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The Optimality of Debt versus Outside Equity.

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Abstract

This paper presents a theory of outside equity based on the control rights and the maturity design of equity. We show that outside equity is a tacit agreement between investors and management supported by equityholders' right to dismiss management regardless of performance and by the lack of a prespecified expiration date on equity. Furthermore, as a tacit agreement outside equity is sustainable despite management's potential for manipulating or diverting the cash flows and regardless of how costly it is for equityholders to establish a case against managerial wrongdoing. We establish that the only outside equity that investors are willing to hold in equilibrium is outside equity with unlimited life, the very outside equity that corporations issue. Consistent with empirical evidence, this model predicts that debt-equity ratios will be higher in industries where cash flow variability is low relative to industries where cash flow variability is high. Furthermore, our theory implies that investors practice maturity-matching: they match the maturity of the optimal debt contract with the life of the physical assets and the maturity of the equity contract with the life of the company's real options.

Keywords: security design, non-verifiability of cash flows, managerial moral hazard, debt, outside equity, capital structure

JEL Classification: G34, L14

Introduction

This paper presents a theory of outside equity based on the control rights and the maturity design of equity. We show that outside equity is a tacit agreement between investors and management supported by equityholders' right to dismiss management *regardless* of performance and by the lack of a prespecified expiration date on equity. Furthermore, as a tacit agreement outside equity is sustainable despite management's potential for manipulating or diverting the cash flows and regardless of how costly it is for equityholders to establish a case against managerial wrongdoing.

The model we present here incorporates outside equity financing, management's potential for diverting cash flows as private benefits of control and costly verification of managerial performance. Earlier models in the security design literature could incorporate only two of these three features. Those models that allow for management diverting cash flows as private benefits of control and costly state verification (Townsend (1979), Diamond (1984), Gale and Hellwig (1985), Hart and Moore (1989), Bolton and Scharfstein (1990)) are incompatible with outside equity[1]. Those security design models that explicitly introduce outside equity financing either assume away the verification problem partially (Chang (1992)) or eliminate management's ability to divert cash flows as private benefits of control in some states of the world (Williams (1989))[2].

The innovation in this paper is the comprehensive specification of equity. This specification is equivalent to the traditional specification in terms of cash flow claims, ownership and control rights but complements the traditional specification in terms of a critical but

[1]See Harris and Raviv (1992) for an elaborate discussion.

[2]For an excellent survey of the most recent literature, including this paper, see Duffie and Rahi (1995). Allen (1989), Harris and Raviv (1992) and Allen and Winton (1992) are excellent surveys of the earlier literature.

previously disregarded aspect: the maturity of the security[3]. In contrast to the literature that (explicitly or implicitly) takes the life of equity and debt claims as equal, this model allows debt and equity to have different maturities. Given the set of theoretically possible financing arrangements with different control rights, cash flow claims and maturity, it becomes possible to pinpoint the securities that investors are willing to hold.

It turns out that investors would never be willing to hold outside equity with a prespecified maturity date[4]. First, equityholders cannot enforce contracts written on cash flows or earnings of the company because courts cannot verify their realizations. Secondly, managerial incentive contracts do not work either. When the entrepreneur-manager has the potential to divert cash flows as private benefits then offering him a percentage of these cash flows does not provide any incentive at all (Hart and Moore (1989)). Even the threat of a dismissal fails to effectively discipline management when there is a prespecified expiration date on equity. However, long term equity financing arrangements that are in the interest of both parties may still be sustainable (Fluck (1993)). These arrangements do not contract on particular realizations of cash flows or other financial variables or on the completion of a particular transfer of fixed payments. They are sustainable because both parties have a strong incentive to continue their business relationship. Outside equity with unlimited life is such an arrangement. Outside equity with unlimited life is compatible even with nonverifiability of cash flows and with management's ability to divert cash flows as private benefits.

[3]Debt maturity or the use of short term versus long term debt was investigated in Myers (1977), Barnea, Haugen and Senbet (1980), Flannery (1986), Hart and Moore (1989, 1995), Stulz (1990), Berkovitz and Kim (1991), Diamond (1991, 1993), Gertner and Scharfstein (1991), Rajan (1992) and Snyder (1993). No investigation has been proposed for the study of the maturity of outside equity, alone or relative to debt maturity.

[4]Limited life equity is the only feasible equity contract in the framework of previous security design models. Limited life equity has been specified as a contract that gives cash flow claims and control rights to equityholders for T periods. At time T, equity expires, the company gets liquidated and the proceeds from the sale of the assets get distributed among the owners.

It is *the combination of the control rights and the maturity design of outside equity* that mitigates the moral hazard problem. In contrast to debtholders whose right[5] to dismiss management or to liquidate the company applies only in case of a default, equityholders have the right to dismiss management or to liquidate the firm independently of the realization of cash flows. Debt avoids the verification problem by promising a fixed payment and by control rights that are contingent on this fixed payment. Equity avoids the verification problem by giving equityholders unconditional control rights. By having a right to vote outside equityholders pose a constant threat of potential dismissal to the entrepreneur-manager. Because they have unlimited time horizon or, alternatively, they lack a prespecified expiration date on their claim their threat is credible. When outside equity with unlimited life is issued the entrepreneur-manager faces a threat of dismissal that does not diminish over time and a continuing incentive for honoring outside equityholders' claim[6]. The credible threat of dismissal and the incentive for continuation effectively discipline the entrepreneur-manager.

The first part of the paper shows that in addition to debt, investors are willing to hold outside equity in our model. Interestingly enough, the maturity design of the equilibrium outside equity in our model is consistent with the maturity design of the outside equity corporations issue: it is of unlimited life.

The second part of this paper investigates whether the entrepreneur-manager is willing to issue outside equity with unlimited life. Since the seminal papers of Miller and Modigliani (1958), Jensen and Meckling (1976) and Myers (1977) capital structure[7] decisions

[5]Recent research on control rights of debt includes Harris and Raviv (1989), Hart and Moore (1989, 1994), Aghion and Bolton (1991), Zender (1991), John and Senbet (1991), Zwiebel (1994) and on the role of seniority Hart and Moore (1990, 1995), Diamond (1993) and Winton (1995).

[6]If we think in terms of the company's probability of survival, unlimited life is equivalent to a constant rate for the survival of the company over time.

[7]Harris and Raviv (1991) and John (1993) are excellent sources for references of this literature.

have been extensively studied in the corporate finance literature. This paper investigates our entrepreneur's decision whether to seek debt or equity financing in equilibrium. We adopt the standard debt contract of Hart and Moore (1989) into our framework and show that unlike outside equity, equilibrium debt contracts have prespecified expiration shorter than the life of the physical assets. The intuition behind our maturity-matching result is closely related to that of Myers (1977). Both results are driven by the investment policy being the discretionary choice of the manager. The analog of Myers' assumption that the manager's option to invest expires before debtholders can take over is our assumption that it is the entrepreneur-manager who he can restart the project following a liquidation.

We then characterize projects that can raise debt, projects that can raise outside equity and those that can raise both. Our next step establishes whether an entrepreneur would choose debt, outside equity or a mix of the two, provided that there is a demand for both. It turns out that in addition to debt outside equity with unlimited life also emerges as the financing choice for positive net present value projects. We find that projects that can raise debt can also raise outside equity but not vice versa. If the cash flows are stable, the entrepreneur issues either debt or outside equity or a mix of the two. If the cash flows are more volatile then the entrepreneur issues outside equity financing. Despite universal risk-neutrality, the *variability of the cash flows* determines the financing choice of the project in our model. The intuition is interesting: since outside equity has a better technology to spread the moral hazard risk over time, outside equity can absorb more cash flow risk.

This result appears to be consistent with the empirical evidence[8] that companies with

[8] Most major introductory finance textbook contains a table demonstrating that debt-equity ratios decline across industries as business risk increases. A number of cross-sectional studies (Gordon (1962), Bray (1967), Carleton and Silberman (1977), Toy et al. (1974), Ferri and Jones (1979), Marsh (1982), Bradley, Jarrel and Kim (1984), Kester (1986), Titman and Wessel (1988), Friend and Hasbrouck (1988) and Friend and Lang (1988) provide direct evidence on the relationship between operating risk and debt-equity ratios.

stable cash flows (public utilities) have high debt-equity ratios whereas companies with volatile cash flows (computer industry) use a high proportion of outside equity in their financing mix.

Section 2: The basic model

We consider a risk-neutral entrepreneur who seeks financing for his project from risk-neutral investors. Investors and entrepreneurs use the same positive discount factor, δ, to value future payoffs.

The project yields a periodic operating cash flow $\tilde{v}$. The cash flow, $\tilde{v}$, is an i.i.d. random variable that takes on values $v + x > 0$ and $v - x > 0$ with equal probabilities. The project requires an investment outlay of I and involves the operation of an equipment with economic life of 2 years.

