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**Equilibrium with Debt and Equity
Financing of New Projects: Why More
Equity Financing Occurs When Stock
Prices are High**

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Equilibrium with Debt and Equity Financing of New Projects: Why More Equity Financing Occurs When Stock Prices Are High*

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Section 1: Introduction.

In this paper, we analyze the manager's financing decision for a new project. We give the manager a choice between financing with debt or equity, or foregoing the project. Our purpose is to provide a signaling model in which debt, equity and foregoing are actually observed in the unique equilibrium and the financing mode provides information to the investors about the quality of the new project to be financed. We investigate how the financing decision is affected by the value of the existing assets of the firm or by the quality of the set of available projects. We show that the volume of equity financed projects increases as the opportunity set gets better and that more equity financing is observed for firms which have large assets in place. This enables us to provide an explanation for the existing paradox that more equity financing is observed when the firm's stock price is high. These results also suggest an explanation for why some researchers¹ have found that the movement in stock prices due to equity financing is related to the size of the firm.

Our work is most closely related to the seminal paper of Myers and Majluf [1984] and the extension to a more general setting by Narayanan [1986]. These papers provide a signaling based explanation for the selection of the financing instrument.² However, as Myers and Majluf state, "*...the firm never issues equity. If it issues and invests, it always issues debt, regardless of whether the firm is over- or under-valued.*"³ Thus, they are unable to explain why equity financing may also exist. Other related papers are Heinkel [1982] which studies a separating equilibrium in which the proportion of the funds for a new project which is raised by an issuance of debt signals the quality of the new project. This result apparently hinges on his assumption that the higher the quality of the new project, the more risky it is.⁴ More recently, Williams [1987] has studied the choice between debt, equity and warrants and the information conveyed by this choice. This analysis is done under the assumption that the current value of the firm is unknown and does not address the information about a new project that is conveyed by the choice of financing.⁵

¹ See, for example, Asquith and Mullins [1986].

² Narayanan has also shown that, in a Wilson anticipatory equilibrium, the capital structure of a firm may be determined by its production function and business risk.

³ Myers and Majluf, page 208. Italics in the original.

⁴ Dropping this assumption essentially leaves the model Narayanan studied.

⁵ There are a number of other papers that have used debt and equity as a signal. These include, among others, Ross [1977, 1978] who shows that debt can be used as a signal about the quality of the firm while Leland and

In our model, the manager has the choice of financing a new project either with debt or with equity or he may choose to forego it. We distinguish the firm's costs of financing the project from the returns earned by the investor. The former will be referred to as "issuing costs" and includes the costs of mitigating the agency problem. We assume that the costs of issuing debt exceed the costs of issuing equity based on an argument made by Jensen and Meckling [1976] that a firm that issues debt will add costly covenants to mitigate the agency problem between the manager and the debtholders.⁶ We also assume that the manager (and not the current stockholders) has private information about the true value of the new project and maximizes the wealth of the existing shareholders.⁷ All other information, the value of assets in place, the number of shares outstanding, the cost of the new project and the additional costs associated with issuing debt, is assumed to be public knowledge.

In the unique, sensible equilibrium,⁸ we show that the manager will choose to debt finance the best projects, equity finance the intermediate projects and forego the worst. For convenience, we assume that the value of a project which is debt financed is revealed to the market.⁹ The equilibrium is a partially revealing one in which the value of the project is revealed if it is debt financed but is not if it is either equity financed or foregone. The fact that the project's value is not revealed when it is equity financed may permit the manager to equity finance some negative net present value projects. This occurs because the manager with a negative net present value project may be able to pool and issue new shares at a sufficiently high price so that the wealth of existing shareholders is increased at the expense of new stockholders, even if this project is undertaken.¹⁰ We also provide an example which shows that the issuance of equity can result in a decrease in the

Pyle [1977] use the proportion of equity held by the owner-manager as a signal about the quality of the firm. In addition, a number of multiple signaling models have been studied recently. These include Ambarish, John and Williams [1986], Constantinides and Grundy [1986] and Viswanathan [1986]. Finally, we note that there are tax based explanations to the use of debt and equity financing. For a recent survey, see Kim [1987].

⁶ For details, see the next section.

⁷ Our assumption is consistent with most of the signaling literature. Another objective function which is used by Miller and Rock [1985], among others, is a linear combination of the selling stockholders' and the remaining shareholders' wealth. A more detailed discussion is contained in the next section.

⁸ 'Sensible' refers to those equilibria that satisfy Kreps' Intuitive Criterion. For details, see the Appendix.

⁹ This assumption is for mathematical tractability in that it allows for an easy description of the highest quality project that is equity financed. If it were dropped, the equilibrium would consist of two pooling prices, one for debt and one for equity. Because we are assuming that there is an additional cost to issuing debt, such an equilibrium exists and our conclusions would not be affected. For further discussion see footnote 22

¹⁰ Because the current stockholders are no better informed about the value of the new project than the market, they cannot distinguish between the good and the bad projects themselves until the information about its value becomes public. Hence, if the project is bad, they cannot take advantage of the market by selling before the information is revealed.

firm's stock price.¹¹

Another contribution of this paper is that the proportion of projects that are debt financed is negatively related to the level of the additional costs of debt financing. Hence, we predict that if these costs differ across firms, those with higher costs are more likely to equity finance their new projects. Further, if these costs increase through time, there will be an economy-wide movement toward equity financing of new projects.¹²

Most importantly, we provide an explanation for why the proportion of equity financed projects is high when the firms' stock prices are high, a fact that has been noted by Taggart [1977] and Marsh [1982].¹³ To do this, we note that a firm's stock price is made up of two components, the part valuing the assets in place and the part valuing the firm's future projects. We show that an increase in the value of the assets in place leads to an increase in the proportion of equity financed projects. Similarly, an increase in the overall profitability of the set of new projects leads to an increase in the proportion of equity financed projects. Therefore, regardless of the underlying cause, when the firm's stock price is high, our model predicts that more equity financing will be observed.

The model has implications for the effect of firm size (assets in place) on the movement in the firm's stock price due to equity financing. If we compare two firms that are identical except for the value of the assets in place, then the larger one will experience a larger market response to the decision to equity finance. In other words, the difference in the post-financing prices is larger than the difference in the pre-financing stock prices.

