DETERMINANTS OF CORPORATE BORROWING*

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Many corporate assets, particularly growth opportunities, can be viewed as call options. The value of such 'real options' depends on discretionary future investment by the firm. Issuing risky debt reduces the present market value of a firm holding real options by inducing a suboptimal investment strategy or by forcing the firm and its creditors to bear the costs of avoiding the suboptimal strategy. The paper predicts that corporate borrowing is inversely related to the proportion of market value accounted for by real options. It also rationalizes other aspects of corporate borrowing behavior, for example the practice of matching maturities of assets and debt liabilities.

1. Introduction

There is an important gap in modern finance theory on the issue of corporate debt policy. The theory should be able to explain why tax savings generated by debt do not lead firms to borrow as much as possible, and it should explain the phrase 'as much as possible'. It should explain why some firms borrow more than others, why some borrow with short-, and others with long-maturity instruments, and so on.

A variety of ideas has been advanced to fill this gap. Modigliani and Miller (MM) have suggested (1963, p. 111) that firms maintain 'reserve borrowing capacity' – although the need for such flexibility is not clear in the frictionless capital markets MM rely on – and that the incremental tax advantage of borrowing declines as more debt is issued and interest tax shields become less certain. They and others have also noted that personal taxes – specifically the difference between tax rates on capital gains and rates on regular income – reduce the theoretical tax advantage of corporate borrowing,[1] and Miller (1977) has presented a model in which the advantage entirely disappears. These

[1]See Farrar and Selwyn (1967) and Stiglitz (1972).

arguments rationalize firms' reluctance to borrow 'as much as possible', but they give little specific guidance beyond that.

There are other lines of argument. Firms' debt policies may reflect imperfect or incomplete capital markets.[2] The literature on credit rationing by banks and other lenders may help explain the limits to corporate borrowing.[3] Perhaps managers avoid high debt ratios in an attempt to protect their jobs and stabilize their personal wealth.[4] Perhaps firms' financing decisions are actually signalling devices, conveying information to investors about the firm's business risk and profitability.[5]

Bankruptcy costs (the transaction costs of liquidation or reorganization) probably discourage borrowing, although recent research by Warner (1977) questions whether these costs are large enough to be significant. Perhaps, as Robicheck and Myers (1966) argue, costs of financial distress are incurred when the firm comes under the threat of bankruptcy, even if bankruptcy is ultimately avoided.[6]

There is doubtless some truth in each of these ideas, but they do not add up to a rigorous, complete and sensible explanation of corporate debt policy. This paper presents a new approach which does not rely on any of the ideas mentioned above. It explains why it is rational for firms to limit borrowing, even when there is a genuine tax advantage to corporate borrowing and capital markets are strictly perfect, efficient, and complete. It shows that a form of capital rationing by lenders can exist in such conditions. It specifies an asset characteristic that encourages relatively heavy borrowing; this characteristic is not 'low risk' in any of the usual senses of that phrase. Finally, it explains a number of previously puzzling phenomena. For example, it clarifies why practical people set target debt ratios in terms of book rather than market values, and why firms tend to 'match maturities' of assets and debt obligations.

The theory rests on a relatively simple argument. It starts with the observation that most firms are valued as going concerns, and that this value reflects an expectation of continued future investment by the firm. However, the investment is discretionary. The amount invested depends on the net present values of opportunities as they arise in the future. In unfavorable future states of nature the firm will invest nothing.

Thus part of the value of a firm is accounted for by the present value of *options* to make further investments on possibly favorable terms. This value

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[2]Durand's early critique of the MM propositions (1959) rests on market imperfections. The effects of incomplete markets on the firm's capital structure choice were emphasized later by Robichek and Myers (1966) and Stiglitz (1974), among others.

[3]See, for example, Jaffee (1971) and Jaffee and Russell (1976).

[4]Donaldson (1963).

[5]See Ross (1977) and Leland and Pyle (1976).

[6]But Robichek and Myers did not understand *why* a high probability of bankruptcy should in itself make it difficult to raise additional financing, or why it should lead to suboptimal investment decisions. I say this on the best authority.

depends on the rule for deciding whether the options are to be exercised. The paper shows that a firm with risky debt outstanding, and which acts in its stockholders' interest, will follow a different decision rule than one which can issue risk-free debt or which issues no debt at all.[7] The firm financed with risky debt will, in some states of nature, pass up valuable investment opportunities – opportunities which could make a positive net contribution to the market value of the firm.

Issuing risky debt reduces the present market value of the firm by inducing a future strategy that is suboptimal in the sense just described. The loss in market value is absorbed by the firm's current stockholders. Thus, in the absence of taxes, the optimal strategy is to issue no risky debt. If there is a tax advantage to corporate borrowing, the optimal strategy involves a tradeoff between the tax advantages of debt and the costs of the suboptimal future investment strategy. If Miller (1977) is right, and taxes are irrelevant to the firm's debt–equity choice, then we must seek some other reason for explaining why firms use debt. As this paper does not attempt to be a complete theory of corporate debt policy, those other reasons are not pursued here.[8]

In many ways this paper is like Jensen and Meckling's (1976) analysis of agency costs and optimal capital structure. The suboptimal investment policy is an agency cost induced by risky debt. However, this particular cost was not stressed by Jensen and Meckling. Their theory of optimal capital structure is based on different phenomena. On the other hand, this paper resembles theirs in that the analysis finally rests on costs that have traditionally been viewed as market imperfections, in particular costs of negotiation, monitoring and enforcement of contracts.[9]

The paper's formal argument is presented for a simple case in section 2. The assumptions underlying the formal argument are discussed in detail in section 3. Section 4 gives a general statement of the theory and considers how optimal debt policy changes as firms merge, or as different assets are combined in a single firm. Section 5 sketches empirical implications.

2. The basic idea

2.1. Statement of the problem

At first glance, some of the oddest practical rules of thumb for judging debt

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[7]Of course this point is not in itself new. For example, Fama and Miller (1971, pp. 179–81), and Fama (1976) have noted that conflicts of interest between bondholders and stockholders can affect the firm's operating and investment decisions. However, they argue that such conflicts are easily and cheaply resolved. I disagree, at least with respect to the specific case discussed here. Galai and Masulis (1976) have also recognized that the firm's investment policy depends on capital structure. However, this is a relatively minor part of their paper.

[8]But see Jensen and Meckling (1976).

[9]After I wrote this paper, Michael Brennan showed me preliminary work, done in 1973, which approached the borrowing decision along much the same lines taken here. Unfortunately Brennan's work was never developed and published.

policy are those which depend on ratios of debt to the book value of equity or
to total book capitalization. Anyone familiar with modern finance theory
considers ratios based on market values much more pertinent. Yet there is an
element of sense in the practical procedures. It is not that book values are more
accurate than stock market values, but simply that they refer to assets *already
in place*. A significant part of many firms' market values is accounted for by
assets not yet in place, i.e., by the present value of future growth opportunities.
In this section I will show that the amount of debt 'supported by' growth
opportunities will be less, other things equal, than is supported by assets
already in place. I start with this case because it provides the clearest and most
dramatic illustration of the ideas advanced in this paper.

I will assume that there are no corporate taxes and no bankruptcy costs. The
firm's managers act in the shareholders' interest. Capital markets are perfect
and complete, so that investors can construct portfolios with any conceivable
pattern of returns across future states of nature.[10] Let V be the current equi-
librium market value of the firm, and V_D and V_E the current equilibrium market
values of debt and equity, respectively.

As was previously noted, V can be broken down into the present value of
assets already in place and the present value of future growth opportunities,

$$V = V_A + V_G, \tag{1}$$

where V_A is the market value of assets already in place,[11] and V_G is the present
value of future investment opportunities.