The project may be repeated over and over again. As long as the project continues, the equipment must be replaced every 2 years. The equipment has a positive liquidation value, $L_1 < \delta I$, if sold immediately after the investment is sunk, and a positive liquidation value, $L_2 < L_1$, immediately following the realization of period 1 cash flows. The salvage value of the equipment at the end of its operation is zero. We assume that the operating cash flows of the project always exceed the liquidation value of the equipment, that is, $(1+\delta)(v-x) \geq L_1$ and $\delta(v-x) \geq L_2$.

The combined evidence broadly supports the view that higher operating risk companies have lower debt ratios. Gordon (1962), Bray (1967), Carleton and Silberman (1977), Bradley et al. (1984), Friend and Hasbrouck (1988) and Friend and Lang (1988) found higher operating risk companies tend to have lower debt ratios; Toy et al. found the reverse; Ferri and Jones found no relationship; Marsh (1982), Kester (1986) and Titman and Wessel (1988) found the predicted sign but a weak or statistically insignificant relationship. In Bray (1967) and Toy et al. the results are very difficult to interpret because of multicollinearity. The finding of an insignificant statistical relationship may be due to the endogenous asset substitution effect: higher leverage induces riskier investment policy and thereby increases operating risk.

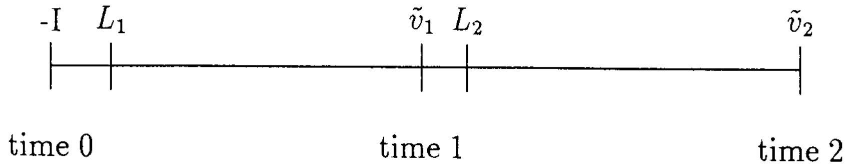

Figure 1: The timing of cash flows

The entrepreneur-manager may seek external financing for the timely replacement of the physical assets at the beginning of each cycle or, alternatively, he may set aside periodic depreciation allowances in the amount of $a = \frac{\delta I}{1+\delta}$, where a solves $I = \sum_{t=0}^{1} a(\frac{1}{\delta})^t$, to internally finance the project following the first cycle. We assume that the project can be internally financed following the first cycle, that is, $v - x \geq a$.

The depreciation account is analogous to retained earnings. If depreciation, a, has been set aside in period 1 and the company gets liquidated immediately after the realization of period 1 cash flows then the liquidation value of the company turns out to be $L_2 + a < \delta I$. Similarly, if depreciation allowance, a, has been set aside in both periods and the company gets liquidated immediately after the realization of period 2 cash flows then the liquidation value of the depreciation account equals the investment outlay[9].

Once the investment is sunk, the realizations of period 1 and period 2 cash flows are learned by both parties. Each period management may divert the cash flows. The true realization of the cash flows is assumed to be nonverifiable by a third party, that is, contracts written on cash flows are prohibitively costly to verify in court. Similarly, whether or not the entrepreneur-manager has set aside depreciation allowance is known to both par-

[9] Alternatively, a can be interpreted as a cost at which the equipment may be completely renewed period after period. When the entrepreneur-manager periodically renews the equipment, the liquidation values are, according to this interpretation, constant across periods, and equal to L_1. This is the only difference between the depreciation account interpretation and the cost of periodic renewal of the equipment interpretation. They are otherwise equivalent and produce the same results in the context of this paper.

ties. Management's manipulation of the depreciation account is also nonverifiable unless the company gets liquidated and the depreciation account is foreclosed. As a general principle, only receipts of payments, such as dividends, debt payments, payments associated with asset liquidation are costlessly verifiable in this model. The true realization of all other financial and accounting variables are assumed to be prohibitively costly to verify.

Finally, the product market is, without loss of generality, assumed to be a natural monopoly, that is, if the project is liquidated it is profitable for the entrepreneur-manager to restart it to meet demand for the product, but if an incumbent runs the project it does not pay for a potential entrant to enter. Our results extend to oligopolistic product markets as well.

The entrepreneur has two financing options. He may seek debt financing or equity financing from investors.

Section 2.1. The model of outside equity

The entrepreneur-manager may raise I by issuing equity to outside investors. Outside equityholders have a claim to the cash flows of the company, $\tilde{v}$, and a right to dismiss and replace management or to liquidate the company independently of the realization of cash flows. Equity may carry any possible maturity date or may be issued with unlimited life. Limited life equity is defined as follows. Investors transfer I to the entrepreneur-manager. In exchange they receive for T periods (1) a claim to the cash flows of the company and (2) a right to dismiss the entrepreneur-manager and to liquidate the firm. At time T, the company is liquidated and the proceeds are distributed among the owners. Following the liquidation of the company, the entrepreneur-manager may again seek financing to restart the project to meet demand for the product.

Management can divert cash flows as private benefits. As a result, outside equityholders' claim translates into an effective claim of cash flows net of depreciation and private benefits of control, that is paid out as dividends, d_{v_t} where the subscript refers to the current cash flow realization.

Table 1: Notations

v_t	realized cash flows; either $v+x$ or $v-x$
d_{v+x}, d_{v-x}	equilibrium dividends offered by the entrepreneur-manager
$\hat{d}_{v+x}$, $\hat{d}_{v-x}$	equilibrium dividends offered by the new manager
$\hat{d}^-_{v+x}$, $\hat{d}^-_{v-x}$	equilibrium dividends offered by the new manager, net of dismissal cost
I	investment outlay
L_1 or L_2	liquidation value of the assets at the beginning of the period
$a = \frac{I}{\sum_{t=0}^{1}(\frac{1}{\delta})^t}$	periodic depreciation allowance

The timing of the model of outside equity[10] is as follows. At time 0 outside equityholders invest I in the project. Each period the entrepreneur-manager may choose to set aside depreciation allowance, a, and reports the earnings of the project. The reported earnings are then paid out as dividends, d_{v_t}.

Equityholders simultaneously decide whether to keep or to replace the entrepreneur-

[10]Similar modelling approach was used in Fluck (1993) for the interaction between management and outside equityholders in an infinite horizon model. Our model of corporation here differs from Fluck (1993) in three respect. First we consider a different problem, the optimality of debt versus outside equity whereas Fluck (1993) proposes a theory of dividends as side-payments and makes predictions about the equilibrium distribution of inside and outside equity ownership. Secondly, ours is a model of an entrepreneur-manager and outside equityholders whereas Fluck (1993) is a model of concentrated inside and disperse outside ownership in which proxy fights challenging insiders may last long or may fail. Thirdly, Fluck (1993) does not consider the problem of internal financing and does not consider outside equity with prespecified expiration. More recently, Fluck (1994) develops a theory on the timing of the wave of MBOs and subsequent going public transactions as response to unexpected movements in the real cost of capital using a similar model of the interaction between internal control and outside equityholders. The present paper is self-contained and does not build on the results of Fluck (1993) or Fluck (1994).

manager or to liquidate the firm. When no challenge is initiated, outside equityholders receive d_{v_t}, the dividends, the entrepreneur-manager has announced, and the entrepreneur-manager receives $v_t - a_t - d_{v_t}$. In the event of a liquidation the entrepreneur-manager receives no payoff and equityholders receive the liquidation value of the physical assets. In the event of a dismissal, the entrepreneur-manager receives no payoff, and outside equityholders bear a cost associated with replacing the manager. Immediately following a dismissal new management with identical qualities – identical cash flows – succeeds old management in control.

The diagram below describes the timing of the model of equity per period. Whereas Figure 1 depicts the timing of the project, Figure 2 below depicts the timing of decisions and actions associated with outside equity financing. Events shown in Figure 1 are not repeated in Figure 2.

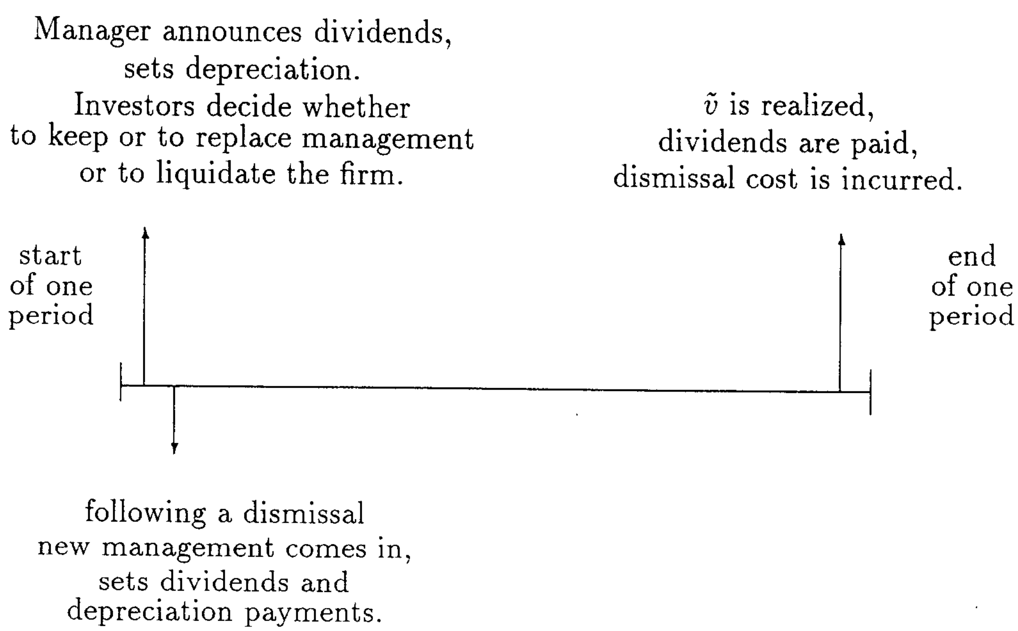

Figure 2: The timing of the model of equity

The set of actions and associated payoffs in the component game are described in the next diagram below. The first element of the payoff vector is the payoff to the entrepreneur-manager, the second is the payoff to investors. The third element, whenever applicable, indicates the payoff to the new manager who is replacing the entrepreneur-manager. The notation $\hat{d}_{v_t}$ and $\hat{a}$ refers to decision variables set by the incoming new manager. Note that $d^-_{v_t}$ denotes dividends net of the cost of replacing management.

