dB^*/d\mu) - U'(\underline{w})(d\underline{w}/dB^*)(dB^*/d\mu)](f) = 0$$

$$\Rightarrow [U'(\bar{w})(d\bar{w}/dB) - U'(\underline{w})(d\underline{w}/dB)](f) = 0. \qquad \text{(P1.5)}$$

Now, (P1.5) and (P1.4) are simultaneously impossible, so the proposition is proven. ■

Proof of Corollary 1: With the inclusion of stock options, the compensation schedule (P1.1) must be extended to the form:

$$w(x;B) = \begin{cases} \underline{w}(B) & \text{if } \underline{x} \le x < B \\ \bar{w}(B) & \text{if } B \le x < x^e \\ \bar{w}(B) + m(x-x^e) & \text{if } x^e \le x \le \bar{x} \end{cases} \qquad \text{(C1.1)}$$

where x^e represents the exercise price on the stock options (if $x^e = 0$, then the stock option is equivalent to giving managers stock).

Management's problem is now to choose B and Q to maximize:

$$E\mathcal{U}^M = \int_0^B U(\underline{w}(B))f(x;\mu,Q)dx + \int_B^{x^e} U(\overline{w}(B))f(x;\mu,Q)dx$$

$$+ \int_{x^e}^X U(\overline{w}(B)+m(x-x^e))f(x;\mu,Q)dx + V(Q).$$

The first order necessary condition for Q is now

$$dV(Q^*)/dQ = [U(\overline{w}(B) + m(\overline{x}(\mu,Q^*) - x^e)) - U(\underline{w}(B))]f \qquad (C1.2)$$

Signalling higher quality, μ, via higher B requires $\partial^2 E\mathcal{U} / \partial B\partial\mu > 0 \Rightarrow dB^*/d\mu > 0$. Incentive compatibility requires B^* satisfies

$$\partial E\mathcal{U} / \partial B = 0 = (\partial B/\partial B)[-U(\overline{w}(B)) + U(\underline{w}(B))]f(B)$$

$$+ \int_0^B (U'(\underline{w}))(d\underline{w}/dB)f(x;\mu,Q)dx + \int_B^X (U'(\overline{w} + m(x-x^e))(d\overline{w}/dB)f(x;\mu,Q)dx$$

$$\partial^2 E\mathcal{U} / \partial D\partial\mu = (U'(\underline{w}))(d\underline{w}/dB)(-f) + (U'(\overline{w} + m(x-x^e))(d\overline{w}/dB)(f)$$

$$= [U'(\overline{w} + m(x-x^e))(d\overline{w}/dB) - U'(\underline{w})(d\underline{w}/dB)](f) > 0. \qquad (C1.3)$$

However, for optimal perks ($V' = 1$) and (C1.2) we need

$$\partial[U(\overline{w}(B^*(\mu)) + m(x-x^e)) - U(\underline{w}(B^*(\mu)))]f/\partial\mu = 0$$

$$\Rightarrow [U'(\overline{w} + m(x-x^e))(d\overline{w}/dB)(dB^*/d\mu) - U'(\underline{w})(d\underline{w}/dB^*)(dB^*/d\mu)](f) = 0$$

$$\Rightarrow [U'(\overline{w} + m(x-x^e))(d\overline{w}/dB) - U'(\underline{w})(d\underline{w}/dB)](f) = 0. \qquad (C1.4)$$

(C1.3) and (C1.4) provide a contradiction, so the corollary is proven. ■

Proof of Proposition 2: Any such contracts will have the form

$$w(x;D) = \begin{cases} \underline{w} & \text{if } x \le x^d \\ \underline{w} + \omega(x-D) & \text{if } x^d \le x < D \\ \overline{w} \equiv \underline{w} + \overline{\omega} & \text{if } x \ge D \end{cases} \qquad (P2.1)$$

where $\omega(\cdot)$ is the bonus based upon how close the manager comes to his committed dividend, with x^d given by $\omega(x^d - D) \equiv 0$ and $\bar{w}$ given[19] by $\underline{w} + \omega(0)$. As above, $D > \underline{x}$ follows in order to meet $\overline{E\mathcal{U}}$. It will be sufficient for the proof to consider the case where $x^d < \underline{x}$ and $\omega'(0) = 0$.