The usual interpretation is that a positive value of V_G reflects future invest-
ments which are expected to yield a rate of return in excess of the opportunity
cost of capital. However, since the firm may choose *not* to pursue future
investment opportunities, V_G is best regarded as the present value of the firm's
options to make future investments. The distinction being drawn here is between
assets whose ultimate value depends on further, discretionary investment by
the firm, and assets whose ultimate value does not depend on such investment.

We start with a firm with no assets in place ($V_A = 0$) and only one future
investment opportunity. The firm is initially all-equity financed. It must decide
whether to invest I one period hence, at $t = 1$. If it invests, the firm obtains
an asset worth $V(s)$ at $t = 1$, where s is the state of nature then obtaining. If it
does not invest then the investment opportunity expires and has no value to
the firm or to anyone else.

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[10]I adopt this framework to show that the theory developed below does not depend on some
subtle imperfection or gap in *financial* markets. But neither does it depend on full perfection
and completeness – these are sufficient, but not necessary conditions. See section 4.

[11]What about future opportunities the firm is contractually obligated to accept? If the
obligation really is ironclad, then they should be included in V_A. However, usually the firm
can default on such obligations. Given limited liability, the contract can be ironclad only if
there is an escrow account or some other security to back up the investment outlay.

Thus the firm's initial (market value) balance sheet is as follows:

Balance sheet at $t = 0$

Value of growth opportunity	V_G	0	Value of debt
		V_E	Value of equity
Value of firm	V	V	

In the next period the firm must decide whether to invest – that is, whether to exercise its option. *If* it decides to invest, additional shares must be issued to raise the required investment *I*. In that event the value of the firm will be $V(s)$.

Balance sheet at $t = 1$

Value of newly acquired asset	$V(s)$	0	Value of debt
		V_E	Value of equity
Value of firm	$V(s)$	$V(s)$	

If the investment is not made, no additional shares are issued, the option expires, and the firm is worthless. (That is not a necessary assumption: it is sufficient that the value of the option declines if exercise is delayed.)

Obviously, the investment will be made only if $V(s) \geq I$. The decision is shown in fig. 1.[12] For states displayed to the right of s_a ($s \geq s_a$), the investment is made. This is noted by setting the decision variable $x(s) = 1$. For states $s < s_a$, $x(s) = 0$. Thus s_a is the 'breakeven' state.

Given complete markets, the value of the firm at $t = 0$ is

$$V = \int_0^\infty q(s)x(s)[V(s)-I]\mathrm{d}s, \tag{2}$$

where $q(s)$ is the current equilibrium price of a dollar delivered at period $t = 1$ if and only if state s occurs. Under all-equity financing $x(s) = 0$ for $s < s_a$, and $x(s) = 1$ for $s \geq s_a$, so

$$V = \int_{s_a}^\infty q(s)[V(s)-I]\mathrm{d}s. \tag{3}$$

[12]For convenience, the states are plotted in order of increasing $V(s)$. This entails no loss in generality. Also, $V(s)$ is not necessarily a linear function of s, although I have drawn it that way.
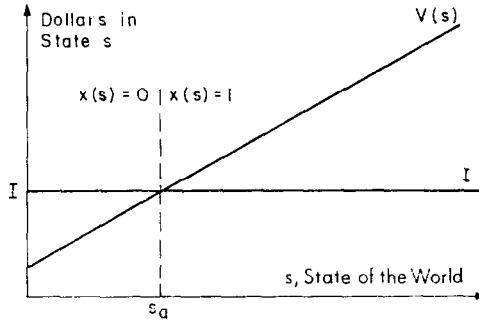
Fig. 1. The firm's investment decision under all-equity financing as a function of the state of the world, s, at the decision point.

2.2. The link between borrowing and the market value of the firm

Since the firm will be worth nothing in states $s < s_a$, it can issue no safe debt. However, it can issue risky debt with the promised payment P. It it does so, its initial balance sheet is

Balance sheet at $t = 0$

Value of growth opportunity	V_G	V_D	Value of debt
		V_E	Value of equity
Value of firm	V	V	

Note that the proceeds of the debt issue are used to reduce the required initial equity investment. They are not held as cash or used to purchase other assets. If they were our mental experiment would be spoiled, for the debt would be partly 'supported by' the cash or other assets, not solely by the investment opportunity.

Assume first that the debt matures before the investment decision is made, but after the true state of nature is revealed. Then if $V(s) - I \geq P$, it will clearly be in the stockholders' interest to pay the debtors off. If $V(s) - I < P$, however, the bondholders will take over, and will exercise the firm's option to invest if $V(s) \geq I$. Thus the equilibrium market value of the debt at $t = 0$ is

$$V_D = \int_{s_a}^{\infty} q(s)[\min(V(s) - I, P)] ds. \tag{4}$$

In this case shareholders can borrow the entire value of the firm if they wish.
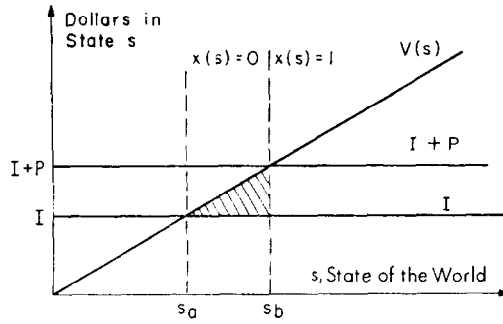
Fig. 2. The firm's investment decision with prior debt financing as a function of the state of the world, s, at the decision point.

If P is made large enough to exceed $V(s)-I$ in all states, then $V_D = V$ as given by eq. (3). The amount borrowed is a matter of indifference to stockholders – Modigliani and Miller's Proposition I is well known to hold under present assumptions.[13]

The interesting case occurs when the debt matures *after* the firm's investment option expires. Then outstanding debt will change the firm's investment decision in some states.

If the firm raises the amount I and exercises its investment option, its balance sheet will be:

Balance sheet at $t = 1$, given $x(s) = 1$

Value of newly acquired asset	$V(s)$	$\min[V(s), P]$	Value of debt
		$\max[0, V(s)-P]$	Value of equity
Value of firm	$V(s)$	$V(s)$	

But from the shareholders' viewpoint, the option is worth exercising only if $V(s)$ exceeds the sum of I, the required outlay, and P, the promised payment to the firm's creditors. If $V(s) < I+P$ and the investment is made, shareholders' outlay I will exceed the market value of their shares. The new situation is shown in fig. 2. Here $x(s) = 0$ for $s < s_b$ and $x(s) = 1$ for $s \geqq s_b$; s_b is the 'breakeven' state in which $V(s) = I+P$.

The firm's value at $t = 0$ is now given by

$$V = \int_{s_b}^{\infty} q(s)[V(s)-I]\,ds, \tag{5}$$

[13]Hirshleifer (1968, pp. 264–268).

where s_b depends on P, the promised payment to creditors. So long as $s_b > s_a$, there is a loss of value in some states of nature. The loss is shown by the shaded triangle in fig. 2. A higher P implies a larger triangle and a lower V. In fact, if P is set high enough, $V(s)$ will be less than $I+P$ in all states and $x(s)$ will be zero in all states. The firm will be worthless because its growth option will expire unexercised.