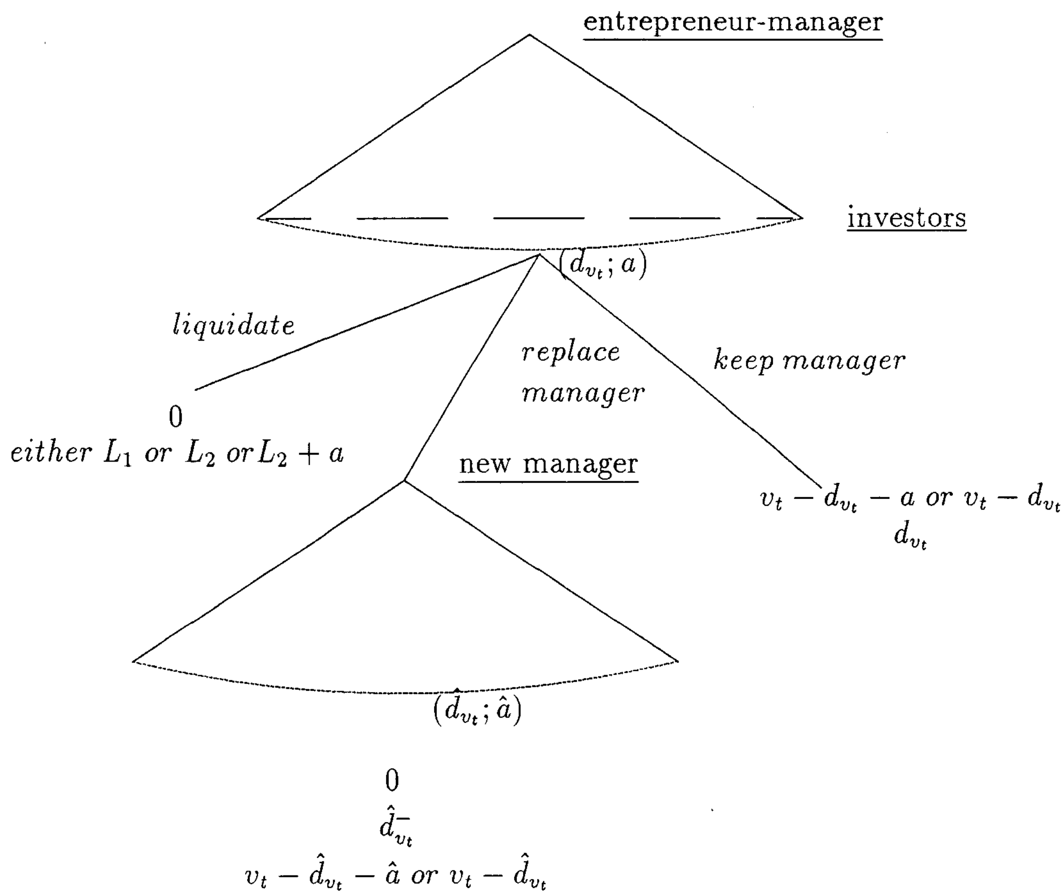

Figure 3: The component game

When the component game is played only once, the unique Nash equilibrium outcome is liquidation since dividends offered by either manager in any Nash equilibrium would always fall short of the liquidation value of the company. If, however, the financing relationship continues over time then equilibria in which management voluntarily limits private benefits of control, pays adequate dividends and sets aside appropriate depreciation allowance may become supportable by the credible threat of dismissal or liquidation.

Section 2.2: The Model of Debt

The entrepreneur-manager may also issue debt with various maturities. For modelling debt financing we adopt the standard model of debt from Hart and Moore (1989). For financing a two-period project such as the one described in Figure 1, this debt contract specifies investors transferring funds I to the entrepreneur upfront in exchange for payments P_t by the entrepreneur over the life of the debt. Debtholders are also given control rights, conditional on payments not being met. In contrast to equityholders, who can dismiss management or liquidate the firm regardless of performance, the debtholders' control right is conditional on the event of a default. As long as payments are met, the entrepreneur-manager has the control rights. In the event of a default, the control rights are transferred to debtholders.

The debt contract expires at maturity if payments are met. In the event of a default at time t, parties have the option to renegotiate. The rules of the renegotiation from Hart and Moore (1989) are as follows. The debtor can make a single take-it-or-leave-it offer. This offer consists of a date t cash payment from the debtor to holders of the debt contracts and a fraction of the assets to be liquidated at date t, the proceeds being transferred to the debtholders. If the debtholders accept, the new agreement replaces the original one. If the debtholders reject, then he has the right to liquidate the assets or to unilaterally forgive part of the debt. At this point the debtor can make a cash payment and the assets will be liquidated until either the remaining portion of the debt is paid off or all the assets have been liquidated. The creditors are Bertrand competitors. They are willing to finance a project if they break even.

Section 3: Securities that investors are willing to hold

Section 3.1: Outside equity

Investors hold outside equity only if they are confident that their cash flow claim will be honored in the future. Since cash flows are not verifiable, potential outside equityholders rationally foresee management diverting cash flows as private benefits of control. The only way outside equityholders may induce management to voluntarily limit appropriation of private benefits is by credible threats of dismissal. Credible threats of their dismissal induce management to voluntarily limit appropriation of private benefits of control so as to retain control over the operation of the assets in the future. Unless outside equityholders are prepared to exercise it, the threat of dismissal is not credible, however. It is the maturity design of outside equity that gives or takes away the credibility of the dismissal threat.

Suppose that there is a prespecified expiration date on equity. In the following paragraphs we describe, using backward induction, that neither the threat of dismissal and nor the threat of liquidation can sustain outside equity financing with a prespecified expiration date. The reader can straightforwardly follow the coming argument in Figure 3.

In the period before equity expires neither the entrepreneur-manager nor the incoming manager would be willing to pay dividends that match or exceed the liquidation value of the company. Equityholders would not dismiss the entrepreneur-manager if dismissal is costly, their best response is to liquidate the project. Consequently, in the last period the project gets liquidated, the entrepreneur-manager receives no pay and equityholders end up with L_2.

In the second to last period, the entrepreneur-manager knows that the project is going to be liquidated in the last period and that he is going to get no payoff then. So he realizes that the second to last period is effectively his last period. Consequently, he acts the same way as in the last period. Again, equityholders would not dismiss the entrepreneur-manager if dismissal is costly; they can only lose by doing so. The incoming manager has no incentive to act any differently in the last period than its predecessor. Consequently, equityholders' best response in the second to last period is to liquidate the project.

Using backward induction, this argument leads to the unique subgame perfect equilibrium outcome of this dynamic game in which equityholders liquidate the project in the first period. Consequently, whenever $I \geq L_1$, outside equity with prespecified expiration can not be supported by threats of dismissal or liquidation. The following proposition summarizes this observation.

Proposition 1 *No investor is willing to hold outside equity with a prespecified expiration date.*

Proof: in Appendix.

As we have seen above, neither the threat of liquidation nor the threat of dismissal can support outside equity with a prespecified expiration date. The threat of liquidation fails to support outside equity because equityholders can not commit *not* to exercise this threat in the last period. The threat of dismissal fails to support outside equity when there is a prespecified expiration date because this threat is not credible: investors whose claim has a prespecified expiration date are not prepared to replace unsuitable management when it is time to do so. Only those investors whose claim is of unlimited life can credibly threaten management with dismissal. When deciding whether or not to dismiss management, these investors compare a stream of future corporate earnings that is non-decreasing over time against the one-time cost of dismissing management. The stake of these investors in the company's future is large enough at any point in time to outweigh the cost of replacing unsuitable management.

Proposition 2 *The only outside equity that investors are willing to hold is of unlimited life.*

Proof: in Appendix.

As Kreps (1990) has pointed out in his discussion of repeated games, infinite horizon is equivalent to finite but indefinite horizon. Similarly, in our context unlimited life represents a finite but indefinite life rather than infinite life. A project has a finite but indefinite life if its real options (growth opportunities) may run out in any period with positive probability. The distinction between finite life with a prespecified expiration date and finite but indefinite life is that in the latter case there is no single prespecified date T, at which the company goes out of business with probability 1.