Management will choose perks and dividends to maximize:

$$E\mathcal{U}^M = \int_0^{x^d} U(\underline{w}(D))f(x;\mu,Q)dx + \int_{x^d}^{D} U(\underline{w}(D) + \omega(x-D))f(x;\mu,Q)dx$$

$$+ \int_D^X U(\bar{w}(D))f(x;\mu,Q)dx + V(Q).$$

The f.o.c. for Q is now

$$\partial E\mathcal{U}/\partial Q = U(w(\underline{x}(\mu,Q);D))f + U(\bar{w})(-f) + (dV/dQ)$$

$$= U(\underline{w} + \omega(\underline{x}(\mu,Q)-D))f + U(\bar{w})(-f) + (dV/dQ) = 0, \qquad \text{(P2.2)}$$

where $\omega(\underline{x}-D) > 0$ as $x^d < \underline{x}$.

The sufficient condition[20] for a maximum is that

$$\partial^2 E\mathcal{U}/\partial Q^2 = V''(Q) + U'(w(\underline{x}(\mu,Q);D))\omega'(\underline{x}(\mu,Q)-D))(\partial\underline{x}(\mu,Q)/\partial Q)(f)$$

$$= V''(Q) - U'(w(\underline{x}(\mu,Q);D))\omega'(\underline{x}(\mu,Q)-D))(f) < 0.$$

Incentive compatibility in the choice of D requires

$$\partial E\mathcal{U}/\partial D = \int_0^{x^d} U'(\underline{w})(d\underline{w}/dD)f(x;\mu,Q)dx + \int_D^X U'(\bar{w}(D))(\partial\bar{w}(D)/\partial D)f(x;\mu,Q)dx$$

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[21]In general there could also be a jump when D is met, just as with B. However, $\omega(\cdot)$ can be designed to closely imitate a contract with such a jump, and I am assuming there is no extra jump. Also, in general the *functional form* for $\omega(\cdot)$ could depend upon the level of D committed to, but I am assuming it does not. Thus, there is potentially more flexibility with compensation dependent on dividends than I am considering.

Again, additive separability in the objective implies $\partial^2 E\mathcal{U}/\partial Q^2$ and $\partial^2 E\mathcal{U}/\partial D^2$ are sufficient conditions for a maximum.

[21]In general there could also be a jump when D is met, just as with B. However, $\omega(\cdot)$ can be designed to closely imitate a contract with such a jump, and I am assuming there is no extra jump. Also, in general the *functional form* for $\omega(\cdot)$ could depend upon the level of D committed to, but I am assuming it does not. Thus, there is potentially more flexibility with compensation dependent on dividends than I am considering.

$$+ \int_{x^d}^{D} (U'(\underline{w} + \omega(x-D))((d\underline{w}/dD) - \omega'))f(x;\mu,Q)dx = 0, \qquad \text{(P2.3)}$$

noting that the terms involving the limits of integration vanish because $f(x^d) = 0$ (as $x^d < \underline{x}$) and $\omega(x{=}D) = \overline{w}-\underline{w}$.

The second order condition for a maximum is

$$\partial^2 E\mathcal{U}/\partial D^2 = \int_0^{x^d} [U''(d\underline{w}/dD)(d\underline{w}/dD) + (d^2\underline{w}/dD^2)U']f(x;\mu,Q)dx$$

$$+ \int_D^X [U''(d\overline{w}/dD)(d\overline{w}/dD) + (d^2\overline{w}/dD^2)U']f(x;\mu,Q)dx$$

$$+ \int_{x^d}^{D} [U''(d\underline{w}/dD - \omega')((d\underline{w}/dD) - \omega') + ((d^2\underline{w}/dD^2) + \omega'')U']f(x;\mu,Q)dx < 0,$$

which is satisfied for $U'' < 0$; $d^2\underline{w}/dD^2$, $\omega'' \leq 0$.