Our final task is to relate our results to the existing empirical literature. As mentioned above, the result that the amount of equity financing rises as the firm's stock price rises is consistent with the empirical work of Taggart and Marsh. Another result, that the larger the value of existing assets the bigger is the announcement effect associated with equity financing, is consistent with the recent work of Asquith and Mullins. The last major result is that the manager chooses to

¹¹ In the general analysis, this result depends on the specifics of the distribution function representing the investors' priors. It is clear from that section that there are a wide class of distribution functions for which this result holds. Unfortunately, one can also provide examples for which the opposite holds.

¹² In the limit, as these costs go to zero, we replicate the conclusions of Myers and Majluf and Narayanan.

¹³ While the previous results did not require any special assumptions about the investors' priors, the remaining results are shown under the special assumption that the investors' priors were uniformly distributed.

debt finance relatively valuable projects, equity finance intermediate valued projects and forego the rest. The relevant empirical results are that issuing new equity leads to a significant reduction in the value of the firm while debt issues have an insignificant effect.¹⁴ We see that our work and the empirical work are both consistent with the pecking order hypothesis though they may differ in the nature of the effects on the stock price of the firm.¹⁵ This difference may be due to the fact that we have focused on the use of debt and equity to fund new projects and because we have explicitly ruled out the use of debt to refinance previously issued debt or the use of debt to replace existing plant and equipment. There is very little empirical work that focuses on the differences due to the stated end use of the money. The only study to split out refinancing and replacement is Mikkelson and Partch. They report, for a very small sample size, that the issuance of debt for uses other than refinancing or replacing capital led to an increase in the value of the firm.¹⁶

The paper is organized as follows. In section 2, we provide a numerical example to help fix the ideas and provide intuition for the more general model which is studied in section 3. In section 4, we do the comparative static analysis. Section 5 contains our conclusions and all of our proofs are in the appendix.

¹⁴ See for example, Asquith and Mullins [1986], and Dann and Mikkelson [1986] who have all documented the announcement effect of equity financing. For the studies on debt financing, see Dann and Mikkelson [1986], Eckbo [1986], and Mikkelson and Partch [1986].

¹⁵ In our model, if the manager chooses debt financing, the stock price rises. However, if the manager equity finances, the stock price can fall.

¹⁶ The average prediction error was 1.11 with a Z-statistic of 2.73, while the effect of equity financing for the same class of expenditures was -5.21 with a Z-statistic of -3.06.

Section 2: The Model.

We begin with a firm whose assets in place are correctly priced because their value is common knowledge. The firm has a known number of outstanding shares and is contemplating an investment in a new project. The cost of the investment is also common knowledge but the return from the investment is private information known only to the manager of the firm.¹⁷ The decision that the manager must make is how to finance this particular project in the event that it is undertaken. He has two alternatives: debt or equity financing. Under equity financing, the manager issues additional shares at a price acceptable to the market. Under debt financing, he issues debt at an acceptable combination of yield and restrictive covenants.¹⁸ These restrictive covenants are an implicit cost of issuing debt and are positive.¹⁹ We also assume that the manager makes his financing choice in the best interest of the current stockholders.

We begin our justification for an implicit cost of issuing debt by building on the explanation provided by Jensen and Meckling as to why the firm issues debt with covenants attached. They showed that since the manager has the ability to transfer wealth from debtholders to stockholders, this agency problem is optimally reduced through the use of covenants. This loss in flexibility is an opportunity cost associated with the issuance of debt which is not associated with issuing equity.

We have assumed that the manager makes this decision in the best interests of the existing stockholders by maximizing the value of existing shares.²⁰ This assumption is usually justified in one of the following ways. First, if the manager owns shares in the firm, and if he is not constrained contractually by the current stockholders, then it is in his own best interest to maximize the value of his holdings. Alternatively, the assumption may be justified by an appeal to the contracting literature. In that case, we assume that the stockholders choose the extreme contract that causes the

¹⁷ We adopt this convention rather than assuming that the NPV of the project is unknown so that we may study the effects of a change in the profitability of the set of potential projects.

¹⁸ For convenience, we assume that the optimal form of debt for the firm has a yield equal to the discount rate and at least one costly covenant.

¹⁹ We also assume that there are no implicit costs of issuing equity.

²⁰ This assumption is the one used by Myers and Majluf, Narayanan, and Ambarish, John and Williams among others. Also, because the original number of shares outstanding is constant, maximizing the value of the firm is the same as maximizing the value of just one share. This is equivalent to assuming that the manager maximizes the terminal value of the firm, that is, the firm value after the quality of the project is revealed.

manager to act in their best interest.²¹ The other standard candidate for the manager's objective function, used recently by Miller and Rock, is a weighted average of the current and future value of a share. Our results are only slightly affected if we were to adopt this objective function so long as the manager places weight on the current stockholders. All that changes are the cut-off values and the parameter restrictions derived below.

One implication of this assumption is that the manager will not choose to undertake the new project if the present discounted value of the stream of expected earnings is such that it reduces the value of existing shares. In order for the manager to issue debt, we assume that he incurs the cost mentioned above and we note that he will not choose to debt finance if the net present value of the project is negative.²²

If the manager equity finances the project, he needs to sell enough additional shares at the chosen issuing price to finance the project. This is accomplished only if the issuing price he chooses induces sufficient demand. In fact, in some cases, this may occur even if the project has negative net present value. Clearly, this may only arise if the investors are unable to infer the true value of the project from the manager's actions, *i.e.*, if we have some type of pooling equilibrium. Below, our example and our analysis of the model show that this situation does, in fact, arise.

More formally, we assume that the true value of the assets in place, V , the cost of the project, I , the additional issuing cost of debt, C (or its per share equivalent c) and the current number of outstanding shares, n , are all common knowledge. From this, the per share value of assets in place, p_A , can be computed as $\frac{V}{n}$. The present value of the stream of returns earned by the new investment project, R , is the manager's private information and as such is not known to either the market or the current stockholders. We assume that the investors' common prior over R is characterized by the cumulative distribution function F with support $[R_\ell, R_h]$.²³

²¹ It is clear that it would be more satisfactory to derive this behavioral assumption as a consequence of the optimal contract between the current stockholders and the manager.