Investors are willing to hold outside equity with unlimited life if it is incentive compatible for the entrepreneur to pay dividends and to set aside depreciation allowances, and thereby retain control in the future, and it is also incentive compatible for outside equityholders not to replace management if equilibrium dividend payments are made. One such equilibrium is specified by the strategies σ^I, σ^M below. The equilibrium strategy σ^I for outside equityholders is not to dismiss the entrepreneur-manager as long as the entrepreneur-manager has paid out equilibrium dividends and has set aside sufficient funds for the timely replacement of the physical assets, and dismiss him immediately if he has failed to do so. The equilibrium strategy σ^M for the entrepreneur-manager and for potential new managers is to limit appropriation of private benefits of control so as to pay out equilibrium dividends and to set aside depreciation allowances in the first period and then period after period as long as no deviation has occured. If a manager finds himself on the job following a deviation from the equilibrium policy then he keeps deviating period after period.

The incentive compatibility conditions associated with these equilibrium strategies (σ^I, σ^M) are presented below. Let $M_{v+x} = v + x - a - d_{v+x}$ and $M_{v-x} = v - x - a - d_{v-x}$. Then, it is incentive compatible for the entrepreneur-manager to voluntarily limit private benefits of control and retain control over the operation of the assets in the future if for every realization of the cash flows he would rather pay out equilibrium dividends, set aside depreciation and thereby remain in office than divert cash flows and face dismissal in the next period.

The following paragraph from Fama (1980) intuitively describes how the equilibrium consumption of private benefits are incorporated into the equity contract ex ante:

"When the manager is no longer the sole security holder, and in the absence of some form of full ex post settling up for deviations from contract, a manager has an incentive to consume more on the job than is agreed in his contract. The manager perceives that, on an ex post basis, he can beat the game by shirking or consuming more perquisites than previously agreed. This does not necessarily mean that the manager profits at the expense of other factors. Rational [internal] managerial labor markets understand any shortcomings of the available mechanisms for enforcing ex post settling up. Assessments of ex post deviations from contract will be incorporated into contracts on an ex ante basis.".

The first four inequalities below represent the managerial incentive conditions when the investment is being made or replaced and when period 1 and period 2 cash flows become known to the parties. The left hand side of each individual rationality constraint is the payoff to the entrepreneur-manager in equilibrium. The right hand side of each inequality represents the entrepreneur-manager's payoff if he announces no dividends and/or fails to set aside depreciation payments and is dismissed in the following period. If the left-hand side exceeds the right-hand side then the entrepreneur-manager's control is sustainable.

$$M_{v-x} + \delta M_{v-x} + \frac{\delta^2(M_{v+x} + M_{v-x})}{2(1-\delta)} \geq v - x; \tag{1}$$

$$M_{v+x} + \delta M_{v-x} + \frac{\delta^2(M_{v+x} + M_{v-x})}{2(1-\delta)} \geq v + x; \tag{2}$$

$$M_{v-x} + \delta M_{v+x} + \frac{\delta^2(M_{v+x} + M_{v-x})}{2(1-\delta)} \geq v - x; \tag{3}$$

$$M_{v+x} + \delta M_{v+x} + \frac{\delta^2(M_{v+x} + M_{v-x})}{2(1-\delta)} \geq v + x. \tag{4}$$

The next two inequalities represent the managerial incentive conditions when the investment is ongoing. Since our model is not stationary[11], the equity constraints are different when the investment is ongoing and when it is being replaced.

$$M_{v-x} + \frac{\delta(M_{v+x} + M_{v-x})}{2(1-\delta)} \geq v - x; \tag{5}$$

$$M_{v+x} + \frac{\delta(M_{v+x} + M_{v-x})}{2(1-\delta)} \geq v + x. \tag{6}$$

[11]The nonstationarity of the equity model stems from the same two sources as that of the Hart and Moore model of debt: (1) as Figure 3 shows, liquidation values are different when the investment is ongoing and when it is being replaced; (2) the information sets are different when the investment is ongoing and when it is being replaced. As we shall see later the nonstationarity does not play a role in the equity conditions. In fact, the same equity conditions can be obtained from a stationary model (see also footnote 9 on page 8). The reason we have adopted the nonstationarity of the Hart and Moore (1989) model in our model of outside equity is to achieve compatibility between the equity and debt financing conditions.

It is straightforward to see that conditions (1), (2) are sufficient for conditions (3), (4), (5), (6) to hold. Consequently, the nonstationarity does not play a role in the equity conditions.

Similarly, it is incentive compatible for outside equityholders to finance the project ex ante if they at least recover their investment:

$$\frac{\delta(d_{v+x} + d_{v-x})}{2(1-\delta)} \geq I. \tag{7}$$

Furthermore, it is incentive compatible for outside equityholders not to liquidate the company in periods when the investment is being replaced and when period 1 and period 2 cash flows become known to the parties, as long as equilibrium dividends have been paid out and a depreciation account has been set aside, if for every v_1 and v_2, taking values $v - x, v + x$:

$$d_{v_1} + \delta d_{v_2} + \frac{\delta^2(d_{v+x} + d_{v-x})}{2(1-\delta)} \geq L_1. \tag{8}$$

Similarly, it is incentive compatible for outside equityholders not to liquidate the company in periods when the investment is ongoing, as long as equilibrium dividends have been paid out and a depreciation account has been set aside, if for every v_1 and v_2, taking values $v - x, v + x$:

$$d_{v_2} + \frac{\delta(d_{v+x} + d_{v-x})}{2(1-\delta)} \geq L_2 + a/\delta. \tag{9}$$

It is straightforward to see that contraint (7) is sufficient for constraints (8) and (9) to hold, provided that $L_1 \leq \delta I$.

Consequently, entrepreneurs with projects that satisfy constraints (1), (2) and (7) are able to raise outside equity financing from investors[12]. The condition for the existence of an equilibrium dividend policy places a constraint on the cash flows relative to the investment outlay of the project.

For the entrepreneur-manager's control to be sustainable we also need that the potential incoming manager have rational beliefs about equityholders. This condition assures that equityholders can not profit from dismissing the entrepreneur-manager following an equilibrium payout.

It is incentive compatible for outside equityholders not to dismiss the entrepreneur-manager in periods when the investment is being replaced and when period 1 and period 2 cash flows become known to the parties, as long as equilibrium dividends have been paid out and a depreciation account has been set aside, if for every v_1 and v_2 taking values $v-x, v+x$:

$$d_{v_1} + \delta d_{v_2} + \frac{\delta^2(d_{v+x} + d_{v-x})}{2(1-\delta)} \geq \hat{d}^-_{v_1} + \delta \hat{d}_{v_2} + \frac{\delta^2(\hat{d}_{v+x} + \hat{d}_{v-x})}{2(1-\delta)} \quad (10)$$

where $\hat{d}$ denotes sequence of dividends the incoming manager offers after the period 1 dismissal of the entrepreneur-manager following an equilibrium payout of d_{v_0} in period 0.

Similarly, it is incentive compatible for outside equityholders not to dismiss the entrepreneur-manager in periods when the investment is ongoing, as long as equilibrium dividends have been paid out and a depreciation account has been set aside, if for every v_1 and v_2 taking values $v-x, v+x$:

$$d_{v_2} + \frac{\delta(d_{v+x} + d_{v-x})}{2(1-\delta)} \geq \hat{d}^-_{v_2} + \frac{\delta(\hat{d}_{v+x} + \hat{d}_{v-x})}{2(1-\delta)} \quad (11)$$

where $\hat{d}$ denotes sequence of dividends the incoming manager offers after the period 2 dis-

[12]The complete set of constraints that supports the equilibrium is presented in the proof of Proposition 2 in the Appendix. It is shown there that constraints (1), (2) and (7) are sufficient conditions for the rest of the constraints to hold.

missal of the entrepreneur-manager following an equilibrium payout of d_{v_1} in period 1.

Section 3.2: Debt

It follows from Hart and Moore (1989) that two-period debt contracts can not be written for the one-time financing of our two-period project, since there is no mechanism to enforce payment at the end of the second period. The optimal contract for the one-time financing of our two-period project is a one-period debt. The expected payment on this contract has to cover the initial investment and it has to be sufficient to compensate investors for potential defaults. The entrepreneur-manager may default when realized cash flows are low and he is unable to make the payment. The entrepreneur-manager may also default when current cash flows are high and future cash flows are low. In this case he could pay but he would rather default.

Notice that, unlike outside equity, debt with a prespecified expiration date can be supported by the threat of liquidation in equilibrium. This is because *debt leaves ownership in the hand of management* and thereby commits investors not to liquidate the company unless payments have failed.