The creditors will receive nothing at all if the growth option is not exercised. If it is exercised, then $V(s)$ must exceed P, so $\min(V(s), P) = P$. Thus,

$$V_D = \int_{s_b}^{\infty} Pq(s)\,ds. \tag{6}$$

Clearly $V_D < V$, except in the limit where $P \to \infty$, $s_b \to \infty$ and $V \to 0$. Also, V must be less than its all-equity value [given by eq. (3)] whenever P is positive. Consequently, the relationship of V_D to P must be as shown in fig. 3. There is a definite limit, $V_D(\max)$, to the amount the firm can borrow (assuming it wants
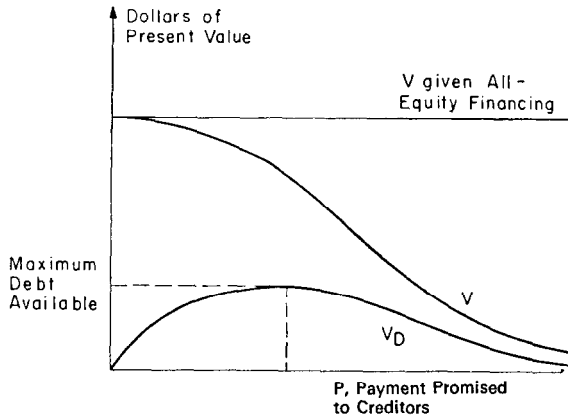

Fig. 3. Firm and debt values as a function of payment promised to creditors.

to). This limit is less than V and falls even further short of what V would be under all-equity financing. This is an interesting result because it shows one way in which credit rationing can occur even in perfect capital markets. After a point the firm cannot borrow more by offering to pay a higher interest rate. In fact, it may find that an offer to pay more *reduces* the amount of credit available to it.

Since the shareholders' objective is to maximize V, the market value of the firm, the optimal policy in the case described by fig. 3 is to issue no debt at all. Any promised payment will lead the firm to abandon a project with positive net present value in some future states. Thus V is a monotonically decreasing function of P, and it is maximized when P and V_D equal zero.

2.3. Comments

The example shows how the existence of corporate debt *can* reduce the present market value of the firm by weakening the corporation's incentive to under-take good future investments. I have not yet argued that the incentive *will* actually lead to the result just described. The incentive problem could be easily avoided in the simple world postulated for the example. For example, creditors could be given the right to exercise the investment option (with their own money) if stockholders get cold feet. But I argue below that the problem is not so easily evaded in reality.

Of course, the example leads to an extreme result: firms with valuable growth opportunities would never issue risky debt. But, as Jensen and Meckling (1976) point out, there are incentive problems – agency costs – associated with equity as well as debt issues. Debt may be the lesser evil. Also there may be tax advan-tages to debt. The appendix shows how taxes affect optimal borrowing in the case just discussed.

3. Discussion

3.1. Assets as call options

What are the essential characteristics of the 'growth opportunity' discussed in the previous section? They flow from the fact that it can be regarded as a call option on a real asset. The option's exercise price is the future investment needed to acquire the asset. Whether the option has any value when it expires depends on the asset's future value, and also on whether the firm chooses to exercise. The decision to exercise is not trivial and automatic, as it is for options written on securities, because it depends on the magnitude of promised payments to bondholders.

Thus the most fundamental distinction is not between 'growth opportunities' and 'assets in place', but between (1) assets that can be regarded as call options, in the sense that their ultimate values depend, at least in part, on further dis-cretionary investment by the firm and (2) assets whose ultimate value does not depend on further discretionary investment.

In reality, the difference between 'assets in place' and 'growth opportunities' is more of degree than kind. The market value of almost all real assets can be partly attributed to associated call options. That is, the ultimate payoff of almost all assets depends on future discretionary investment by the firm. The discretionary investment may be maintenance of plant and equipment. It may be advertising or other marketing expenses, or expenditures on raw materials, labor, research and development, etc. All variable costs are discretionary investments.

For most lenders the relevant asset is the firm itself. Their loans' values depend

on the value of the firm as a going concern, not on the value of any specific physical asset. (It is true that lenders often protect themselves by obtaining security in the form of specific assets for which secondary markets exist. But that is an attempt to avoid the problems analyzed in this paper.) The value of a going concern can be maintained only by positive action; in a competitive industry the firm should have to work hard to simply keep up. This is not simply a matter of maintaining plant and equipment. There is continual effort devoted to advertising, sales, improving efficiency, incorporating new technology, and recruiting and training employees. All of these activities require discretionary outlays. They are options the firm may or may not exercise; and the decision to exercise or not depends on the size of payments that have been promised to the firm's creditors.

Thus the issues introduced in the discussion of growth opportunities are really very general ones. The heart of the matter is that the existence of debt changes the firm's actions in some circumstances. It creates situations ex post in which management can serve shareholders' interests only by making sub-optimal decisions. Ex ante, this reduces the value of the firm (other things equal) and reduces shareholders' wealth.

3.2. The costs of avoiding the problem

Why not eliminate this problem by adding a clause to the debt contract? That is, the contract could include a specific requirement that the firm take on each investment project in all states where its net present value is positive.

Rewriting the contract is not the only alternative. For example, the initial contract could be accepted with the expectation that it would be renegotiated if a favorable investment opportunity would otherwise be passed up.

These are two of the several possible solutions discussed below in the context of the simple case of section 2. The discussion also applies to the general case to be presented in section 4.

All the possible solutions I have been able to identify are costly, in some cases so costly that they seem infeasible. The costs reflect primarily the costs of monitoring and contract enforcement. I am also assuming imperfect markets for growth options and other intangible real assets. That is discussed further in section 4.

3.2.1. Rewriting the debt contract

The firm could accept a debt contract requiring it to undertake all future investments having positive net present value, but that would be an empty promise. There are several reasons. First, the contract could not be enforced when it counts, because limited liability protects shareholders from mandatory future assessments. To make the contract work, the firm's owners would all have to sign contracts as individuals, with each shareholder bearing a pro rata

share of the possible assessment. The difficulties of obtaining such an agreement go beyond the costs of paperwork, distributing information, and monitoring.[14] Consider an individual who accepts, in principle, that shareholders ought to forfeit part of their right to limited liability. (Presumably, the possible assessment would be limited to some maximum amount.) It is not in his interest, acting individually, to guarantee his share of the potential assessment. The resulting increase in firm value accrues to all shareholders, not to him alone. In other words, the commitment to advance funds is, from the individual shareholder's viewpoint, a public good.

Second, even if such a contract were laboriously constructed, there would rarely be any objective basis for judging whether it is breached. In the example discussed in section 2, bondholders could press for specific performance only by showing that $V(s) > I$. But for most corporate investments $V(s)$ is not objectively observable. Instead it is estimated by management, who will no doubt be appropriately pessimistic if their unbiased estimate of $V(s)$ is greater than I but less than $I+P$. Even if $V(s)$ is observable, its magnitude is typically under management control. If it turns out that $V(s)$ is potentially between I and $I+P$, a management that acts in the shareholders' interests will surely be able to find some suboptimal policy that dissipates the opportunity, forcing its actual value below I. No sane lawyer attempts to write a contract requiring management to 'abstain from suboptimal decisions'.

In most cases the only enforceable contract would be a promise by the firm, backed up by the present value of I in escrow, to take the investment opportunity *whatever happens*. Then the value of the firm, including the escrow, is

$$V = \int_0^\infty V(s)\,\mathrm{d}s. \tag{7}$$

Since the investment in this case is not discretionary, the existence of debt does affect it, and the firm can go to 100 percent debt if it wishes.

Why do we not observe firms committing themselves to future investments? Evidently this action has offsetting costs. The firm's net debt position under such a contract is V_D less the value of the escrow. If the escrow exceeds V_D, the firm ends up as a net lender rather than a net borrower. In that case, what is the point?

More important, the debt contract forces the firm to accept projects with negative net present values in unfavorable states of nature. Thus the value of the firm declines by

$$\Delta V = \int_0^{s_a} [V(s) - I]q(s)\,\mathrm{d}s < 0.$$

Note that $V(s) < I$ in states $0 < s < s_a$.