For a credible signalling equilibrium, it must be the case that it is easier for the higher quality firm to pay the higher D, or that $\partial^2 E\mathcal{U} / \partial D \partial\mu > 0 \Rightarrow dD^*/d\mu > 0$. Now, from (P2.3), this condition is that

$$\partial^2 E\mathcal{U}/\partial D\partial\mu = [U'(\overline{w}(D))(\partial\overline{w}(D)/\partial D) - U'(\underline{w} + \omega(\underline{x}-D))((d\underline{w}/dD) - \omega'(\underline{x}-D))]f > 0.$$

Now, optimal perks require that $V'(Q^*) = 1$. Thus, from (P2.2), for simultaneous signalling and optimal perks we need $D^*(\mu)$ such that

$$[U(\overline{w}(D^*(\mu))) - U(\underline{w}(D^*(\mu)) + \omega(\underline{x}(D^*(\mu))-D^*(\mu))]f = 1,$$

for all μ. Thus, simultaneous optimal perks and signalling require that in equilibrium,

$$d\{[U(\overline{w}(D^*(\mu))) - U(\underline{w}(D^*(\mu)) + \omega(\underline{x}(\mu,Q))-D^*(\mu))]\}f / d\mu$$

$$= [U'(\overline{w}(D))(d\overline{w}/dD)(dD^*/d\mu)$$

$$- U'(\underline{w}(D) + \omega(\underline{x}-D))((d\underline{w}/dD)(dD^*/d\mu) + \omega'(d\underline{x}(\mu,Q)/d\mu - dD^*(\mu)/d\mu)]f$$

$$= (\partial^2 E\mathcal{U}/\partial D\partial\mu)(dD^*/d\mu) - [U'(\underline{w}(D) + \omega(\underline{x}-D))\omega'(d\underline{x}(\mu,Q)/d\mu)]f = 0.$$

Since the first term must be positive, the requirements will be satisfied if the second term is negative, which requires

$$[U'(\underline{w}(D) + \omega(\underline{x}-D))\omega'(d\underline{x}(\mu,Q)/d\mu)]f > 0.$$

With U' and ω' positive, this is satisfied since $d\underline{x}(\mu,Q)/d\mu = 1$. Thus, simultaneous signalling with optimal perks is possible with a contract based only on dividends, and the proposition is proven. ■

Proof of Corollary 2: The compensation schedule can be written as

$$w(x;D) = \begin{cases} \underline{w}(D) & \text{if } \underline{x} \le x < x^d \\ \underline{w}(D) + \omega(x-D) & \text{if } x^d \le x < D \\ \overline{w}(D) & \text{if } D \le x < D + x^e \\ \overline{w}(D) + m(x-x^e) & \text{if } D + x^e \le x \le \overline{x} \end{cases} \tag{C2.1}$$

where x^e again represents the exercise price on the stock options.

Management's problem is now to choose D and Q to maximize:

$$E\mathcal{U}^M = \int_0^{x^d} U(\underline{w}(D))f(x;\mu,Q)dx + \int_{x^d}^{D} U(\underline{w}(D) + \omega(x-D))f(x;\mu,Q)dx$$

$$+ \int_D^{x^e} U(\overline{w}(D))f(x;\mu,Q)dx + \int_{x^e}^{X} U(\overline{w}(D)+m(x-x^e))f(x;\mu,Q)dx + V(Q).$$

From the f.o.c. on Q, for optimal perks we need

$$[U(w(\overline{x}(\mu,Q^*)) - U(w(\underline{x}(\mu,Q^*))]f$$

$$= [U(\overline{w}(D) + m(\overline{x}(\mu,Q^*) - x^e)) - U(\underline{w}(D) + \omega(\underline{x}(\mu,Q^*)-D))]f = V'(Q^*) = 1$$

for all μ. The s.o.c. is satisfied so long as

$$V'' - mU'(w(\bar{x}(\mu,Q^*))(d\bar{x}/dQ)f + U'(w(\underline{x}(\mu,Q^*))\omega'(\underline{x}(\mu,Q^*)-D)(d\underline{x}/dQ)f < 0.$$

Signalling higher quality, μ, via higher D requires $\partial^2 E\mathcal{U} / \partial D\partial\mu > 0 \Rightarrow dD^*/d\mu > 0$. Incentive compatibility requires D^* satisfy

$$\partial E\mathcal{U}/\partial D = \int_0^{x^d} U'(\underline{w})(d\underline{w}/dD)f(x)dx + \int_D^X U'(\bar{w}(D)+ m(x-x^e))(\partial\bar{w}(D)/\partial D)f(x)dx$$

$$+ \int_{x^d}^D (U'(\underline{w} + \omega(x-D))((d\underline{w}/dD) - \omega'))f(x)dx = 0, \qquad \text{(C2.3)}$$