²² This follows from the assumption that if debt is issued, the true value of the investment project is revealed to the market. This is not a restrictive assumption because having already shown that issuing debt causes the manager to incur some implicit costs (due to the covenants), adding another source of additional costs (those costs incurred to reveal the quality of the project) simply increases these costs. Since our results depend only on these costs being positive, adding another positive component does not change any of our conclusions.

²³ Until we reach the comparative statics section, there is no need to place any additional restrictions, such as continuity or absolute continuity on the distribution function F .

In the event that the manager chooses to equity finance, we denote the issuing price by p and compute the number of additional shares issued to finance the new project, n_1 , as $\frac{I}{p}$. If the manager's choice of financing mode and the resulting issuing price reveals the manager's private information, then p must equal the true (post investment) stock price, $\rho(R)$. If the manager's choice does not fully reveal his private information then conditional on the investors' inference, p must be not larger than the expected true price.

To illustrate and provide intuition for our results, we present an example. Let $V = 500, I = 1000, n = 50$, and let the investors' prior be uniform over $\{900, 1300, 1600\}$. Note that $p_A = 10$. Since the manager knows the true value of R , his decision will, in general, depend on it. Thus, we must compute his best action for each possible value of R .

For $R = 900$, the project has net present value of -100. Consequently, as we mentioned above, the manager will not choose to debt finance. This follows from the fact that the (post investment) share price is $\frac{V+R-I-C}{n}$ which is less than $p_A = V/n$ when $R < I + C$. Consequently, he can either equity finance this project, if possible, or forego the project.

For $R = 1300$, the project has a positive net present value of 300. If the manager debt finances this project, then the post investment price per share is $\rho(1300) = \frac{500+1300-1000}{50} - c = 16 - c$. Similarly, for $R = 1600$, $\rho(1600) = 22 - c$.

Now consider the manager's decision to equity finance. We begin by computing the minimum issue price at which the manager would choose to issue equity rather than his next best alternative.²⁴ For $R = 900$, the manager's best alternative is to forego the project. Thus he equity finances the project if

$$\frac{V + R}{n + n_1} \equiv \frac{V + R}{n + (I/p)} \geq p_A.$$

Solving for the issue prices that he would accept, we find that $p \geq 100/9 \equiv \Phi(900)$. Notice that he is unable to equity finance if the market infers R correctly, because the maximum price that the investors would pay is less than p_A and the minimum price the manager would accept is not smaller than p_A .

²⁴ The analysis that follows is done under the assumption that the manager precommits to invest the funds in the project for which they were raised. However, if the project is a negative NPV project, both old and new stockholders would benefit from releasing him from this commitment after the money has been raised because undertaking the project reduces the value of the firm. A discussion of the differences in the analysis when the manager does not precommit is postponed to sections 3 and 4.

For $R = 1300$, the manager's next best alternative depends on C . He prefers debt financing to foregoing the project if $c \leq 6$ because for all such c , the terminal value of a share is larger if the project is debt financed rather than foregone. Thus, he equity finances if

$$\frac{V + R}{n + n_1} \geq \max \left\{ \frac{V + R - I}{n} - c, \frac{V}{n} \right\}.$$

Substituting for n_1 , if $c \leq 6$, then he will equity finance if the issuing price is at least $\frac{20(16-c)}{20+c} \equiv \Phi(1300)$. Otherwise, he will equity finance if $\frac{V+R}{n+n_1} \geq p_A$ which is equivalent to $p \geq \frac{20p_A}{36-p_A}$. For $R = 1600$, the manager's next best alternative is debt financing if $c \leq 12$. Thus, he will equity finance if $p \geq \frac{20(22-c)}{20+c} \equiv \Phi(1600)$ if $c \leq 12$ and $\Phi(1600) = \frac{20p_A}{42-p_A}$ otherwise.²⁵

Unfortunately, the minimum issuing price is not necessarily monotonic. This follows from the fact that the next best alternative depends upon whether $R \geq I + C$ or not. For small C , the relevant alternative is debt financing in the former case and to forego the project in the latter case. The intuition for this is the following. If $R \geq I + C$, then the manager is less willing to choose equity financing for large values of R as the issue price is less than the post-investment stock price. However, if the old stockholders lose more if the project is debt financed, then they are willing to accept this wealth transfer to the new stockholders. If $R < I + C$, then the manager is more willing to issue equity for large values of R as the losses from undertaking the negative NPV project are more than offset by the wealth transfer from the new to the old stockholders. The new stockholders accept this possibility because, on average, they earn a normal return on their investment.

We now investigate the pooling equilibria in our example.²⁶ We begin by considering the possibility of a complete pooling equilibrium. That is, we consider the parameter values for which the manager chooses the same issuing price, p , for all R , which makes $E[R | p] = E[R]$. For this to be an equilibrium, it must be the case that the investors' expectation of the future stock price (at the time R is revealed) given equity financing is at least the issuing price. Otherwise, the new investors would not purchase the newly issued shares.

²⁵ Notice that these minimum issuing prices may well be less than p_A . This may occur because the current stockholders would be willing to transfer a portion of the profits from the investment to the new stockholders if no other means of financing the project is preferred.

²⁶ In the Appendix, we show that when R is a continuous random variable, no separating equilibrium exists. Since, in the example, R is a discrete random variable, a separating equilibrium may exist for certain values of C . As this is special to the example, we ignore it in the following discussion.

Thus, to ensure that equity financing is the manager's choice independent of R we must have an issue price p such that

$$p \geq \max\{\Phi(1600), \Phi(900)\},$$

because $\Phi(1600) \geq \Phi(1300)$. A straightforward computation shows that $\Phi(1600) \geq \Phi(900)$ if $c \leq 7$. If c is larger, then the issuing price must exceed $\Phi(900)$ which is equal to $\frac{100}{9}$. If c is not larger then the issuing price must exceed $\Phi(1600)$ for there to be a complete pooling equilibrium.

We know one other important fact. The manager prefers higher issuing prices to lower issuing prices. Thus, the manager that chooses to issue equity will choose the highest issuing price that induces the new investors to purchase the newly issued shares. Above we computed the new investors' expectation of the value of a newly issued share under the hypothesis that every project was equity financed. Thus, the candidate equilibrium issuing price is that price which is just equal to their expectation. Letting p^e be this price, it satisfies

$$p^e = \frac{V + E[R]}{n + (I/p^e)} = \frac{500 + \frac{1}{3}(3800)}{50 + (1000/p^e)}.$$

Solving, we obtain $p^e = 15\frac{1}{3}$. For this to be an equilibrium, it must be that every project would be equity financed.²⁷ Otherwise, the investors' expectations would have been wrong.