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[14]There are many things creditors would have to guard against. For example, shareholders can protect themselves against possible assessment by setting up a thinly capitalized, intermediate corporation to hold the firm's shares.

Thus there is a tradeoff between the loss ΔV and the gain created by the commitment to invest. Of course, if it is unlikely that $V(s)$ will be less than I, then the cost ΔV is small and the commitment to invest in all states may be worthwhile. Nevertheless this exception proves the rule. The lower the probability that $V(s)$ will be less than I, the less the asset has of the essential characteristics of a growth opportunity, and the more it is like an asset in place.

3.2.2. Renegotiating the debt contract

Thus it seems extremely difficult to write and enforce a debt contract which requires optimal (i.e., firm value maximizing) capital budgeting decisions. But if the problem cannot be solved ex ante, perhaps it can be solved ex post. If creditors and shareholders find themselves in a position where the net present value of an investment project is positive, but less than the payment promised to creditors, then it is in both sides' interest to renegotiate the debt contract. Renegotiation may lead to an arrangement in which creditors accept less than the face amount of their securities in exchange for the owners' commitment to put up funds for further investment. The arrangement may call for either party to buy out the other, or for a third party to buy out the first two.

Renegotiation is not impossible, merely costly. There are the direct costs of renegotiating, perhaps magnified by the mutual suspicion which tends to arise in situations of financial distress. Second, the creditors cannot renegotiate intelligently without an estimate of the net present value of the project in question. They cannot depend on management's estimate, since the shareholders' interest is served by downplaying the opportunity's value.[15] Yet it is doubtful that creditors could obtain an adequate estimate of this value without continual monitoring of the firm's actions and prospects – a costly duplication of one important aspect of the management function.

These monitoring and renegotiation costs are worthwhile to the extent that the incidence of suboptimal investment decisions is reduced, but the prospect of these costs nevertheless reduces the present market value of the firm. Moreover, the reduction is an increasing function of the amount of debt the firm carries.

3.2.3. Shortening debt maturity

One apparently easy way out is to shorten the maturity of outstanding debt. Debt that matures *before* an investment option is to be exercised does not

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[15]The firm may even 'demand' renegotiation when $V(s) > I+P$. After all, they can always claim that $V(s) < I+P$. Without monitoring creditors cannot know which is the truth. This may be one reason why conditions of financial distress often are resolved by a third party buying out all security holders – via a merger, for example. Of course this simplifies capital structure and removes many of the conflicts of interest that would otherwise lead to good opportunities being passed up. But the possibility of a third party offer also assists debtor-creditor negotiations, since debtors are less tempted to downplay the firm's investment prospects.

induce suboptimal investment decisions. Thus it seems that permanent debt capital is best obtained by a policy of rolling over short maturity debt claims.

The roll-over cannot be automatic however. If it is, we are back to the problem described in section 2. Borrowing short does not, in itself, reduce monitoring costs. What it does offer is the setting for continuous and gradual renegotiation, in which the firm can in principle shift at any time back to all-equity financing, or to another source of debt capital. This seems to be a good solution, but there are costs of maintaining such a continuous, intimate and flexible relationship.

3.2.4. Mediation

There is still another possibility. Creditors could reserve the right to bring in an independent fact-finder and mediator *ex post* when there are symptoms of financial distress and suspicion that a suboptimal investment policy is being followed. Both creditors and debtors may be better off placing their fate in the hands of an impartial third party than attempting to negotiate bilaterally.

The major disadvantage of this approach is the difficulty of defining when the mediator is to be called in. The firm would not give its creditors an open option to force artibration, yet there seems no fully objective way of defining the degree of 'financial distress' or 'suboptimal investment policy' that justifies calling the mediator.

The potential advantage of the approach is that creditors may be willing to cut back on routine monitoring if the option of mediation is available. This saves money and makes the firm more valuable than it would be otherwise. Monitoring by creditors cannot be eliminated though. If it were the creditors would have no way of knowing when to call the mediator!

In many cases the process of bankruptcy or reorganization is really a mediation and fact finding service provided by society at large. Sometimes debt contracts are tightly construed in this process, but often creditors' absolute priority over stockholders is sacrificed in the search for a reorganization plan that can be accepted by all parties. This makes sense: *Ex post* fact finding and mediation are needed to reduce routine monitoring costs and reduce the conflicts of interest and incentives for deception that inevitably arise in conditions of financial distress. Bankruptcy law provides for these services. But the services have little value if reserved exclusively for terminal cases. Thus the law holds out some hope for debtors as well as creditors.

3.2.5. Restrictions on dividends

Jeffrey Halis, in his comments on an earlier verion of this paper, has described how restricting dividend payments can protect against the suboptimal investment decisions induced by risky debt.

In the simple case discussed in section 2, I assumed that the investment I was fresh equity capital, raised by issuing stock. But suppose the firm has

plenty of cash on hand. It can either invest the cash or pay it out to the stock-holders. In that case the investment is financed not by a stock issue, but by forgoing a dividend. The firm's investment decision is unchanged.

But if dividends are restricted, the firm must invest in *something*. If funds can be placed either in cash or a real asset offering $V(s) > I$, the real asset will be chosen and the value of the firm will be maximized.

I regard this as a strong rationale for restrictive covenants on dividends, and a *partial* solution to the warped investment incentives created by risky debt. The reasons it is only a partial solution include the following:

(1) There are still monitoring costs, since there are so many possible channels for transferring capital to the firm's owners. This is particularly difficult when owners are also managers. As Jensen and Meckling (1976) point out, transfers can take a variety of non-pecuniary forms.

(2) The investment incentives are still not exactly right. That is, the best investment policy from the shareholders' viewpoint is not the one which maximizes the market value of the firm. Shareholders will prefer risky assets to safe ones, other things equal. Thus they may reject valuable safe assets in favor of riskier assets with lower, or even negative net present value. This has been discussed by Jensen and Meckling (1976) and Galai and Masulis (1976).

(3) The dividend restriction, if binding, may force the firm to invest in assets with negative net present values in unfavorable states of nature. That is, it may force firms to retain cash that really should be distributed to the firm's owners.[16]

(4) A dividend constraint is helpful only when cash is actually available for payout. Consider the following scenario. Firm X issues what seems a moderate amount of long-term bonds. It accepts a covenant restricting dividend payments if retained earnings fall below a certain threshold.[17] Additional debt is also restricted in these circumstances. But the firm falls on bad times, and losses accumulate to the point where the dividend con-straint is binding. In this situation there is little cash for dividends or plowback. The shortage of cash does not matter if there are no good investment opportunities. But it may make economic sense to spend money to save the firm. If so, the funds will have to be raised by stock issue, unless the debt contract is renegotiated. But here the analysis of section 2 applies directly. Moreover, the firm's financial distress has made its bonds riskier

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[16]If there is a tax advantage to corporate borrowing, there is a tax disadvantage to lending. The purchase of marketable securities is a negative net present value investment.

[17]It would not make sense for the firm to forfeit the right to pay dividends in all circum-stances – see paragraph (3) just above. Nor would the firm allow creditors to say when divi-dends could be paid, since creditors are better off any time earnings are retained, regardless of whether the firm has valuable investment opportunities.

than they were when issued. As is shown below, the riskier the debt, the weaker is shareholders' incentive to commit additional capital to the firm.

3.2.6. Honesty is the best policy

This paper is about a game that stockholders can play at the short-run expense of creditors. But in the longer run, stockholders bear the costs – the costs of inappropriate investment decisions and the cost of playing the game itself, particularly the costs of monitoring and contract enforcement by creditors.

We would expect society to work out contractual, legal and institutional arrangements which minimize the overall cost of the game, assuming that there are valid reasons to issue risky debt. Yet totally eliminating the cost of the game seems impossible so long as the firm is tempted to play it.