with the second order condition satisfied if

$$\partial^2 E\mathcal{U}/\partial D^2 = \int_0^{x^d} [U''(d\underline{w}/dD)(d\underline{w}/dD) + (d^2\underline{w}/dD^2)U']f(x;\mu,Q)dx$$

$$+ \int_D^X [U''(d\bar{w}/dD)(d\bar{w}/dD) + (d^2\bar{w}/dD^2)U']f(x;\mu,Q)dx$$

$$+ \int_{x^d}^D [U''(d\underline{w}/dD - \omega')((d\underline{w}/dD) - \omega') + ((d^2\underline{w}/dD^2) + \omega'')U']f(x;\mu,Q)dx < 0,$$

which is satisfied for $U'' < 0$; $d^2\underline{w}/dD^2$, $\omega'' \le 0$.

$$\text{Now, } \partial^2 E\mathcal{U} / \partial D\partial\mu = U'(\underline{w}(D) + \omega(\underline{x}-D))(\omega'(\underline{x}-D))f(x;\mu,Q)dx$$

$$+ U'(\underline{w}+\omega(\underline{x}(\mu,Q))(d\underline{w}/dD)(-f) + U'(\bar{w} + m(\bar{x}(\mu,Q)-x^e))(d\bar{w}/dD)(f)$$

$$= U'(\underline{w}(D) + \omega(\underline{x}-D))(\omega'(\underline{x}-D))f(x;\mu,Q)dx > 0,$$

where the second equality follows from the optimal perks requirement. Thus, the corollary is proven. ■

Proof of Proposition 3: With contracts based only upon dividends (see P2.1), the manager chooses the signal, D, and perks, Q to maximize

$$E\mathcal{U}^M = \int_{-\infty}^{x^d(D)} U(\underline{w}(D))f(x;\mu,Q)dx + \int_{x^d(D)}^D U(\underline{w}(D) + \omega(x-D)f(x;\mu,Q)dx$$

$$+ \int_D^{\infty} U(\underline{w}(D) + \bar{\omega})f(x;\mu,Q)dx \quad + \quad V(Q).$$

The first order conditions are

$$\partial E\mathcal{U}^M/\partial D \;=\; \int_{-\infty}^{x^d(D)} U'(\underline{w})\underline{w}'(D)f(x;\mu,Q)dx$$

$$+ \int_{x^d(D)}^{D} U'(\underline{w} + \omega)(\underline{w}'(D) - \omega'(x-D))f(x;\mu,Q)dx$$

$$+ \int_D^{\infty} U'(\underline{w} + \bar{\omega})\underline{w}'(D)f(x;\mu,Q)dx$$

$$= \int_{-\infty}^{\infty} U'(w)\underline{w}'f(x;\mu,Q)dx - \int_{x^d(D)}^{D} U'(w)\omega'f(x;\mu,Q)dx = 0, \qquad \text{(P3.1)}$$

$$\partial E\mathcal{U}^M/\partial Q = \int_{-\infty}^{x^d(D)} U(\underline{w}(D))f_Q(x;\mu,Q)dx \;+ \int_{x^d(D)}^{D} U(\underline{w}(D) + \omega(x-D)f_Q(x;\mu,Q)dx$$

$$+ \int_D^{\infty} U(\underline{w}(D) + \bar{\omega})f_Q(x;\mu,Q)dx + V'(Q) = 0,$$

evaluated, of course, at D^* and Q^*.

In what follows, three rules will be useful:

(1) definitions:

(a) $f(x;\mu,Q) = f(\mu + \varepsilon - Q) = f(\varepsilon)$

$\Rightarrow f_Q = df(\varepsilon)/dQ = f'(d\varepsilon/dQ) = f'$, i.e. $f_Q = f'(\varepsilon) = f'(x)$.

Similarly, $f_{\mu} = -f'(x)$.

(b) (i) $\partial U/\partial x = U'(\partial w(x;D)/\partial x) = U'(\partial \omega(x-d)/\partial x) = U'\omega'$.