Clearly, $15\frac{1}{3}$ is larger than $\frac{100}{9}$ so that if $c > 7$ then the project will be equity financed regardless of R .²⁸ If $c \leq 7$ then the largest minimum issuing price is $\Phi(1600)$. For this to be an equilibrium, we obtain another constraint on c . That is, $15\frac{1}{3} \geq \Phi(1600)$ if and only if $c \geq 3\frac{41}{53}$. Thus, if $c \geq 3\frac{41}{53}$, then the manager chooses to equity finance and sell at $p^e = 15\frac{1}{3}$ regardless of R . Furthermore, once the value of R is revealed with the passage of time, the true value of the firm's shares becomes $\rho(R) \equiv \frac{V+R}{n+n_1}$. That is, $\rho(900) = 1400/[50 + (1000/(15.33))] = 12.15$, $\rho(1300) = 15.62$, and $\rho(1600) = 18.23$.

It is left to consider what happens if $c < 3\frac{41}{53}$. In this case, we know that if the investors believe that equity financing will be chosen regardless of R , the firm with $R = 1600$ will not equity finance. So hypothesize an equilibrium in which debt financing is used if $R = 1600$ but equity financing is used otherwise. In such an equilibrium, the investors' expected future stock price conditional

²⁷ In this example, we do not specify the investors' off-the-equilibrium path beliefs. We implicitly take them to be consistent with Kreps' Intuitive Criterion and show that we are studying the sensible non-separating equilibrium in the Appendix.

²⁸ Recall that, in this case, the largest minimum issuing price is $\Phi(900)$.

on equity financing is now computed as if the manager will choose to equity finance only when R equals 900 or 1300. Thus, this expected price is $\frac{32p}{20+p}$. Obviously, this is smaller than their expectation in the previous case.

As above, the candidate equilibrium issuing price is p^e defined by

$$p^e = \frac{32p^e}{20 + p^e} = 12.$$

For this candidate to be an equilibrium issuing price, it must be larger than the largest minimum issuing price for the projects that are to be equity financed. Again, we must distinguish between the case in which $\Phi(900) > \Phi(1300)$ and when it is not.²⁹ If it is, then the appropriate largest minimum issuing price is $\frac{100}{9}$. If it is not, then the largest minimum issuing price is $\Phi(1300)$. Obviously, 12 exceeds $\frac{100}{9}$. Thus, we must find the conditions on c under which 12 also exceeds $\Phi(1300)$. Simple computations show that this holds for $c \geq 2\frac{1}{2}$. Consequently, if $3\frac{41}{53} > c \geq 2\frac{1}{2}$ then we have an equilibrium in which the manager issues debt to finance the project if $R = 1600$ and issues equity at $p^e = 12$ otherwise. That is, we have a partially pooling equilibrium. In this case, the firm's stock price when R becomes known either through the passage of time (for $R = 900$ or 1300) or through debt financing ($R = 1600$) is computed as follows. If $R = 900$, then $\rho(900) = 1400/[50 + (1000/12)] = 10\frac{1}{2}$. Similarly, $\rho(1300) = 13\frac{1}{2}$. If $R = 1600$, then the firm debt finances and $\rho(1600) = 22 - c$. Proceeding in this manner, it is easy to show that we cannot have equity financing for $c < 2\frac{1}{2}$ as it is not possible to maintain a partially pooling equilibrium.³⁰

From the above discussion, it is clear that when $c < 2\frac{1}{2}$, the equilibrium has no equity issued. Thus, the stock price when R is revealed is $\rho(900) = 10$, $\rho(1300) = 16 - c$ and $\rho(1600) = 22 - c$. This follows from the fact that the manager chooses to forego the project if $R = 900$ and debt finance it otherwise.

Next we turn to a computation of the firm's current stock price. We can decompose it into two components, the component due to the value of the assets in place and the component due to future investment possibilities. So consider the stock price prior to the firm's investment decision

²⁹ Note that if $7 > c \geq 6$, then $\Phi(1300) = \Phi(900)$ because the manager's best alternative is to forego the project rather than debt finance it for these values of c .

³⁰ The reason a separating equilibrium exists in this example is because we have taken the set of possible values of R to be discrete.

when $c \geq 3\frac{41}{53}$. Letting p^s be this price, we see that

$$p^s = \sum_R \frac{1}{3} \rho(R) = 15\frac{1}{3}.$$

Notice that this is exactly the issuing price in this pooling equilibrium. This is to be expected because no new information about the quality of the project (R) is revealed when the manager equity finances regardless of the value of R .

Now consider the case when $3\frac{41}{53} > c \geq 2\frac{1}{2}$. As we showed above, if R is either 900 or 1300, then the manager equity finances the project and if R is 1600, then the project is debt financed. Thus, the stock price prior to the firm's investment decision is

$$p^s = \frac{1}{3} \left[10.5 + 13.5 + (22 - c) \right].$$

Letting $c = 3$, we get that $p^s = 14\frac{1}{3}$. Notice that the equity issuing price, 12, is less than this expectation which means that the firms that equity finance suffer a decrease in their stock price, a fact consistent with many empirical studies. The intuition for this result is not that the firms are necessarily investing in projects with negative returns but that the choice of the financing instrument signals information to the market. In equilibrium, if the project has $R = 1600$, it is debt financed and the stock price rises from $14\frac{1}{3}$ to 19. However, the two lower quality projects are equity financed and observing this, their value falls from $14\frac{1}{3}$ to 12. Note that the manager with the project with $R = 1300$ willingly suffers this loss as debt financing gives him a terminal value of 13 instead of 13.5. The manager of the firm with $R = 900$ is prepared to accept the fall in the firm's stock price (from $14\frac{1}{3}$ to 12) as his next best alternative, foregoing the project, reduces the value even more (to 10).³¹ In this example, the original stockholders actually do better if the manager accepts the negative NPV project as the new shareholders transfer to them an amount greater than the loss from accepting the project.