Voluntary forbearance would be the simplest and best solution to the investment incentive problem. An announced policy of taking all future investment opportunities with positive net present values is the best policy if believed by creditors and capital markets. But a reputation for honesty is acquired mainly by performance. It is therefore most often pursued by firms that expect to stay in business for a long time. It is also easier to acquire for firms which do *not* borrow heavily against the value of growth opportunities. The truly honest man avoids temptation.

3.2.7. Monitoring and protective covenants

It is important to remember that monitoring costs are borne by stockholders. In well-functioning capital markets lenders foresee the costs, which are therefore reflected in the equilibrium promised interest rates for various debt contracts. When debt is issued, the costs' present value is reflected in the market value of the firm and absorbed by stockholders, who have the residual claim on firm value. It is up to shareholders to decide whether to accept these costs. They could borrow on terms which exclude renegotiation and monitoring. They may not be able to borrow as much,[18] and they may have to pay an extremely high promised interest rate, but they can do it.

The reason why firms accept loan terms which compensate lenders for monitoring and renegotiation is that the costs thus incurred are offset by the increase in firm value due to a lower incidence of suboptimal investment decisions or other agency costs.

It is the same with loan covenants. Managers complain about 'restrictive covenants' but they are rational from the debtors' point of view as well as the creditors'. It is true that lenders may demand such covenants before lending money *at a given interest rate,* but the choice of covenants is fundamentally the shareholders'. Where covenants exist, we must conclude that managers and shareholders have found that it pays to accept them. They freely choose to

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[18]See section 2.

accept constraints today which rule out behavior which *seems* rational tomorrow. The resulting arrangement is an exact financial analogue to a situation described by Homer (c. −900, pp. 227–228):

> I carved a massive cake of beeswax into bits and rolled them in my hands until they softened – no long task, for a burning heat came down from Hêlios, lord of high noon. Going forward I carried wax along the line, and laid it thick on their ears. They tied me up, then, plumb amidships, back to the mast, lashed to the mast, and took themselves again to rowing. Soon, as we came smartly within hailing distance, the two Seirênês, noting our fast ship off their point, made ready, and they sang . . . The lovely voices in ardor appealing over the water made me crave to listen, and I tried to say 'Untie me!' to the crew, jerking my brows; but they bent steady to the oars.

3.3. Secondary markets for real assets

Consider a firm which is holding a real asset for which there is a secondary market. In each period the firm will compare the present value of using the asset (for at least one more period) with the cash it could obtain by selling it. If it decides to use the asset, it is in effect investing the secondary market value.

Fig. 1 depicts this case exactly, if we interpret $V(s)$ as the value in use by the firm, given state s, and I as the secondary market value. (I could also depend on the state occurring.) The rational decision is to sell if $V(s) < I$.

However, if the firm has debt outstanding, having promised to pay the amount P, the rational move from the shareholders' point of view is to sell if $V(s) < I+P$. When this condition holds, selling generates the amount I, whereas not selling generates only $V(s) - P$, which is less than I. The shareholders should attempt to liquidate and run, leaving the creditors holding the empty bag.

If this option is open, then all of the analysis presented in section 2 applies exactly. The fact that we were there concerned with possible future investment, and here with possible disinvestment, is immaterial. The two cases are exactly symmetrical. Holding I, the set of contingent values $V(s)$, and other parameters equal, we can say that the 'debt capacity' of an asset in place is exactly the same as that of a growth opportunity.

This pleasant symmetry does not carry over into real life however. For one thing, it is illegal (specifically, fraudulent) to liquidate assets and distribute the proceeds to shareholders if bankruptcy is imminent. More important, it is relatively easy to write a clause in the debt contract prohibiting this maneuver. So long as the creditors have veto power over dividends or any form of return of capital under conditions of financial distress, they are protected.[19]

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[19]They do not care if the asset is liquidated and the proceeds put in cash or securities. Normally these assets will provide better security than the original ones.

The existence of a secondary market for an asset will, in general, increase the present market value of the firm, providing that the appropriate restrictive covenants can be written. That is, the option to abandon is valuable. This is directly evident from fig. 1. The existence of a secondary market allows a higher payoff $(I > V(s))$ for states $s < s_a$, while the payoff for states $s > s_a$ is the same. However, if the appropriate restrictive covenants for some reason cannot be written or enforced, then the existence of a secondary market may actually reduce the value of the firm, and reduce the amount of debt that can be issued against any promised payment P.

4. Generalization

4.1. Restatement of the problem: Imperfections in real asset markets

The value of the firm as a going concern depends on its future investment strategy. Thus it is useful for expositional purposes to think of the firm as composed of two distinct asset types: (1) *real assets*, which have market values independent of the firm's investment strategy, and (2) *real options*, which are opportunities to purchase real assets on possibly favorable terms.

The existence of valuable real options presumes some adjustment costs, market power, or other imperfections in the real sector. There are no investment opportunities offering positive net present value if product and factor markets are perfectly competitive and in continuous, long-run equilibrium. The value of real options reflects the possibility of rents or quasi-rents.

Moreover, the theory presented here rests not only on costs of monitoring and enforcement of contracts, but also on certain specific imperfections in the market for real options. It is necessary that the value of a growth option vanishes or declines if it is not exercised by the firm. This assumption may be justified in several ways:

(1) The real options may be firm-specific, having no value to any other firm. This could occur if real options are to some extent embodied in real assets, so that the options cannot be purchased separately. Real options may also be firm-specific if generated by experience curves, leaning-by-doing, or other similar phenomena.

(2) If real options are not firm-specific they may nevertheless be traded in thin and imperfect secondary markets. If so, the real option's 'liquidation value' is less than its value as part of a going concern. This limits the extent to which a real option can be used as specific security for a debt claim. Even if a clear and enforceable contract could be written, permitting creditors to claim a specific real option if not exercised by the firm at the optimal time, creditors would face a costly and lengthy task in recovering the value of

their security. By the time they sue, recover the option, and resell it or exercise it themselves, the value of the opportunity may vanish.

One can think of real options that are separable, objectively identifiable, relatively long-lived, and for which reasonable secondary markets exist. Examples are patents, certain trademarks, franchises and operating licenses. Such options should 'support' debt to the same extent as otherwise similar real assets.

This paper takes the existence of real options as given. It does not ask whether they are acquired via purchase of real assets, via learning-by-doing, or via direct expenditure in research, advertising, training or some other activity. The development of a theory of the firm which treats real options as endogenous is a challenging subject for future research.

The immediate problem is to extend the arguments given in section 2 to cases in which investment occurs in more than one period, and in which firms hold more than one type of asset.

4.2. Long-term borrowing

A detailed dynamic model of the firm's investment and borrowing behavior is beyond the scope of this paper. But it is not hard to predict the qualitative effects of debt financing on the firm's investment policy and market value.

We consider a firm holding options on real assets, one of which should be partially or wholly exercised at time t. Exercising the option requires a fresh commitment of equity capital by shareholders.[20] The firm may have assets in place at t. It also has bonds outstanding which mature at some point beyond t.[21]

Since $V_t = V_{E,t} + V_{D,t}$ the effect of an incremental discretionary investment on the market value of equity is $dV_E/dI = dV/dI - dV_D/dI$. The investment policy which maximizes the value of the firm is to continue investing as long as $dV/dI > 1$. This means exercising all options which (1) have positive net present value and for which (2) period t is the expiration date or the optimal time for exercise. But options having positive net present value are not necessarily attractive to the firm's owners. Whether they are depends on the sign and magnitude of dV_D/dI.