(ii) $\partial[U'(w(x;D)\omega'(x-D)]/\partial x = U''(\partial w(x;D)/\partial x)\omega' + \omega''U'$

$= U''(\omega')^2 + \omega''U'$.

$$\partial[U'(w(x;D)\omega'(x-D)]/\partial D = U''(\partial w(x;D)/\partial D)\omega' + (\partial\omega'(x-D)/\partial D)U'$$
$$= U''(\underline{w}' - \omega')\omega' - \omega''U'$$
$$= U''\underline{w}' - (U''(\omega')^2 + \omega''U').$$

(2) integration: $\int_a^b U(\underline{w}(D))f'(x)dx = U(\underline{w}(D))[f(x)]_a^b.$

(3) integration by parts: $\int_a^b U(w(x;D))f'(x)dx = \int_a^b U(w(x;D))df(x)$
$$= [U(w(x;D)f(x)]_a^b - \int_a^b f(x)(\partial U(w(x;D)/\partial x)dx$$

Using these rules, the f.o.c. for Q can be written as

$$\partial E\mathcal{U}^M/\partial Q = \int_{-\infty}^{x^d(D)} U(\underline{w}(D))df(x) + \int_{x^d(D)}^{D} U(\underline{w}(D) + \omega(x-D)df(x)$$

$$+ \int_D^{\infty} U(\underline{w}(D) + \bar{\omega})df(x) + V'(Q)$$

$$= [U(\underline{w}(D))f(x)]_{-\infty}^{x^d} + [U(\underline{w} + \omega)f(x)]_{x^d(D)}^{D} - \int_{x^d(D)}^{D} U'(\underline{w} + \omega)\omega' f(x)dx$$

$$+ [U(\underline{w}(D) + \bar{\omega})f(x)]_D^{\infty} + V'(Q)$$

$$= V'(Q) - \int_{x^d(D)}^{D} U'(\underline{w} + \omega)\omega' f(x)dx, \qquad \text{(P3.2)}$$

where the last equality follows because all of the terms involving the interior limits of integration cancel, and $f(-\infty) = f(\infty) = 0$.

Again using these integration rules, we can see that the second order conditions will be satisfied if

$$\partial^2 E\mathcal{U}^M/\partial D^2 = \int_{-\infty}^{x^d} (U''(\underline{w}')^2 + U'\underline{w}'')f(x;\mu,Q)dx$$

$$+ \int_{x^d(D)}^{D} (U''(\underline{w}'-\omega')^2 + (\underline{w}''+\omega'')U')f(x;\mu,Q)dx$$

$$+ \int_{D}^{\infty} (U''(\underline{w}')^2 + U'\underline{w}'')f(x;\mu,Q)dx$$

$$- U'\omega'(0)f(D) + (dx^d/dD)U'\omega'(x^d-D)f(x^d) < 0, \qquad \text{(P3.3)}$$

$$\partial^2 E\mathcal{U}^M/\partial Q^2 = V''(Q) - \int_{x^d(D)}^{D} U'(\underline{w} + \omega)\omega' f_Q(x;\mu,Q)dx$$

$$= V''(Q) - [U'\omega' f]_{x^d(D)}^{D} + \int_{x^d(D)}^{D} (U''(\omega')^2 + \omega''U')f(x)dx < 0. \qquad \text{(P3.4)}$$

Now, signalling requires that the optimal choice of D be higher for higher μ:

$$\partial^2 E\mathcal{U}^M/\partial D d\mu = \int_{-\infty}^{\infty} U'(w(x;D))\underline{w}' f_\mu(x;\mu,Q)dx - \int_{x^d(D)}^{D} U'(w)\omega' f_\mu(x;\mu,Q)dx \qquad \text{(P3.5)}$$

Finally, inducement of optimal perquisites requires $V'(Q^*) = 1$ for all μ. From (P3.2), this requires that

$$d\left\{- \int_{x^d(D^*(\mu))}^{D^*(\mu)} U'(\underline{w}(D^*(\mu)) + \omega(x - D^*(\mu))\omega'(x - D^*(\mu))f(x;\mu,Q)dx \right\} / d\mu = 0$$

or

$$- \int_{x^d(D^*(\mu)}^{D^*(\mu)} U'(\underline{w}(D^*(\mu)) + \omega(x-D^*(\mu))\omega'(x-D^*(\mu))f_\mu(x;\mu,Q)dx$$

$$- \int_{x^d(D^*(\mu)}^{D^*(\mu)} \left\{[U''(\underline{w}')(dD^*/d\mu) - \omega'(dD^*/d\mu)]\omega' - U'\omega''(dD^*/d\mu)\right\}f(x;\mu,Q)dx$$

$$+ (dx^d(D^*)/dD)(dD^*(\mu)/d\mu)U'(w(x^d(D^*),D^*)\omega'(x^d(D^*) - D^*)f(x^d(D^*))$$