Let us illustrate the computation[13] of the contractual debt payment for the one-time financing of our two-period project. Assume that $\delta(v+x) > v-x$. Recall that payments are to be made following the realization of period 1 cash flows when period 2 cash flows are known to both parties. First suppose that cash flows are higher in period 1 than the period 1 value of cash flows in period 2. Then, by threatening with foreclosure, the maximum investors can expect from the entrepreneur-manager is his valuation of the project, that is, the period 1

[13] The computation of the one-time financing of our two-period project closely follows Hart and Moore (1989). The projects here and there are slightly different though. Hart and Moore (1989) only considered projects with deterministic cash flows in one period and uncertain cash flows in the other (uncertainty was limited to only one period).

value of the period 2 cash flows. Consider next the situation wherein period 1 cash flows are lower than the period 1 value of period 2 cash flows. The entrepreneur-manager is cash flow-constrained in this case. The most investors can guarantee themselves then, is a cash payment equal to the period 1 cash flows plus some value from liquidating a portion of the assets. The entrepreneur-manager would be willing to transfer the period 1 cash to investors, only if his valuation of the period 2 cash flows following the foreclosure is no less than the period 1 cash flows. Otherwise, he would rather make no payment and let investors foreclose all the assets. Consequently, when period 1 cash flows are lower than the period 1 value of period 2 cash flows, the entrepreneur-manager's incentive-compatibility constraint determines the portion of the assets to be liquidated so that cash flows from the remaining assets make the entrepreneur-manager just indifferent between transferring the period 1 cash flows to investors and facing a partial foreclosure, or not paying at all and facing full foreclosure. In short, the maximum payment investors can expect from the entrepreneur-manager is the smaller of either the period 1 cash flows or the period 1 value of the period 2 cash flows.

Investors are not willing to write longer term debt contracts for the financing of our replacement project either. When writing a debt contract, investors avoid scheduling any repayment of I at the end of the economic life of the project and beyond. They match the maturity of the debt contract with the life of the assets (maturity-matching)[14] rather than with the continuation prospect of the project. Debtholders avoid scheduling payments just before replacement becomes due since this is the very time when the asset has no value if default occurs. Since the entrepreneur-manager controls the timing of default, if he chooses

[14]Investors match the maturity of the optimal debt contract with the life of the assets so that the longest term debt they are willing to hold is one period shorter than the economic life of the project. In contrast, they match the maturity of outside equity with the continuation prospects of the project.

to default, he would time his default when debtholders are in their weakest bargaining position and will then renegotiate with them according to his terms.

To see how the argument works, suppose that there is a payment scheduled just before replacement becomes due, and the entrepreneur-manager chooses to default on this payment. Then, according to the rules of the game, he has the option to renegotiate. He offers to pay nothing, and the creditors either accept his offer and get zero, or liquidate the project and get zero. If the project gets liquidated it is profitable for the entrepreneur-manager to restart it and even if holders of this off-equilibrium debt contract like to commit never to provide financing for this entrepreneur in the future, the availability of another, self-enforcing contract, one-period debt or unlimited life equity, makes it worthwhile for other investors, say finance companies or venture capitalists, to come along and provide financing to the entrepreneur-manager. Holders of one-period debt will still face defaults in some states of the world, even in states where the cash flow constraint is not binding, but they will keep refinancing because they expect to break even. Proposition 3 summarizes this result.

Proposition 3 *The maturity of the equilibrium debt contract is shorter than the economic life of the project.*

Proof: in Appendix.

Given the repetitive nature of the entrepreneur's project, Proposition 3 implies that all loans are made at the time when replacement becomes due and all debt payments are due at the end of the period immediately following the replacement. That is, the entrepreneur has to pay back the debt in full in each odd-numbered period. Because of the two period nature of the project, there is no distinction between long-term and short-term debt. Had the project have an economic life of, say, three periods both one-period and two-period debt contracts would arise as a consequence of Proposition 3.

This result critically depends on the liquidation value being zero at the end of the economic life of the project. Positive salvage value at the end of the cycle would give rise to two-period debt contracts in addition to one-period debt contracts in equilibrium. As long as the salvage value at the end of the second period is smaller than L_2, the liquidation value at the end of the first period, then two-period equilibrium debt contracts will feature a larger payment in the first period than in the second period. Renewable two period debt may also be written in equilibrium.

There still remains an important distinction between the equilibrium design of debt and outside equity, however. Whereas no equilibrium debt contract will extend payments beyond the economic life of the project, outside equity with unlimited life will. Outside equity will specify investors transferring I to the entrepreneur-manager in period 0 in exchange for payments forever.

The question naturally arises why outside investors, who are willing to hold outside equity with unlimited life, are not willing to hold long term debt or unlimited life debt[15]. The explanation lies in the different control rights implied by debt and equity. When the project is financed by outside equity, equityholders have unconditional control rights; the right to terminate the project and the right to dismiss the entrepreneur-manager independently of the cash flows or any other financial variables. Having unconditional control rights, outside equityholders can force the entrepreneur-manager to set aside sufficient depreciation allowances,

[15] Unlimited life debt is defined as a perpetual bond. Debtholders transfer I to the entrepreneur-manager in exchange for payments forever. The entrepreneur-manager has control rights unless default occurs. In the event of a default the parties may renegotiate. The debtor can make a single take-it-or-leave-it offer. If the creditor accepts, the new agreement replaces the original one. If the creditor rejects, then he has the right to liquidate the assets or to unilaterally forgive part of the debt. At this point the debtor can make a cash payment and the assets will be liquidated until either the remaining portion of the debt is paid off or all the assets have been liquidated.

even though depreciation charges are nonverifiable. The depreciation account makes the equityholders' bargaining position particularly strong. In contrast, when the project is financed by debt, the entrepreneur-manager has the control rights in all states except default. Since the debtholders' control rights are conditional on the entrepreneur-manager not making a verifiable payment, debtholders can not induce the entrepreneur-manager to set aside depreciation allowances. When the project is financed by debt, it is *not* incentive-compatible for the entrepreneur-manager to set aside depreciation charges in equilibrium, so *debt financing induces management to follow myopic investment strategy*[16]. In the absence of the depreciation account the value of the assets declines over the life of the equipment and so weakens the debtholders' bargaining position. Consequently, *debtholders design the equilibrium contract so as to alleviate this debt-induced managerial myopia*: they match the maturity of the debt contract with the life of the assets and schedule declining payments over time.

The intuition behind our maturity-matching result is closely related to that of Myers (1977). In both cases it is recognized that investment policy is the discretionary choice of the manager. The analog of Myers' assumption that the manager's option to invest expires before debtholders can take over is our assumption that it is the entrepreneur-manager who he can restart the project following a liquidation.

If depreciation charges were verifiable then *covenant debt* would be as good in enforcing depreciation payments as outside equity. When depreciation charges are nonverifiable, then debt covenants fail to sustain a depreciation account whereas outside equity remains effective in forcing management to set aside depreciation payments for the timely replacement of the physical assets.

[16]See Holmstrom (1982), Narayanan (1985), Stein (1989) and Shleifer and Vishny (1990) and Goswami et al. (1994) for recent research on managerial myopia. Debt can also make managers more focused and less of an empire-builder as demonstrated Jensen (1986), Hart and Moore (1995) and Zwiebel (1994).

Section 4: Capital structure decision with deterministic cash flows

The previous section established that investors are willing to hold only one debt and one outside equity instrument in our framework; debt with a maturity of one period and outside equity with unlimited life. The next step is to investigate conditions under which one-period debt or outside equity with unlimited life turns out to be the entrepreneur-manager's choice of financing. At first we focus on projects with deterministic cash flows, then we move on to projects with stochastic cash flows.

Section 4.1. Raising debt

Suppose that v, the periodic cash flow of the project is non-stochastic, that is, $x = 0$. It immediately follows from Hart and Moore (1989) that investors are willing to finance the project by debt only if $\delta^2 v \geq I$ provided that the liquidation value of the project, L_2, is less than the funds needed. If there were no moral hazard problem then any project with $\delta v \geq I > \delta^2 v$ could also raise debt with maturity of one period. Because of the moral hazard problem, however, investors can not enforce any payments at any point in time in excess of the current value of the entrepreneur-manager's expected future payoff at that point in time conditional on the continuation of the project. Since the entrepreneur-manager's valuation of the project is only δv when the repayment becomes due, the maximum investors can expect him to repay then is the smaller of $\frac{I}{\delta}$ and δv.

Section 4.2: Raising outside equity

After rewriting conditions (1), (2) and (7) the necessary condition to raise outside equity turns out to be

$$\frac{(1-\delta)I}{\delta} \leq \delta v - a, \tag{12}$$

that is,

$$v \geq \frac{(1-\delta)}{\delta^2} I + \frac{a}{\delta}. \tag{13}$$

Since depreciation solves $I = \sum_{t=0}^{1} a(\frac{1}{\delta})^t$, a turns out to be $\frac{\delta I}{1+\delta}$. After substituting for a, the equity financing condition becomes

$$v \geq \frac{(1-\delta)I}{\delta^2} + \frac{I}{1+\delta}. \tag{14}$$

The comparison of debt and outside equity financing conditions reveals that projects that are unable to raise debt may still raise outside equity.