At any point in time the value of outstanding bonds is related to the value of the firm and to the uncertainty about the firm's future value,[22]

$$V_{D,t} = f_t[V_t, \sigma^2(\tilde{V}_{t+1}/V_t)],$$

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[20]The commitment can be a dividend forgone.

[21]There may or may not be a cash payment P_t due to bondholders. I assume, however, that any such payment is made after the firm decides whether to exercise its investment option. Any payment made before this decision is a sunk cost.

[22]Discussions with Jeffrey Halis were helpful in simplifying the following exposition.

where $\sigma^2(\tilde{V}_{t+1}/V_t)$, henceforth σ^2, is the variance rate of overall market value. Therefore,

$$\frac{dV_{E,t}}{dI_t} = \frac{dV_t}{dI_t}\left(1 - \frac{\delta f_t}{\delta V_t}\right) - \frac{\delta f_t}{\delta \sigma_t^2}\left(\frac{\delta \sigma_t^2}{\delta I_t}\right). \tag{8}$$

In other words, there is a transfer of value from stockholders, who make the investment, to bondholders, who contribute nothing. Call this transfer Z,

$$Z_t \equiv \frac{dV_t}{dI_t} - \frac{dV_{E,t}}{dI_t}$$

$$= \frac{dV_t}{dI_t} \cdot \frac{\delta f_t}{\delta V_t} + \frac{\delta f_t}{\delta \sigma^2} \cdot \frac{\delta \sigma^2}{\delta I_t}. \tag{9}$$

Appropriate investment incentives exist only when $Z_t = 0$.

First take the case where $\delta \sigma_t^2 / \delta t = 0$, so that the firm's 'risk class' is unaffected by the decision to exercise. Now $\delta f_t / \delta V_t$ will always be positive except in the limiting case where the debt is default risk free. Thus $Z_t > 0$. The existence of risky debt in period t weakens the incentive to invest, induces a suboptimal investment strategy, and reduces the market value of the firm in all periods prior to t.

This result rests on no assumption about the firms' other assets or opportunities. The only assumption made about the debt is that there is some risk of default in t or afterwards, so that changes in the market value of risky debt are positively related to changes in the market value of all the firm's assets.

Eqs. (8) and (9) assume a continuous investment schedule (with decreasing returns to scale) rather than discrete projects which have to be accepted or rejected. In this situation the firm invests less than the optimal amount. The discrete case is shown in fig. 4. In the figure $\Delta V(s) - I(s)$ is the net present value of the investment option if exercised. It is positive for all states $s > s_a$. ΔV_D is the capital gain to bondholders if the option is exercised -- but exercise will not occur unless $\Delta V(s) \geq \Delta V_D(s) + I(s)$. Thus a valuable option is forgone in some states of nature.

The shaded area in figure 4 indicates the loss of value in a range of states at time t. The implications are just as shown in fig. 3.

4.2.1. Target debt ratios

What happens if the incremental investment I is partially or wholly debt financed? There is no way for the firm to gain at the expense of the new bondholders, but the increase in the firm's debt ratio erodes the old bondholders' position. Therefore ΔV_D, the capital gain to old bondholders, is reduced and possibly eliminated.

This presumes that the additional borrowing is tied to the incremental investment, as it would be by a covenant restricting total borrowing to a certain proportion of the value of assets in place. Here we have one rationale for target debt ratios. A simple debt ratio constraint is unlikely to eliminate the incentive problem discussed in this paper, but it helps.

4.2.2. Spillover effects

The fact that too little will be invested in some or all states of nature at time t reduces the value of the firm prior to t. Consider how this affects investment strategy in $t-1$. The suboptimal strategy at t reduces V_{t-1}. This, in turn, reduces the market value of outstanding debt at $t-1$, assuming the debt matures after t's investment decision. It also makes the debt riskier: $\delta f_{t-1}/\delta V_{t-1}$ increases.[23] Therefore, Z_{t-1} increases, and investment incentives are weakened in period $t-1$ as well as t.
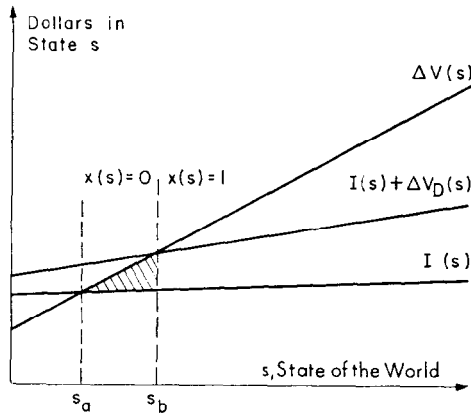

Fig. 4. The firm's investment decision with prior debt financing – multiperiod case. $I(s)$ = discretionary outlay; $\Delta V(s)$ = increase in firm value if outlay is made $(x(s) = 1)$; $\Delta V_D(s)$ = increase in debt value if outlay is made, including debt service in t.

A similar effect may occur after period t, if the existence of risky debt in t leads the firm to pass up valuable investment opportunities. If this happens, the value of the firm is less in $t+1$, debt in $t+1$ is less valuable and riskier, and investment incentives are weakened.

Thus, if the existence of risky debt in t causes an inappropriate investment strategy in t, it will also cause an inappropriate strategy both before and after t. This strengthens the negative link between the existence of risky debt and the present market value of the firm.

[23]I assume that $\delta^2 f/\delta V^2 < 0$. See Merton (1974).

4.2.3. Shifts in asset risk

Up to this point I have assumed that discretionary investment does not affect σ_t^2, the variance rate of market value. But the effects of a shift in risk are easily seen from eqs. (8) or (9). If investment decreases σ_t^2 then Z_t, the transfer to bondholders, is greater than was assumed above, and the incidence and extent of suboptimal investment choices increases.[24] An increase in σ_t^2, on the other hand, is favorable. In fact, as Jensen and Meckling (1976) have emphasized, the increase in σ_t^2 could be so great that Z_t is negative, leading the firm to exercise investment options with negative net present values.

We have an interesting, perhaps surprising, conclusion. The impact of risky debt on the market value of the firm is less for firms holding investment options on assets that are risky relative to the firms' present assets.[25] In this sense we may observe risky firms borrowing more than safe ones.

4.3. Borrowing against a portfolio of assets

One alleged advantage of corporate diversification is that diversified firms can borrow more. A combination of assets with less than perfectly correlated returns gives a variance rate for the combination's value that is less than the average rate of the assets considered separately. The usual conclusion is that this increases the amount the firm can or should borrow.[26]

The conclusion does *not* follow from the theory presented here. The following preliminary analysis indicates that there should be no consistent relationship between 'diversification' and 'debt capacity'.

We return to the simple world analyzed in section 2. Now there are two firms holding two real options. We simplify notation by redefining $V_i(s)$ as the *net* value (at $t = 1$) of firm i's option contingent on s. Previously net value was $V_i(s) - I_i$. Present value is

$$V_i = \int_{S_i} q(s) V_i(s) \mathrm{d}s, \tag{10}$$

where S_i is the set of all states for which i exercises its option. It will do so when $V_i(s) > P_i$, where P_i is the amount it has promised to creditors. P_i is a positive constant, but the debt is risky: $V_i(s) < P_i$ in some states.

Now suppose firms i and j merge. The new firm holds a portfolio of the two options. The original debt of the two firms is merged into one class with a promised payoff $P_i + P_j$. Is the present market value of the merged firm greater

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[24]The risk of the real asset acquired is taken into account in its net present value. Thus $\mathrm{d}V_t/\mathrm{d}I_t$ already reflects the effects of a shift in σ^2 on firm value.

[25]A special case of this result can be derived from fig. 2. Greater uncertainty about the value $V(s)$ corresponds to a steeper slope of $V(s)$ plotted against s. The steeper the slope, the smaller the area of the shaded triangle representing lost value.