$$- (dD^*(\mu)/d\mu)U'(w(D^*,D^*)\omega'(0)f(D^*) = 0. \qquad \text{(P3.6)}$$

Now, from (P3.5), substitute $\partial^2 E\mathcal{U}^M/\partial D d\mu - \int_{-\infty}^{\infty} U'(w(x;D))\underline{w}'f_\mu(x;\mu,Q)dx$ for the first term, and use the integration rules to give

$$\partial^2 E\mathcal{U}^M/\partial D d\mu + [U'\underline{w}'f]_{-\infty}^{x^d(D^*)} + [U'\underline{w}'f]_{D^*}^{\infty}$$

$$+ [U'\underline{w}'f]_{x^d(D^*)}^{D^*} - \int_{x^d(D^*(\mu))}^{D^*(\mu)} U''(\underline{w}')\omega' f(x;\mu,Q)dx$$

$$- \int_{x^d(D^*(\mu)}^{D^*(\mu)} \left\{[U''(\underline{w}')(dD^*/d\mu) - \omega'(dD^*/d\mu)]\omega' - U'\omega''(dD^*/d\mu)\right\} f(x;\mu,Q)dx$$

$$+ (dx^d/dD)(dD^*/d\mu)U'(w(x^d(D^*(\mu)),D^*(\mu))\omega'(x^d(D^*) - D^*)f(x^d(D^*))$$

$$- (dD^*/d\mu)U'(w(D^*(\mu),D^*(\mu))\omega'(0)f(D^*(\mu))$$

$$= \partial^2 E\mathcal{U}^M/\partial D d\mu - \int_{x^d(D^*(\mu))}^{D^*(\mu)} U''(\underline{w}')\omega' f(x;\mu,Q)dx$$

$$- \int_{x^d(D^*(\mu)}^{D^*(\mu)} \left\{[U''(\underline{w}')(dD^*/d\mu) - \omega'(dD^*/d\mu)]\omega' - U'\omega''(dD^*/d\mu)\right\} f(x;\mu,Q)dx$$

$$+ (dx^d/dD)(dD^*/d\mu)U'(w(x^d,D^*)\omega'(x^d-D^*)f(x^d)$$

$$- (dD^*/d\mu)U'(w(D^*(\mu),D^*(\mu))\omega'(0)f(D^*(\mu)) = 0.$$

Now, for signalling we must have $\partial^2 E\mathcal{U}^M/\partial D d\mu > 0$, so for simultaneous optimal perks we need the rest of the expression to be negative:

$$- \int_{x^d(D^*(\mu))}^{D^*(\mu)} U''\omega'[\underline{w}'(1 + dD^*/d\mu) - \omega'(dD^*/d\mu)]f(x;\mu,Q)dx$$

$$+ \int_{x^d(D^*(\mu)}^{D^*(\mu)} U'\omega''(dD^*/d\mu)f(x;\mu,Q)dx$$

$$+ (dx^d/dD)(dD^*/d\mu)U'\omega'f(x^d) \;-\; (dD^*/d\mu)U'\omega'f(D^*) \;<\; 0.$$

Now, this expression can be satisfied by choices of $\omega(\cdot)$ with appropropriate concavity giving a equilibrium with simultaneous signalling and optimal perks. Since it has already been shown that a set of contracts based only upon debt cannot solve the problem with uniformly distributed uncertainty (proposition 1), debt cannot simultaneously solve the problem with more general uncertainty, and the proposition is proven. ■

As an illustration that ω can be appropriately chosen for proposition 3, consider the case of risk neutral managers with U(w) = w. In this case, (P3.5) and (P3.6) are simultaneously satisfied if

$$+ \int_{x^d(D^*(\mu)}^{D^*(\mu)} \omega''f(x)dx + (dx^d/dD)\omega'(x^d-D)f(x^d) \;-\; \omega'(0)f(D^*) \;<\; 0.$$