Proposition 4 *If a project can raise debt-financing then it can also raise outside equity financing but not vice versa.*

Proof: in Appendix.

This is because debt is issued only if the smaller of the period 1 and the period 2 cash flow in present value terms exceeds the investment outlay. This implies that not only some positive net present value projects but even projects with positive net present value cash flows *in the low state* may be unable to raise debt financing. They can, however, raise outside equity since outside equity – as we have shown above – can smooth payments over time.

Section 4.3: Choosing between debt and outside equity

When investors are willing to hold both debt and outside equity, the entrepreneur has the choice of which security to issue for financing the firm. The entrepreneur chooses the type of financing that maximizes his expected payoff. In case of debt-financing the present value of entrepreneur-manager's payoff over the long run is

$$\frac{\delta v(1+\delta)-I}{1-\delta^2}. \tag{15}$$

In order to specify the entrepreneur-manager's payoff when outside equity is issued we need to compute the equilibrium dividend policy. After rewriting conditions (1), (2) and (7) we get that

$$\frac{(1-\delta)I}{\delta} \leq d^* \leq \delta v - a. \tag{16}$$

Since investors are Bertrand competitors (see Section 2.2) they are willing to finance the project if they break even, that is, if $d^* = \frac{(1-\delta)I}{\delta}$. In other words, investors are willing to finance the project even if all the rents accrue to the manager, that is, if

$$w^* = v - a - \frac{(1-\delta)I}{\delta}. \tag{17}$$

The comparison of the managerial payoffs associated with issuing debt or outside equity reveals that

$$\frac{\delta v(1+\delta)-I}{1-\delta^2} = \frac{\delta w^*}{1-\delta}, \tag{18}$$

that is, the entrepreneur-manager is indifferent between issuing debt and issuing equity when there is a demand for both. Consequently, in equilibrium returns are equalized across securities. Proposition 5 summarizes the result.

Proposition 5 *Whenever investors are willing to hold both debt and outside equity, then the entrepreneur-manager is indifferent between the two and may as well issues either one or a mix of the two.*

Proof: in Appendix.

Section 5: Capital structure decision with stochastic cash flows

In this section we consider projects with stochastic cash flows as specified in Section 2.

Section 5.1. Raising debt:

In this section we investigate the conditions under which projects with stochastic cash flows of the above type can raise debt financing. Since these projects are more complex than those considered by Hart and Moore (1989), we can not apply their debt-financing constraint directly. Since the creditor can only assure a payment that is the smaller of (1) the present value of the future cash flows for the entrepreneur; (2) the current cash flows plus the maximal amount that can be raised by liquidating assets so that cash flows from the remaining assets make the entrepreneur-manager just indifferent to transfer the current cash flows as payment, the debt-financing condition for the above projects will take the following form:

$$F \equiv \delta E \left(\min \left\{ \delta \tilde{v_2}, \max \left\{ \tilde{v_1}, \tilde{v_1} + \left(1 - \frac{\tilde{v_1}}{\delta \tilde{v_2}} \right) L_2 \right\} \right\} \right) \geq I. \tag{19}$$

To see how the cash flows affect the entrepreneur's access to debt financing we investigate the monotonicity properties of (19). After computing the minima for each of the four possible realizations of cash flows and taking the expected value we obtain that

$$F = \begin{cases} \delta^2 v & \text{if } \delta(v+x) \leq v - x \\ \delta \left[\frac{1}{4}(1+\delta)(v-x) + \frac{1}{2}\delta v + \frac{1}{4} \left(1 - \frac{v-x}{\delta(v+x)} \right) L_2 \right] & \text{otherwise.} \end{cases} \tag{20}$$

Notice that this condition depends on both the first and the second moment of the random cash flow variable. Hence, F is decreasing in the variance of the periodic cash flow provided that

$$\frac{(v+x)^2}{vL_2} \geq \frac{2}{\delta(1+\delta)}. \tag{21}$$

The intuition behind the condition is as follows. If the variance of the cash flow is low relative to the discount factor, so that $x \leq \frac{v(1-\delta)}{1+\delta}$, then the present value of the high (as well as the low) realization of the cash flow falls short of the current value of the low realization. If it is the case then investors expect to receive the smaller of $\frac{I}{\delta}$ and δv when payment becomes due. The project can raise debt if and only if $\delta v \geq \frac{I}{\delta}$.

As the standard deviation of the cash flow increases beyond $\frac{v(1-\delta)}{1+\delta}$, the expected present value of the incentive compatible payments on debt begins to fall since $\delta(v+x) \geq v-x$ is a sufficient condition for (21). Then the value of x^2 that solves (19) for equality, x_d^2, is the cutoff variance for the debt-financing of a project. The following proposition summarizes the result on the accessibility of debt-financing. The proof can be derived from the steps outlined above.

Proposition 6 *Positive net present value projects with variance above the cutoff level x_d^2 can not raise debt financing.*

Section 5.2. Raising outside equity:

In this section we investigate the conditions under which projects with stochastic cash flows can raise outside equity financing. We show that a project that is unable to raise debt may still be able to raise outside equity.

Recall from Section 3.1. that investors are willing to hold outside equity if there exists a pair of equilibrium dividend payments d_{v+x}, d_{v-x} to satisfy

$$\frac{\delta(d_{v+x}+d_{v-x})}{2(1-\delta)} \geq I,$$

and it is individually rational for the entrepreneur-manager to voluntarily limit diverting cash flows of the project as private benefits of control and to retain control over the operation of the assets in each state, if

$$(2-\delta^2)(v-x-d_{v-x}-a)+\delta^2(v+x-d_{v+x}-a)\geq 2(1-\delta)(v-x) \tag{22}$$

$$(2-2\delta+\delta^2)(v+x-d_{v+x}-a)+(2\delta-\delta^2)(v-x-d_{v-x}-a)\geq 2(1-\delta)(v+x). \tag{23}$$

Conditions (22) and (23) are obtained by reorganizing conditions (1) and (2) and substituting for M_{v+x} and M_{v-x}.

Note that conditions (22) and (23) are such that receiving the same *portion* of the cash flows than in the deterministic cash flow case may not necessarily satisfy the entrepreneur-manager in the high state. Consequently, the entrepreneur-manager may choose to underreport earnings by a disproportionally larger amount in the high state. As a result, the maximum outside equityholders can guarantee themselves in the high state is less, as a proportion of the cash flows, than the maximum outside equityholders could guarantee themselves in the deterministic cash flow case. This implication of the model can be interpreted as a bonus, a stock option (like in Holmström and Ricart-Costa (1986) even though the incentives and the managerial choices are quite different) *or that shareholders are more inclined to forgive management consuming excessive private benefits when earnings are high.*

For the purpose of investigating the demand for debt versus outside equity, conditions (7), (22) and (23) can be replaced by a sufficient condition that guarantees the outside equity financing of a stochastic cash flow project in equilibrium, that is:

$$\delta v - a - \frac{\delta(1-\delta)(2-\delta)}{2-\delta(2-\delta)}x \geq \frac{(1-\delta)I}{\delta}. \tag{24}$$

Condition (24) shows that depending on the riskiness of the cash flows a project may or may not raise outside equity. It all depends on whether the variance of the cash flows is below or above x_e^2, the value of x^2 that solves (24) as an equality.

Proposition 7 *Positive net present value projects with variance at or below x_e^2 can raise outside equity.*

Proof: in Appendix.

The next question is to investigate whether a risky project that is turned down for debt-financing can still raise outside equity financing. Here we only consider projects whose deterministic cash flow equivalent can raise debt financing. Deterministic cash flow equivalent of a project is a two-period deterministic cash flow project whose cash flow is equal to the expected periodic cash flow of the respective stochastic project. Only if its deterministic cash flow equivalent can raise financing can a risky project hope for raising financing.

Proposition 8 *A risky project that is unable to raise debt may still raise outside equity.*

Proof: in Appendix.

To see why this is the case, let us rearrange condition (24) and substitute in for a. Outside equity is held by investors whenever

$$\delta^2 v(1+\delta) - \delta^2 \frac{(1-\delta^2)(2-\delta)x}{2-\delta(2-\delta)} \geq I. \tag{25}$$

Recall that debt financing is available whenever

$$\frac{1}{4}\delta(1+\delta)(v-x) + \frac{1}{2}\delta^2 v + \frac{1}{4}\left(1 - \frac{v-x}{\delta(v+x)}\right)\delta L_2 \geq I. \tag{26}$$

Recall from the basic model that $L_2 < \delta(v - x)$. Hence the left side of (26) is bounded from above by

$$\delta^2(v - \frac{x}{2}) + \frac{1}{4}\delta(v - x).$$

It turns out that $\delta > .7374$ is a sufficient condition for

$$\delta^2(v - \frac{x}{2}) + \frac{1}{4}\delta(v - x) \leq \delta^2 v(1 + \delta) - \frac{\delta^2(1 - \delta^2)(2 - \delta)}{2 - \delta(2 - \delta)}x. \tag{27}$$

In other words, the left side of (26) is bounded from above by the left side of (25) for any reasonable discount factor. This is equivalent to saying that a risky project that is turned down for debt-financing can still raise outside equity financing.