The intuition that we can get from the example is as follows. First, if $c = 0$, we will not observe equity financing as no type of pooling is supportable as an equilibrium. Thus, if there are no additional costs to issuing debt, then only positive net present value projects are undertaken and all are debt financed.³² Second, if $3\frac{41}{53} > c \geq 2\frac{1}{2}$, we have an equilibrium in which the highest

³¹ Later, we will show that when we have a continuum of R 's, there will be realizations at the lower end where the manager's best choice is to forego the project.

³² Note that, as we mentioned in the introduction, this result replicates the Myers and Majluf.

net present value project is debt financed while the remaining projects are equity financed. This immediately implies that it is possible that negative net present value projects will be undertaken. This happens because the issuing price is large enough to compensate the original stockholders yet equal to the new stockholders' expectation of the future stock price in full knowledge of the fact that there is a positive probability that the manager is financing a negative net present value project. So we see that for debt costs in this range, only the better projects are debt financed. Finally, if the additional costs of issuing debt are large, it is possible that every project is equity financed.

Section 3: Analysis of the Model.

We assume that R has a distribution function, F , with support $[R_l, R_h]$ and that $R_l < I + C < R_h$. As before, we must analyze the manager's decision for each possible R . However, we can simplify the task by considering a manager's choice when R is less than $I + C$ or when R is at least $I + C$.

If the manager debt finances this project, then it must be the case that the new (post investment) stock price must be at least as large as the pre-investment stock price. Formally, this means that he debt finances if

$$\frac{V + R - I - C}{n} \geq \frac{V}{n}.$$

Obviously, this is satisfied if $R \geq I + C$ and is not otherwise. In the former case, the manager either debt or equity finances the project while in the latter case, he either equity finances or foregoes it.

To equity finance when $R < I + C$, it must be the case that

$$\frac{V + R}{n + n_1} \geq \frac{V}{n},$$

because foregoing the project is this manager's best alternative to equity financing. Substituting $\frac{I}{p}$ for n_1 , and rewriting yields

$$p \geq \frac{VI}{nR} \equiv \Phi(R).$$

We are defining $\Phi(R)$ as the minimum issuing price that induces a manager with a project of quality R to equity finance it. That is, if the manager can issue new shares at a price greater than or equal to $\frac{VI}{nR}$ then he will equity finance a project with $R < I + C$.

To equity finance when $R \geq I + C$ requires that the return to the existing shareholders should exceed the return under the best alternative, which is debt financing in this case. That is,

$$\frac{V + R}{n + n_1} \geq \frac{V + R - I - C}{n}.$$

Substituting for n_1 and rearranging yields

$$p \geq \frac{I[V + R - I - C]}{n[I + C]} \equiv \Phi(R).$$

The game representation of our model is the same as in the example. The structure of the game is that the manager chooses first and the investor,³³ after observing the manager's choice, decides whether to invest in the project if it is undertaken.³⁴

Somewhat more carefully, the manager chooses a function, $\sigma(R)$, which says what his decision is as a function of his private information, R . The investor chooses a function which says whether or not he will purchase the issued shares at the issuing price. Thus, the manager chooses an issue price, p , to maximize $\frac{V+R}{n+[I/p]}$ if this can be made larger than the maximum of (i) the returns to the original stockholders from debt financing, $\frac{V+R-I-C}{n}$ and (ii) the returns from foregoing the project, $\frac{V}{n}$. If not, the manager chooses which of (i) or (ii) he prefers. If $\rho(R)$ is the actual price per share that the firm's shares trade for once R is known, then the investor chooses his function to maximize $E[\rho(R) | p] - p$. That is, the investor chooses to purchase shares only if this value is non-negative.

Thus, we have a signaling game in which the manager is the sender and the investor is the receiver. We provide only a heuristic definition of equilibrium here. An equilibrium is a pair of functions, one for the manager and one for the investor and a set of beliefs for the investor with the following properties. (1) Given the strategy choice and the beliefs of the investor, the manager's function maximizes the value of a share held by an original stockholder for each possible realization of R . (2) Given the function chosen by the manager, the investor chooses a function that maximizes his returns from purchasing the firm's stock remembering that he may choose to purchase no shares. (3) Whenever possible, the investor's beliefs should satisfy Bayes' rule. We

³³ We can take the set of identical investors to act as if they were one investor because we have limited their strategic possibilities to choosing whether or not to purchase the newly issued shares.

³⁴ Recall that we have assumed that if the manager debt finances, R is revealed immediately but that if he equity finances R is revealed to the investor at the same time that it is revealed to the market.

choose to employ a refinement of this equilibrium, the intuitive criterion, due to Kreps [1984] in order to reduce the number of equilibria to a unique, sensible equilibrium. For details, see the Appendix.

We begin by computing the set of types³⁵ that pool in equilibrium for any set of feasible parameter values. Our situation is somewhat unusual in that the minimum issuing price that is acceptable to the manager is not monotone in R . As shown above, the manager's next best alternative differs depending upon whether or not $R < I + C$. We find that the minimum acceptable issuing price, $\Phi(R)$, is decreasing in R for $R < I + C$ and is increasing in R for $R \geq I + C$. Thus, for any issuing price the set of types that prefer to issue equity at that price may not include either R 's near R_ℓ or near R_h . In other words, we must compute both the lowest and the highest values of R such that the manager equity finances a project of those qualities.

If the equilibrium pooling price is p , the lowest value of R for which the manager prefers to equity finance will be denoted by $R_*(p)$ and satisfies $p = \frac{IV}{nR_*}$. Thus, if $R_*(p) < I + C$, then

$$(1) \quad R_*(p) = \frac{IV}{np}.$$

Note that this is independent of C because the next best alternative is to forego the project. Similarly, the highest value of R for which the manager prefers to equity finance will be denoted by $R^*(p)$ and it satisfies $p = \frac{I[V+R^*-I-C]}{n(I+C)}$. Thus, if $R^*(p) \geq I + C$, then

$$(2) \quad R^*(p) = \frac{np(C+I)}{I} + C - V + I.$$

In the Appendix, we show that $R^*(p) \geq I + C$ and $R_*(p) < I + C$ for all $p \geq \frac{IV}{n(I+C)}$ which is the value of a share if $R = I + C$ and the project is debt financed.³⁶

In equilibrium, the investors must be willing to purchase the issued shares. This means that given the manager's equilibrium strategy, the expected value of a newly issued share must be at least its purchase price. Since we have assumed that the manager's strategy is to forego the project

³⁵ We revert to the standard short-hand "types" to avoid the more cumbersome " R 's such that the manager with a project of quality R ".