[26]Lewellen (1971). See also Higgins and Schall (1975).

than the sum of the separate market values of i and j? Does diversification ameliorate the investment incentive problem created by the existence of risky debt?

The present value of option i in portfolio with the other option j is

$$V_i(j) = \int_{S_i(j)} q(s)V_i(s)\,ds, \tag{11}$$

where $S_i(j)$ is the set of states in which option i is exercised. $S_i(j)$ includes states s for which $V_i(s) \geq P_i + P_j - \max[V_j(s), 0]$ *and* for which $V_i(s) \geq 0$.

The conditions defining $S_i(j)$ need a word of further explanation. First, there is no incentive to exercise an option with negative net present value. $V_i(s)$ must be positive to justify investment. Suppose both options have positive net present value. Then the firm will accept both or neither, depending on whether $V_i(s) + V_j(s)$ exceeds $P_i + P_j$. However, suppose $V_j(s)$ is negative. In this case i is exercised only if it can carry the burden of j's debt, that is, if $V_i(s) > P_i + P_j$.

The problem can now be stated as follows. What is the relationship of $V_i(j) + V_j(i)$ to $Vi + V_j$? Alternatively, is $DV_i + DV_j > 0$, where $DV_i \equiv V_i(j) - V_i$ and $DV_j \equiv V_j(i) - V_j$? DV_i can be loosely interpreted as 'diversification value' – more precisely, as the change in the present value of option i due to the co-existence of j and its associated debt burden.[27]

Under general assumptions we cannot say whether $DV_i + DV_j$ is positive. Consider box (2) in table 1. In this case both options are valuable ($V_i(s) > 0$ and $V_j(s) > 0$) but firm i would not have exercised its option absent the merger, because the promised payment to i's creditors exceeds the net present value of exercise ($V_i(s) < P_i$).

The new firm may confront an all-or-nothing decision. It may take both projects if

$$V_i(s) + V_j(s) - P_i - P_j \geqq 0.$$

Otherwise it may take neither one.

Here is a numerical example:

Case	V_i	P_i	V_j	P_j
A	50	100	80	20
B	50	100	60	20

[27]Note I am asking whether the present value of the *firm* increases at $t = 0$ when i and j are combined. $DV_i + DV_j$ will be fully captured by equity if debt with a promised payment $P_i + P_j$ is issued *after* assets i and j are combined. However, if two separate debt issues are made, promising P_i and P_j and secured by V_i and V_j, respectively, and if i and j are then combined (a surprise to the two creditor groups), then creditors may receive a capital gain at the expense of equity.

Table 1

Investment decisions which maximize equity value when two real options and their associated debt are combined into one firm.

	Net present value of option i, $V_i(s)$, relative to promised payment, P_i, on debt issued against project i		
Net present value of option j, $V_j(s)$, relative to promised payment, P_j, on debt issued against project j	$V_i(s) \geq P_i$	$P_i > V_i(s) \geq 0$	$V_i(s) < 0$
$V_j(s) \geq P_j$	(1) Take both $DV_i = 0$ $DV_j = 0$	(2) Take both if $V_i(s) + V_j(s) - P_i - P_j \geq 0$. Otherwise reject both. X_i may = 1 (0 before); $DV_i \geq 0$, X_j may = 0 (1 before); $DV_j \leq 0$.	(3) Reject i, take j if $V_j(s) - P_i - P_j \geq 0$. X_j may = 0 (1 before); $DV_i = 0$, $DV_j \leq 0$.
$V_j(s) < P_j$ $V_j(s) \geq 0$	(4) Take both if $V_i(s) + V_j(s) - P_i - P_j \geq 0$. Otherwise reject both. X_i may = 0 (1 before); $DV_i \leq 0$, X_j may = 1 (0 before); $DV_j \geq 0$.	(5) Reject both. $DV_i = 0$, $DV_j = 0$.	(6) Reject both. $DV_i = 0$, $DV_j = 0$.
$V_j(s) < 0$	(7) Reject j, take i if $V_i(s) - P_i - P_j \geq 0$. X_i may = 0 (1 before); $DV_i \leq 0$, $DV_j = 0$.	(8) Reject both. $DV_i = 0$, $DV_j = 0$.	(9) Reject both. $DV_i = 0$, $DV_j = 0$.

Note: 'Before' refers to the decisions that would be made by firms i and j acting separately.

In case A the merger rescues project i. Both projects are taken because $V_i + V_j - P_i - P_j = +10$. (Note that the firm is liable for the full promised payment to bondholders regardless of whether project i is taken.) In case B project i is rejected and it drags j down with it: $V_i + V_j - P_i - P_j = -10$. In case A, $DV_i > 0$ and $DV_j = 0$, so the merger increases value. In case B, $DV_i = 0$ and $DV_j < 0$, so value is reduced.

Table 1 displays all possible outcomes. In boxes (2) and (4) the merger may or may not help. In boxes (3) and (7) it cannot help but may hurt. In the other boxes there is no effect. Overall one cannot say.

It may be possible to reach more specific conclusions by making stronger assumptions about the joint distributions of $V_i(s)$ and $V_j(s)$.[28]

5. Conclusions

The analysis presented in this paper adds up to a partial theory of the corporate borrowing decision. The theory does not rely on imperfect or incomplete *financial* markets. Although I have dealt only with certain simple cases, it still leads to testable propositions.

According to the theory, the amount of debt issued by the firm should be set equal to V_D^*, that amount which maximizes the market value of the firm. It has no direct relationship to the probability of default or the amount lenders are willing to advance.

The theory predicts that V_D^* will be inversely related to the ratio of V_G to V, where V_G is the part of firm value V accounted for by growth opportunities, or, more generally, the part of V that is contingent on discretionary future expenditure by the firm. In the broader interpretation discretionary expenditures include all future investment and variable costs, which, if undertaken, increase the end-of-period value of the firm. Although a general measure of this concept is difficult to derive from accounting data, the following specific propositions should hold, other things equal, if the theory is right:

(1) Assets-in-place should be financed with more debt than growth opportunities. The investment in assets-in-place is a sunk cost and, by definition, not discretionary. (I assume that secondary markets for assets-in-place do not exist or that sale in secondary markets can be regulated by the debt contract.)

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[28]However, examination of table 1 prompts the suspicion that $DV_i + DV_j$ will be more often negative than positive, particularly if $V_i(s)$ and $V_j(s)$ lack strong positive correlation. Observe that in box (2) $DV_i \geqq 0$ is offset by $DV_j \leqq 0$. Similarly in box (4) $DV \geqq 0$ and $DV_i \leqq 0$. But in boxes (3) and (7) the only possibilities are $DV_j \leqq 0$ and $DV_i \leqq 0$, respectively. If $V_i(s)$ and $V_j(s)$ are negatively correlated, so that boxes (3) and (7) are likely cases, the present value of $DV_i + DV_j$ will probably be negative. But this is the case in which intuition tugs us to say that 'diversification value' ought to be largest!

(2) For assets-in-place, the following factors should be associated with heavy debt financing: (a) capital-intensity and *high* operating leverage, and, of course, (b) profitability, ideally measured in terms of expected future value of the firm's assets.

The theory also provides a rationalization for certain aspects of the operations of bond markets. I have already explained why firms are not observed borrowing against the present value of future growth opportunities. Sinking funds can be interpreted as a device to reduce creditors' exposure in parallel with the expected decline in the value of assets in place when the loan is made. It is also some protection against the debtors running off with the cash flow that these assets produce.

This same argument explains why firms attempt to match the maturities of their assets and liabilities. As far as I can see, standard finance theory gives no reason why firms should not finance long-lived assets with short-term debt, or conversely, short-lived assets with long-term debt. But we can interpret matching maturities as an attempt to schedule debt repayments to correspond to the decline in future value of assets currently in place.