Interestingly enough, outside equityholders are willing to bear more risk as measured by the variability of the cash flows than debtholders. Notice, however, that the risk from variability of cash flows is only part of the risk borne by securityholders. Another component of the risk borne by securityholders is the risk associated with managerial moral hazard. We have shown here that *outside equity can spread this moral hazard risk over time, whereas debt concentrates it on the payback period.* Since outside equity has a better technology for spreading moral hazard risk, *more cash flow risk can be absorbed by outside equity.*

Section 5.3: Choosing between debt and equity:

In the previous section we established that projects that can raise debt can also raise outside equity. When investors are willing to hold both, the entrepreneur can decide which security to issue. In the context of deterministic cash flow projects we have seen that the entrepreneur-manager is indifferent between debt or equity and may as well issue either one or both as long as he gets all the rents from the project. This is not necessarily the case with stochastic cash flow projects. The reason is that whenever $\delta(v + x) > v - x$ then debt-financing involves inefficient liquidation in equilibrium. Since investors receive I in case of both debt and equity financing, it is the manager who suffers as a result of liquidation. Hence, whenever $x > \frac{v(1-\delta)}{1+\delta}$, the entrepreneur-manager strictly prefers issuing outside equity to issuing debt. Otherwise, he is indifferent between the two and may as well issue either one.

Consequently, only stable projects with standard deviation $x \leq \frac{v(1-\delta)}{1+\delta}$ use debt-financing. These projects may also use outside equity or a mix of debt and outside equity. Projects with higher cash flow variability $\frac{v(1-\delta)}{1+\delta} < x \leq x_e$ use only outside equity financing. For projects with high cash flow variability x exceeding x_e neither debt nor outside equity is available. These projects must use other means of financing such as inside equity. Consistent with empirical evidence, this model predicts that debt-equity ratios will be higher in industries where cash flow variability is low relative to industries where cash flow variability is high.

Conclusion:

This paper resolves a long-standing puzzle in the security design literature, namely that no investor is willing to hold outside equity when management has the ability to divert cash flows as private benefits and when managerial manipulation of cash flows is costly to verify. We have shown here that investors are willing to hold outside equity but with unlimited life only: the very outside equity that corporations issue in practice. In contrast, all debt contracts have prespecified maturity dates in equilibrium: investors match the maturity of debt with the life of the physical assets and the maturity of outside equity with the growth prospects of the company.

Furthermore, we have demonstrated that beside debt, outside equity with unlimited life is the financing choice of positive net present value projects. Whenever a project can raise debt, it can also raise outside equity but not vice versa. In other words, depending on the characteristics of their projects, entrepreneurs, who can not raise debt may still raise outside equity. In particular when cash flows are stable then the entrepreneur may issue debt or outside equity or a mix of the two. If the cash flows are volatile so that no funds can be raised by issuing debt then investors may still be willing to provide outside equity financing.

This theory also offers interesting insights for other types of securities that firms use such as preferred stocks and income bonds[17]. Since failure to pay dividends on preferred stock or interest on income bonds can not force the firm into bankruptcy, preferred stocks and income bonds appear to be incompatible with nonverifiability of cash flows and managerial ability to divert cash flows as private benefits. Interestingly, however, investors would be willing to hold these securities provided that they are issued simultaneously or subsequently with outside common equity of unlimited life. Since preferred stockholders and income bondholders have a higher priority claim, common equityholders can only satisfy their claim after preferred stockholders and income bondholders satisfied theirs, thereby preferred stockholders and income bondholders can rely on outside common equityholders to effectively discipline management. This arrangement is sustainable as long as the preferred stock or income bond issue is small relative to common equity.

A related very important theoretical question is to analyze financing decisions of firms that issue both debt and equity simultanously or *subsequently*[18]. The first steps in this di-

[17]For an interesting theory of income bonds see Allen and Gale (1988). In a model of adverse selection where the cost of distorting the measurement system is positively correlated with firm type, the authors show that bad firms are more likely to offer securities such as income bonds, whose payments are contingent on earnings. In addition, Allen and Gale establish that the equilibrium where all firms offer a noncontingent contract is universally divine in the sense of Banks and Sobel (1988).

[18]Another interesting issue, the simultanous use of inside and outside equity financing, has been investigated in Fluck (1993), (1994), and, subsequent to the current paper, in Myers (1995). Fluck shows that in equilibrium a manager's willingness to invest in his company and the size of his equity stake are determined by and vary with market factors, such as the real cost of capital. Myers (1995) finds that when management has a significant equity stake in the company then limited life equity is also sustainable. His work sheds new light on companies' use of "sweat equity" for compensating management.

rection were carried out in Zender (1991) and Zwiebel (1993). Zender developed debt and *inside equity* as optimal instruments in a model where cash flows and control rights were allocated to investors endogenously. Zender addressed the question why residual claimants are assigned control rights while claimants with rights to a fixed cash flow stream are denied direct control over decisionmaking. Zender showed that when investment decisions must be made by a single party, then debtholders' cash flows are fixed in order to provide the equity-holder with efficient incentives for investment. Assuming an initial setting of outside equity with a three-period life, Zwiebel (1994) developed a model in which managers voluntarily set debt to restrict themselves. Whereas debt restricts managerial empire-building, it also serves as a voluntary and credible commitment by management to forego bad investments to prevent takeover challenges. Managers choose to issue debt to trade off empire-building ambitions with the need to retain the empire to realize these ambitions. Zwiebel assumes a somewhat different moral hazard setting from ours and does not try to derive debt and outside equity as optimal contracts, nevertheless his analysis is a novel way of dealing with the optimal leveraging decision of management once the initial equity is in place.

Having established the optimality of outside equity with unlimited life in the present paper, our next challenge is to revisit the optimal financing decisions of firms that have issued outside equity with unlimited life and are beyond their initial financing stage. This problem is beyond the scope of the current paper and is largely awaiting future research. One paper pursuing this direction is Fluck and Lynch (1995) which focuses on the financing decisions of firms that merge to exploit financial synergies. Fluck and Lynch develops a theory of mergers and divestitures wherein the motivation for mergers stems from the inability of firms to finance marginally profitable, possibly short-horizon projects as stand-alone entities due to agency problems between managers and potential claimholders based on the model developed in the present paper. A conglomerate merger can be viewed as a technology that allows marginally profitable projects, that investors would otherwise reject, to obtain financing. Their theory is well-suited to explain the empirical evidence that diversified firms are less valuable than more focused stand-alone entities and sheds some new light to the recent spate of mergers between biotechnology and pharmaceutical companies.

Appendix:

Proof of Proposition 1:

We prove by contradiction that neither the threat of liquidation nor the threat of dismissal can induce the entrepreneur-manager to pay out dividends along the path of play in any Nash equilibrium when outside equity has a prespecified expiration date. Suppose that in some Nash equilibrium the entrepreneur-manager pays dividends at some stages with positive probability. Let T be the last stage at which this is so; that is, there is zero probability of cooperation along the equilibrium path in stages T+1,T+2,...,N, where N is the expiration date on equity. Now examine the incentives of the entrepreneur-manager who is meant to cooperate along the path of play in stage T. He will do no better than zero in the remaining stages by following the equilibrium since investors will not retain him subsequently along the equilibrium path. By not paying out any dividends in stage T and in every subsequent stage, the entrepreneur-manager does better immediately than if he follows the equilibrium prescription, and he can do no worse than zero subsequently. Hence the entrepreneur-manager will not cooperate in stage T, and we reached a contradiction. We can also reach contradiction by examining the incentives of investors who are meant to cooperate along the path of play in stage T. □

Proof of Proposition 2:

To establish that a dividend policy is an equilibrium we need to check whether (i) the entrepreneur-manager are willing to pay equilibrium dividends and to set aside depreciation; (ii) investors are willing to finance the project ex ante in exchange for equilibrium dividends; (iii) investors are willing to keep the entrepreneur-manager as long as equilibrium dividends are paid and depreciation are properly set aside; (iv) investors are willing to dismiss the entrepreneur-manager if he failed to pay equilibrium dividends and/or failed to set aside a depreciation account; (v) the entrepreneur-manager keep diverting all cash flows after any history of deviation. The corresponding equilibrium conditions are listed below.

(i) The entrepreneur-manager are willing to pay equilibrium dividends and to set aside depreciation in exchange for staying in office in the future if conditions (1), (2), (3), (4), (5) and (6) hold.

(ii) Investors are willing to finance the project ex ante in exchange for equilibrium dividends if condition (7) is satisfied.

(iii) investors are willing to keep the entrepreneur-manager as long as equilibrium dividends are paid and depreciation are properly set aside if conditions (8), (9), (10) and (11) hold.