³⁶ This is the smallest acceptable issuing price for any value R . Since no one would prefer to issue equity for a lower price, regardless of R , the investors should infer from such an issuing price that someone chose a non-maximizing strategy. This means that no belief is sensible. In this case, we assume that the investors' beliefs are such that the shares are purchased. One set of beliefs which are sufficient to generate this result are the investors' original prior.

if $R < R_*(p)$, to equity finance it at the issuing price p if $R \in [R_*(p), R^*(p)]$ or to debt finance it if $R > R^*(p)$, issuing equity at p signals to the investors that $R \in [R_*(p), R^*(p)]$. Formally, this means that $E[R | p] \equiv E[R | R \in [R_*(p), R^*(p)]]$. Therefore, since the investors must wish to purchase the newly issued equity, the issue price p must satisfy $p \leq \frac{V + E[R | R \in [R_*(p), R^*(p)]]}{n + (I/p)}$. The unique, sensible equilibrium issuing price is the largest one that satisfies this equation and we denote it by p^e .³⁷ We note that if $p^e \leq \frac{V}{n}$ then in equilibrium, only positive NPV projects are undertaken. Otherwise, some negative NPV projects will be equity financed. (See Figure 1.)

The intuition for these results is as follows. We satisfy the equation with equality because the issuing price is chosen by the manager prior to the investors' decision. Since the manager wishes to maximize the terminal value of an old share, the manager wishes to issue at the highest price acceptable to the new investors. Thus, the issuing price will satisfy the equation with equality. It is the largest price that satisfies the equation because the investors' beliefs at any of the other prices fail to be sensible. That is, to support any other price that satisfies the equation, the investors' must believe that the manager makes a non-maximizing choice for some values of R . In the Appendix, we show that we have a unique equilibrium in which there is the possibility of observing all three choices: debt financing of the project, equity financing of the project and foregoing the project, and is depicted in Figure 2. Further, we show that p^e satisfies

$$(3) \quad np^e = V - I + E[R | p^e].$$

Our next task is to establish conditions under which $R^*(p^e) < R_h$. If this inequality holds, then we will have an equilibrium in which for some values of R , the manager debt finances the project but for other values, he equity finances it. Recall that

$$\begin{aligned} R^*(p^e) &= \frac{C + I}{I} np^e - V + I + C \\ &= \frac{C + I}{I} E[R | p^e] + \frac{C}{I} V, \end{aligned}$$

where the latter expression follows from substituting for np^e from (3). Since $E[R | p^e] < R_h$, there exists a $C > 0$ such that $R_h > R^*(p^e)$. Hence, for $C > 0$, but small enough, our equilibrium has both debt and equity issued. For the remainder of the paper, we focus on this case.

³⁷ We show that there is at least one solution and in the event that there are multiple solutions, all but the largest fail to satisfy Kreps' criterion.

We have now established the existence of a unique signaling equilibrium with the properties that one may observe any of three decisions by the firm's manager. He may choose to debt finance the new project, he may choose to equity finance it or he may forego the project altogether. We have also provided sufficient conditions for this to occur.

Before doing the comparative static analysis, we must consider the consequences of eliminating the assumption that the manager is precommitted to undertake any project for which he raises funds. Fortunately, dropping this assumption causes only minor changes in the analysis. In particular, the decision to equity finance a negative NPV project is affected. If the manager does not have to undertake such a project, then if the issuing price, p , is not less than $\frac{V}{n}$, he will equity finance, not undertake the project and, thus, transfer wealth from new to old stockholders. Hence, if the equilibrium issuing price exceeds $\frac{V}{n}$, then $R_*(p^e) = R_l$. Otherwise, $R_*(p^e) = I$. With this adjustment, all of the analysis done above can be replicated to show that the qualitative conclusions do not change. We include a brief discussion of the effects of dropping this assumption on our comparative statics results at the end of the next section.

Section 4: Comparative Statics.

There are a number of exogenous parameters that may vary. Those that are of interest include the cost of debt financing,³⁸ C , the value of assets in place, V , and the cost of the project, I . We begin by varying C because this permits us to consider the consequences of higher or lower debt costs on the extent of debt financing in the economy.

Comparative statics cannot be done in the usual way because the unique equilibrium issuing price is the maximum issuing price at which the conditional expected value of a share is equal to the issuing price, and the "maximum" function is not differentiable. So, we adopt an approach which is slightly more cumbersome but which has the advantage of providing a global rather than a local result. We study how the expectation function, $E[\rho(R) \mid R \in [R_*(p^e), R^*(p^e)]]$ shifts when C changes for a given p^e . Knowing this, we can then determine whether the new equilibrium issuing

³⁸ Since we have not yet allowed the original number of outstanding shares, n , to vary, we may consider changes in the cost of debt financing to be changes in the per share cost rather than in the total cost. When changes in n are considered below, we will have to be careful and keep in mind that the additional cost of debt is invariant to changes in n .

price rises or falls and whether it becomes more or less likely that the firm's project is equity financed.

Turning to the effects of an increase in C , we recognize that the shift in the expectation function depends completely on how $R^*(p^e)$ changes when C changes.³⁹ From (2), it can be seen that $R^*(p^e)$ increases as C increases. Thus, the conditional expectation function, $E[R \mid R \in [R_*(p^e), R^*(p^e)]]$ shifts up when C rises and causes a higher new equilibrium issuing price. Thus, an increase in C raises the issuing price of new equity and increases the range of R that is equity financed. We refer to this latter fact as an increase in the proportion or volume of projects that are equity financed. This is an acceptable interpretation under the assumption that there are many firms facing the choice studied here.

Next, we look at the effect of an increase in V holding n constant. This is equivalent to examining the effects on financing decisions due to changes in p_A induced by an increase in V . From (1) and (2), we know that holding p^e constant, an increase in V causes $R_*(p^e)$ to rise and $R^*(p^e)$ to fall. Thus the effect on the conditional expected value of R of an increase in V , holding p^e constant, is ambiguous. Since we cannot determine this effect, we cannot draw any inferences about the volume of equity financed projects. (See figures 3 and 4.)