Of course, these predictions are not a complete statement of the theory's implications. Others were noted in the main text of the paper. No doubt there are still others that I haven't grasped yet.

5.1. Areas for further research of real asset valuation

All of this paper's interesting results stem from the idea of regarding real assets as options whose ultimate value depends on future discretionary investment by the firm. It may be that this idea's most important application will turn out to be the valuation of real assets. Let me conclude by stating one important theorem.

Following MM [Miller and Modigliani (1961)], we can regard the market value of the firm as representing two components, the present value of (earnings generated by) assets-in-place, and the present value of growth opportunities. In MM's model, growth opportunities have value if investors expect the rate of return earned on future investments to exceed the firm's cost of capital. No distinction is drawn between the cost of capital for assets-in-place versus future investment.[29]

This model can be given an interesting reinterpretation in terms of option theory. At any point in time the firm is a collection of tangible and intangible assets. Assume the tangible assets are accumulated units of productive capacity – i.e. real assets – all drawn from the same risk class. The intangible assets are options to purchase additional units in future periods. The sum of these option

[29]See, in particular, Miller and Modigliani (1966).

values is clearly what MM mean by the present value of growth. A similar interpretation can be put on going concern value.

We immediately have the question of whether growth options arrive randomly or systematically, whether they are 'free' or must be purchased by the firm, and whether they have value if split off from the assets the firm already holds. It may be that real options are acquired only through the purchase of real assets in place – i.e., exercising options today may create more options for possible exercise tomorrow. This paper has barely begun to consider how corporate investment decisions might be modelled.

But back to MM. Note that stock options are riskier than the stocks they are written on. Suppose that is true for real options also.[30] Consequently, the observed risk of a common stock (e.g., its beta) will be a positive function of the proportion of the stock's value accounted for by growth in MM's sense. Two implications are immediately obvious.

(1) Neoclassical valuation models, like MM's, which use the same 'cost of capital' to evaluate earnings from present versus future investment, are mis-specified. (Whether this is empirically serious is, of course, unclear.)
(2) One cannot measure the equilibrium capitalization rate for a firm's stock (e.g., by measuring its beta and calculating $E[R]$ from the capital asset pricing model) and then use it as a hurdle rate for capital budgeting. This will be an overestimate of the correct rate for any firm having valuable growth opportunities.

Appendix

This appendix analyzes the link between debt financing and firm value when interest is a tax-deductible expense. Only corporate taxes are considered. The effects, if any, of *investors'* income tax liabilities on the firm's debt–equity choice are ignored. The analysis is restricted to the simple case discussed in section 2.

As the firm substitutes debt for equity in its initial capital structure, it finds that the present value of tax shields generated by debt at first outweighs the decline in firm value due to loss of valuable investment opportunities. At some point the two effects just balance. Beyond that point further borrowing decreases the value of the firm.

The optimum borrowing level depends on whether the interest tax shields retain their value if the firm goes bankrupt and on whether there is a limit to the amount of interest allowed as a tax-deductible expense. Suppose the firm can deduct the full *promised* interest payment $P - V_D$ in all states. The tax rate

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[30]It is not necessarily true, as Michael Brennan has pointed out. See the discussion in Myers and Turnbull (1977).

is T. Then the value of the firm is

$$V = \int_{s_b}^{\infty} [V(s) - I]q(s)\,\mathrm{d}s + T(P - V_\mathrm{D}) \int_0^{\infty} q(s)\,\mathrm{d}s, \tag{A.1}$$

where s_b is defined by $V(s_b) = I + P - T(P - V_\mathrm{D})$, and the debt value V_D is given by

$$V_\mathrm{D} = \int_0^{s_b} T(P - V_\mathrm{D})q(s)\,\mathrm{d}s + \int_{s_b}^{\infty} Pq(s)\,\mathrm{d}s. \tag{A.2}$$

But an examination of eq. (A.1) reveals a quite unreasonable feature: V can be made arbitrarily large by choosing a large enough value for P. It is more reasonable to suppose that the tax authorities allow deductions based on some maximum promised interest rate R, so that the maximum attainable tax shield is RTV_D. The tax shield actually attained is $\min(RTV_\mathrm{D}, T(P - V_\mathrm{D}))$. The firm's value is

$$V = \int_{s_b}^{\infty} [V(s) - I]q(s)\,\mathrm{d}s + \min(RTV_\mathrm{D}, T(P - V_\mathrm{D})) \int_0^{\infty} q(s)\,\mathrm{d}s. \tag{A.3}$$

As $P \to \infty$, $V \to RTV_\mathrm{D}\int q(s)\,\mathrm{d}s$. But as this happens $V_\mathrm{D} \to V$. At the limit, therefore, $V_\mathrm{D} = RTV_\mathrm{D}\int q(s)\,\mathrm{d}s$, which is satisfied only if $V_\mathrm{D} = 0$.[31] Thus we have the sensible result that V and V_D each approach zero if P is set high enough. Moreover, there is a definite maximum amount of debt that firms can raise if they attempt to do so. This amount is less than the market value of the firm.

The behavior of V and V_D as a function of P is shown in fig. 5. This figure is drawn so that the maximum value of V occurs before that of V_D. That is, the firm does not attempt to borrow as much as it can. This is always true providing that eq. (A.3) holds, and that P is high enough that the tax shield is RTV_D rather than $T(P - V_\mathrm{D})$.[32] To show this, we calculate $\delta V/\delta P$,

$$\frac{\delta V}{\delta P} = -\left(\frac{\delta s_b}{\delta P}\right)[V(s_b) - I]q(s)) + RT\left(\frac{\delta V_\mathrm{D}}{\delta P}\right)\int_0^{\infty} q(s)\,\mathrm{d}s.$$

Evaluating the derivative at $\delta V_\mathrm{D}/\delta P = 0$, we find that $\delta V/\delta P$ must be negative Thus the firm must go beyond the point of maximum firm value in order to borrow the maximum amount. This is not in the shareholders' interest, so the firm will stop at the point where V is maximized.

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[31] Note that $\int RTq(s)\,\mathrm{d}s$ is on the order of 0.05 – that is substantially less than 1.0.
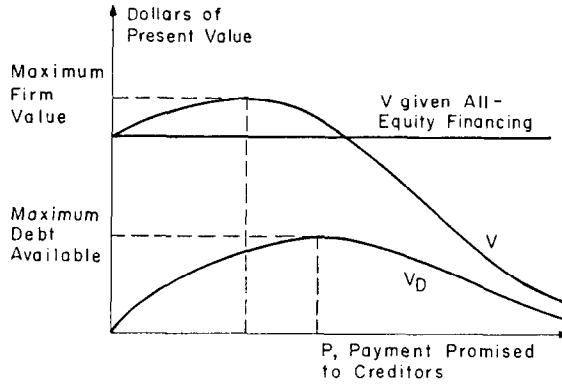[32] Kim (1976) has obtained a similar result.

Fig. 5.   Firm and debt values when debt interest is tax-deductible.

A second case occurs when the tax shield is lost as the firm goes bankrupt. Then,

$$V = \int_{s_b}^{\infty} [V(s) - I + T(P - V_D)]q(s)\,ds, \tag{A.4}$$

and V_D is given by eq. (6).

The general behavior of V and V_D is again as shown by fig. 5, although in this case it cannot be guaranteed that the maximum value of V is reached before the maximum value of V_D. This result holds generally only if the tax shield is restricted to TRV_D (or to any amount that is independent of P). But this is not crucial. The essential point is that the firm will choose P to maximize V, not V_D. Only by coincidence will these two functions reach their maximum levels at the same point. The firm should not attempt to borrow as much as possible.

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