(iv) It is incentive compatible for outside equityholders to replace the entrepreneur-manager who has failed to comply with the equilibrium in the period when the investment was being replaced and when the parties learned the realization of the period 1 and period 2 cash flows, if for every v_1 and v_2, taking values $v - x, v + x$:

(A) investors are better off repeating the project and replacing the manager than repeating the project and keeping the entrepreneur-manager, that is,

$$\hat{d}^-_{v_2} + \frac{\delta(d_{v+x} + d_{v-x})}{2(1-\delta)} - \frac{a}{\delta} \geq 0; \tag{28}$$

(B) investors are better off repeating the project and replacing the manager than liquidating the project, that is,

$$\hat{d}^-_{v_2} + \frac{\delta(d_{v+x} + d_{v-x})}{2(1-\delta)} - \frac{a}{\delta} \geq L_2; \tag{29}$$

(C) investors are better off repeating the project and replacing the manager than dismissing the manager and abandoning the project, that is,

$$\hat{d}^-_{v_2} + \frac{\delta(d_{v+x} + d_{v-x})}{2(1-\delta)} - \frac{a}{\delta} \geq -\frac{a}{\delta} + I + \hat{d}^-_{v_2}. \tag{30}$$

It is incentive compatible for outside equityholders to replace the entrepreneur-manager who has failed to comply with the equilibrium in the period when the investment was ongoing, if for every v_1 and v_2, taking values $v-x, v+x$:

(A) investors are better off repeating the project and replacing the manager than not repeating the project, that is,

$$\frac{\delta(\hat{d}^-_{v+x} + \hat{d}^-_{v-x})}{2(1-\delta)} + \frac{\delta^2(\hat{d}_{v+x} + \hat{d}_{v-x})}{2(1-\delta)} - a \geq \frac{a}{\delta} \tag{31}$$

(B) investors are better off repeating the project and replacing the manager than reinvesting and liquidating the project, that is,

$$\frac{\delta(\hat{d}^-_{v+x} + \hat{d}^-_{v-x})}{2(1-\delta)} + \frac{\delta^2(\hat{d}_{v+x} + \hat{d}_{v-x})}{2(1-\delta)} - a \geq -a + I \tag{32}$$

(C) investors are better off repeating the project and replacing the manager than repeating the project and keeping the entrepreneur-manager, that is,

$$\frac{\delta(\hat{d}^{-}_{v+x} + \hat{d}^{-}_{v-x})}{2(1-\delta)} + \frac{\delta^2(\hat{d}_{v+x} + \hat{d}_{v-x})}{2(1-\delta)} - a \geq -a. \tag{33}$$

(v) Trivially holds. Given that he faces dismissal, it is incentive-compatible for the entrepreneur-manager to divert the cash flows following a deviation.

After reorganizing the equilibrium conditions we get that, given the assumptions of the basic model on the parameters, (1), (2) and (7) are sufficient conditions for the rest of the constraints to hold. □

Proof of Proposition 3:

First we establish that the entrepreneur-manager never sets aside depreciation allowances in equilibrium. Since a depreciation account increases the value of the assets investors can foreclose in the event of a default, the entrepreneur-manager would set aside depreciation allowances only if debtholders offered better terms in exchange of his promising to do so. Debtholders would offer better terms to the entrepreneur-manager in exchange of his promise to set aside depreciation allowances only if one of the following two conditions holds: either the entrepreneur-manager can precommit to fulfill his promise; or, otherwise, if debtholders can induce him to set aside depreciation allowances in equilibrium. However, neither of these condition holds in this model in case of debt-financing: (1) the entrepreneur-manager can not precommit to fulfill his promise; (2) debtholders, in contrast to equityholders, can not induce him to set aside depreciation in equilibrium because their control rights are conditional on the entrepreneur-manager failing to make a verifiable payment only. Consequently, the entrepreneur-manager never sets aside depreciation allowances in equilibrium.

Next suppose that creditors offer a debt contract with maturity equal to the economic life of the project, i.e. the last debt payment is due at the time of replacement. Suppose, furthermore, that the entrepreneur-manager complies with the first payment but defaults on the second payment. Then the debtor could make a take-it-or-leave-it offer to the creditor, offering no payment at all, and the creditor would be indifferent between accepting it, foreclosing the assets with liquidation value zero, or forgiving the debt. If the project gets liquidated it is profitable for the entrepreneur-manager to restart it (see Page 8 paragraph 3) and even if holders of this off-equilibrium debt contract like to commit never to provide financing for this entrepreneur in the future, the availability of another, self-enforcing contract, one-period debt or unlimited life equity, makes it worthwhile for other investors, say finance companies or venture capitalists, to come along and provide financing to the entrepreneur-manager. The same would apply for long term and for unlimited life debt contract. Once the initial debt contract is written, then threatening with non-renewal or termination following a liquidation is no longer credible in this model. Consequently, no debt contract with maturity as long as, or longer than the economic life of the project is incentive compatible for the creditor in the first place. □

Proof of Proposition 4:

The debt-financing condition is: $v \geq I/\delta^2$. The equity-financing condition takes the form of $v \geq \frac{(1-\delta)I}{\delta^2} + \frac{I}{1+\delta}$. Since $I/\delta^2 > \frac{(1-\delta)I}{\delta^2} + \frac{I}{1+\delta}$, a project that can raise equity is not always able to raise debt. □

Proof of Proposition 5:

Since at $w^*_{max} = v - a - (1-\delta)I/\delta$

$$\frac{\delta v(1+\delta) - I}{1-\delta^2} = \frac{\delta w^*_{max}}{1-\delta}. \quad \square$$

Proof of Proposition 7:

Investors are willing to hold outside equity financing if there exists a pair of dividends (d_{v+x}, d_{v-x}) such that (1), (2) and (7) holds.

Rearranging conditions (1), (2) we get

$$2(1-\delta)(1+\delta)M_{v-x}+\delta^2(M_{v+x}+M_{v-x})\geq 2(1-\delta)(v-x); \tag{34}$$

$$2(1-\delta)M_{v+x}+2\delta(1-\delta)M_{v-x}\delta^2(M_{v+x}+M_{v-x})\geq 2(1-\delta)(v+x), \tag{35}$$

that is,

$$(2-\delta^2)M_{v-x}+\delta^2 M_{v+x}\geq 2(1-\delta)(v-x), \tag{36}$$

$$(2-\delta(2-\delta))M_{v+x}+\delta(2-\delta^2)M_{v-x}\geq 2(1-\delta)(v+x). \tag{37}$$

It is straightforward to see that the portion of cash flows sufficient to guarantee the cooperation of the entrepreneur-manager in the deterministic cash flow case is no longer sufficient in the stochastic cash flow case. We solve for the entrepreneur-manager's payoff by setting M_{v-x} equal to the fraction of cash flows that is sufficient to guarantee the cooperation of the entrepreneur-manager in the deterministic cash flow case[19]. By setting $M_{v-x} = (1-\delta)(v-x)$ and setting condition (2) to equality we get that

$$M_{v+x}=(1-\delta)(v+x)+x\frac{2(1-\delta)(2\delta-\delta^2)}{(2-\delta(2-\delta))}. \tag{38}$$

Then plugging M_{v-x}, M_{v+x} into condition (7) we get a sufficient condition for outside equity financing, that is,

$$\delta v-a-\frac{\delta(1-\delta)(2-\delta)}{2-\delta(2-\delta)}x\geq\frac{(1-\delta)I}{\delta}. \tag{39}$$

[19]The resulting payoff-pair will be close to the minimum and sufficient for our purpose, that is, to demonstrate that it is easier to raise outside equity than debt.

Consequently, positive net present value projects with variance below x_e^2, the variance that sets (39) to equality can raise outside equity financing. □

Proof of Proposition 8:

Debt is available whenever

$$\delta\left[\frac{1}{4}(1+\delta)(v-x)+\frac{1}{2}\delta v+\frac{1}{4}\left(1-\frac{v-x}{\delta(v+x)}\right)\right]\geq\frac{I}{\delta}. \tag{40}$$

The left hand side is bounded from above by $\frac{1}{4}\delta(v-x)+\delta^2(v-\frac{x}{2})$ that is also bounded from above by the outside equity financing condition

$$\delta v(1+\delta)-\frac{\delta(1-\delta^2)(2-\delta)}{2-\delta(2-\delta)}x\geq\frac{I}{\delta} \tag{41}$$

for $\delta > .7374$, a condition that includes all reasonable discount factors for our purposes, as shown below.

First, for $\delta > \frac{1}{2}$ it is true that $\frac{1}{4}\delta v < \delta^3$.

Secondly,

$$-\frac{1}{4}\delta x+\delta^2(v-\frac{x}{2})<\delta^2 v-\frac{\delta^2(1-\delta^2)(2-\delta)}{2-\delta(2-\delta)}x,$$

that is,

$$\frac{1}{4}-\frac{\delta}{2}<-\frac{\delta(1-\delta^2)(2-\delta)}{2-\delta(2-\delta)}.$$

The latter holds for $\delta > .7374$. □

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