The intuition is that, holding p^e constant, an increase in V has a direct effect of reducing the set of negative NPV projects because the loss from the worst of these projects is no longer covered by the wealth transfer from the new to the old stockholders. Analogously, the direct effect on the set of positive NPV projects is to reduce the number financed by equity because the losses from financing at the given issue price rise as a result of the increased transfer of wealth from the old to the new stockholders. Consequently, we cannot determine whether the conditional expectation of R rises or falls because it depends on the relative magnitudes of the changes in the lower and upper limits. This also means that we cannot assess the indirect effects of an increase in V through the change in the equilibrium issuing price and, as a result, are unable to determine the effects of a change in V on the volume of equity financing.

An alternative is to consider the effect of an increase in n holding V constant. This is just another way to consider the effect of a change in the per share value of the assets in place. Since the

³⁹ This is because $R_*(p^e)$ is independent of C for a given p^e as can be seen from (1).

additional costs of debt are invariant to the original number of shares outstanding, C is constant in n . Therefore, we see from (3) that a change in n does not change the product np^e . Examining the equations defining $R_*(p^e)$ and $R^*(p^e)$, we see that since n does not change np^e , the set of equity financed projects is not altered.⁴⁰

Finally, we consider the effect of an increase in I . By not changing the distribution function of R or its support, this is equivalent to considering a firm whose whole set of projects is of lower net present value. Examining the defining functions for $R^*(p^e)$ and $R_*(p^e)$, if p^e is held fixed $R_*(p^e)$ rises as I rises but the effect on $R^*(p^e)$ is ambiguous. Thus, the effect of an increase in I on the conditional expectation of R is ambiguous. However, there is reason to believe that the expectation function falls.⁴¹ If it does, then an increase in I lowers the equilibrium issuing price. Unfortunately, this means that the effect of an increase in I on the volume of equity financed projects is ambiguous.

A large portion of the difficulty that we have in determining the effects of a change on the volume of equity financed projects stems from the very minimal assumptions that we have made on the underlying prior distribution function of the new investors. With more structure, more concrete predictions are possible. With this in mind, we specialize to the case in which R is uniformly distributed on the interval $[R_\ell, R_h]$ and assume that $I > C$.

Doing the necessary computations, we find that

$$E[R \mid R \in [R_*(p^e), R^*(p^e)]] = \frac{1}{2} \left[R^*(p^e) + R_*(p^e) \right].$$

Substituting this expression into (3) and solving for np^e yields⁴²

$$(4) \quad np^e = \frac{IV}{(I - C)}.$$

⁴⁰ This occurs because changes in the number of shares outstanding conveys no information about the value of the project in our model.

⁴¹ Recall that $\rho(R) = \frac{p^e[V+R]}{np^e+I}$. Thus, $E[\rho(R) \mid R \in [R_*(p^e), R^*(p^e)]] = \frac{p^e[V+E[R \mid R \in [R_*(p^e), R^*(p^e)]]]}{np^e+I}$. Even though the conditional expectation of R is ambiguous, the only case in which the conditional expectation of $\rho(R)$ rises is when the percentage increase in the conditional expectation of R swamps the direct effect of the increase in I . We do not believe that this is likely to occur.

⁴² Substitution gives $np^e = V - I + (1/2)[\frac{IV}{np^e} + I + C - V + \frac{C+I}{I}np^e]$. Rearranging, we get $\frac{I-C}{I}(np^e)^2 - (V - I + C)np^e - IV = 0$. Using the quadratic formula and noting that the term under the square root is a perfect square $((V - C + I)^2)$, we get equation (4) in the text.

This equation is the basis for the comparative statics that we intend to do. We begin by studying the effects of a change in V . If we differentiate with respect to V ,

$$\frac{\partial np^e}{\partial V} = \frac{I}{I - C} > 0.$$

This implies that the issue price rises when V increases. To study the effect on the volume of equity financed projects, we need to compute $\frac{dR_*(p^e)}{dV}$ and $\frac{dR^*(p^e)}{dV}$. The former is,

$$\frac{dR_*(p^e)}{dV} = \frac{d}{dV} \frac{IV}{np^e} = \frac{d}{dV} (I - C) = 0.$$

The direct effect of an increase in V is that the marginal project that is equity financed rather than foregone is of a higher quality. The reason for this is that when V was lower, the marginal project was the one that resulted in a sufficient wealth transfer so that the existing shareholders were as well off as if the project had been foregone. With a larger V , the "sufficient" wealth transfer must be larger. Hence, the quality of the marginal project that is equity financed must increase. The indirect effect of an increase in the equilibrium issuing price is to give the manager an incentive to not forego certain low value projects because the higher issuing price means that more wealth can be transferred from new to old stockholders. As our computations show, these two effects just offset.

Turning to the computation of $\frac{dR^*(p^e)}{dV}$, we see that

$$\frac{dR^*(p^e)}{dV} = \frac{C + I}{I} \frac{\partial np^e}{\partial V} - 1 = \frac{2C}{I - C}.$$

Clearly, this is positive. Therefore, in this case, we see that an increase in V increases the value of the highest valued project that is equity financed. In other words, projects that would have been debt financed if V had been lower are now equity financed.

The second term, -1 , is the direct effect of an increase in V . It is negative because an increase in V leads to a greater dilution of the original shareholders' wealth, holding the issue price fixed. However, the indirect effect (the first term) is to increase the value of this marginal project because the issue price rises when V increases. With the uniform distribution, the indirect effect outweighs the direct effect. Hence, the equilibrium issuing price rises as V rises and the volume of equity financed projects also increases. Further, we notice that p^e is affected by V in two ways. First, it is increased because $\frac{V}{n}$ rises and, second, it rises if $E[R | p^e]$ rises. The latter occurs because the

lowest valued, equity financed project remains unchanged but the highest valued, equity financed project rises. As a result, our model predicts that the magnitude of the change in the stock price due to equity financing varies positively with V .