Figure 3

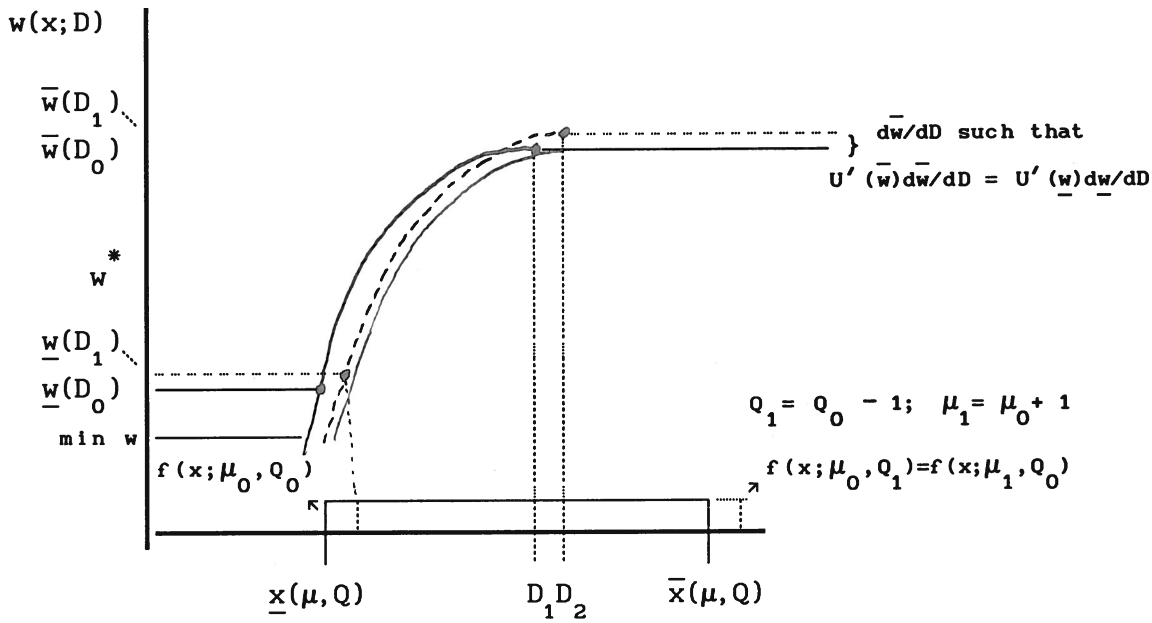
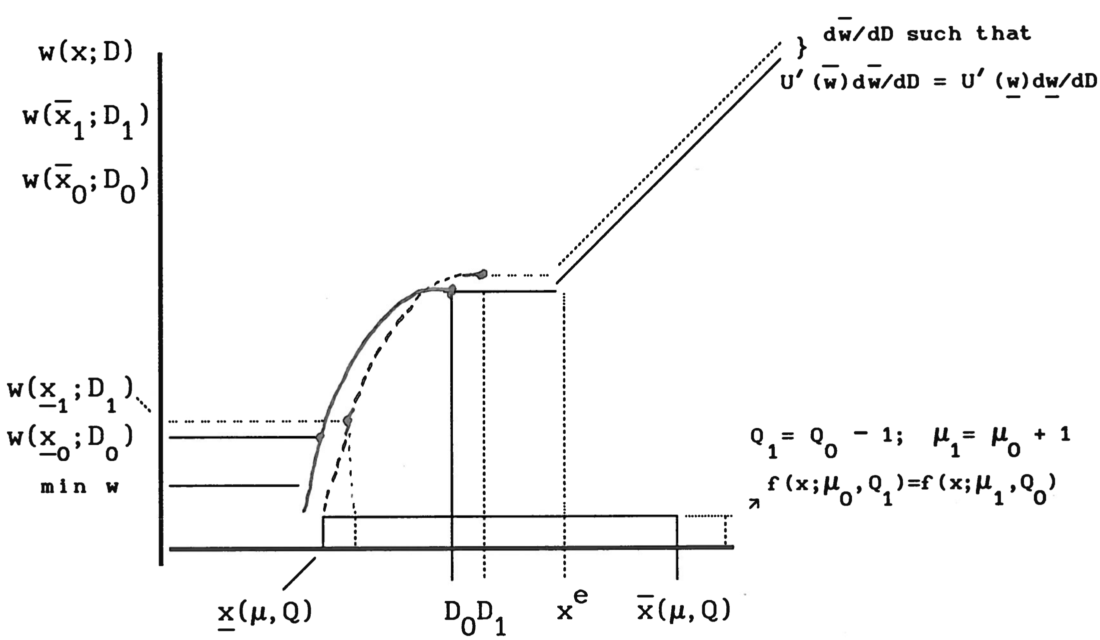


Figure 4



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