Next, consider an increase in I . As above, we begin by computing $\frac{\partial np^e}{\partial I}$. From (4), and after some simplification, we obtain⁴³

$$\frac{\partial np^e}{\partial I} = \frac{-CV}{(I-C)^2} < 0.$$

It remains to determine the effect of a change in I on the volume of equity financed projects. We first compute the effect on the low value marginal equity financed project and then the effect on the high value marginal project.

$$\frac{dR_*}{dI} = \frac{d}{dI} \left(\frac{IV}{I-C} \right) = \frac{d}{dI} (I-C) = 1.$$

Unfortunately, the computation of $\frac{dR^*}{dI}$ is not so straightforward.

$$\frac{dR^*}{dI} = \frac{d}{dI} \left(\frac{V(I+C)}{I-C} - V + I + C \right) = \frac{1}{(I-C)^2} \left[(I-C)^2 - 2VC \right].$$

Without additional restrictions, this derivative is unsignable. However, rewriting it as

$$\frac{dR^*}{dI} = 1 - \frac{2VC}{(I-C)^2},$$

immediately shows that it is always less than or equal to 1. Since $\frac{dR_*}{dI} = 1$, we see that for all $C > 0$, $\frac{dR_*}{dI} > \frac{dR^*}{dI}$. This implies that an increase in I reduces the set of equity financed projects just as a decrease in V does.

We are left with the task of explaining how the comparative statics we have done yield testable implications of our theory. Our model is an analysis of a single firm's decision. By studying how the decision is affected by changes in the underlying parameters, we are able to do cross-sectional comparisons. That is, if we know how the decision is made for different values of the exogenous parameters, we are able to infer how the decision should vary across firms.

For example, we have shown that firms with higher additional costs of debt do more equity financing, *ceteris paribus*. We have also shown that an increase in V leads to an increase in the

⁴³ This result is consistent with the claim we made for a general distribution function.

issuing price and an increase in the volume of equity financed projects. This means that if one examines the financing decisions of firms that differ only with respect to the value of their original assets, we predict that the volume (percentage) of equity financed projects is higher for the firm with the higher V . Similarly, if we compare firms that differ only in the quality of the set of projects under consideration, our theory predicts that the firm with the better projects should equity finance a larger proportion of them.⁴⁴

Thus, according to our model, the proportion of equity financed projects should vary across firms directly with the differences in their pre-investment stock prices. Since this stock price can be decomposed into two parts, the portion attributed to the value of the assets in place and the one due to the expected value of the new project. Since an increase in V and/or a decrease in I results in a higher pre-investment stock price, our conclusion follows. This does not necessarily imply that the change in the stock price is larger with greater assets in place. However, we can use our model to show this result too. Recall that when we analyzed the effect of an increase in the value of assets in place, we saw that the original stock price must have been higher but we also saw that the set of projects that are equity financed got better. By "got better," we mean that the lowest valued, equity financed project remained unchanged but that the highest valued, equity financed project increased. These facts combine to show that the investor's expected value of the equity financed project increases. This means that the change in the firm's stock price is larger than the change in the stock price of another firm which is identical to this firm in all respects except that V is lower. This implies that firm size should have a positive correlation with the change in the stock price.

Unfortunately, some of the cross-sectional test may be very difficult to perform. However, there is an alternative way to view the comparative statics results that may yield additional hypotheses that are more readily tested. This involves viewing the comparative statics as statements about a time series. This interpretation uses the following idea. Suppose that we observe firms through time and observe variations in their stock price. Further, suppose that these variations are correlated in the sense that periodically the market is low priced and periodically high priced. If we can relate our comparative static results to the firm's stock price, then our theory yields a prediction concerning the percentage of equity financed projects across periods when the market

⁴⁴ As noted earlier, if I is increased holding the set of R s constant, the result is a reduction in the quality of the set of projects available because it lowers the NPV of every project.

is low versus when it is high.

Above, we use the effects of changes in V and I to make predictions based on observed differences in the stock prices of different firms. Now, we use them to make predictions about a single firm's actions (and hence, the market's actions) as the stock price changes. The effects of changes in V and I can be used to provide an explanation for why more equity financing is done when stock prices are high. If one is willing to assume that the distribution of projects is not correlated with movements in the value of the original assets for all firms, then our theory predicts that when stock prices are high the percentage of all projects that are equity financed should be higher. The reason for this is that the firm's stock price may be high for either of two reasons, (i) that it has a large value of assets in place or (ii) that it has a better set of projects available. We have shown that in either case, the set of equity financed projects increases. Hence, our model predicts that the observed volume of equity financing should be higher when the firm's stock price is high.

To summarize, in addition to providing a model in which debt financing, equity financing and foregoing are observed in equilibrium, we provide an explanation for the relationship between stock prices and equity financing as noted by Taggart [1977] and Marsh [1982] (and the references therein), and referred to as a puzzle by Myers [1984]. Our work also suggests an explanation for why the firm's size is an important explanatory variable when one studies the effect of financing decisions on stock prices.

Again, before leaving this topic, we wish to describe the effects of dropping the assumption that the manager is precommitted to undertaking all projects for which he has received funding. If the equilibrium issuing price is such that $R_*(p^e) = I$, then the above computations remain unchanged. In the event that $R_*(p^e) = R_\ell$, then the computations differ slightly in an obvious way. These computations show that all of the results reported remain unchanged and so our qualitative conclusions do not depend upon whether there is precommitment or not.⁴⁵

⁴⁵ The computations referred to are available from the authors upon request.

Section 5: Conclusion.

We have studied how the manager decides whether to undertake a new project and how to finance it under the assumption that the manager acts in the best interests of the old stockholders. Our unique equilibrium has the manager choosing to finance the best projects with debt, the intermediate projects with equity and foregoing the worst. In this equilibrium, all equity issued to finance a new project is issued at the same price. This may permit some negative NPV projects to be equity financed. This follows from the fact that the old stockholders can be made better off by the wealth transfer from the new stockholders. Our example shows that it is possible for the stock price to fall upon the announcement of its decision to equity finance the new project and provides a potential explanation for this generally observed phenomenon.

Our comparative statics analysis showed that an increase in the additional costs of debt results in a greater use of equity financing. More importantly, an increase in the value of assets in place leads to a greater use of equity financing. This increase is due to the equity financing of additional high valued projects with no change in the equity financed low value projects. Consequently, it follows that the firm with the higher assets in place sees a larger increase (smaller decrease) in its stock price after the announcement. When we increase the profitability of the set of potential projects, we find that the volume of equity financing goes up. Since either of these two effects may be causing an increase in the stock price of the firm, our analysis is able to explain why the volume of equity financing increases when the stock market is high.

We believe that an extension of our model which includes other types of financing instruments like retained earnings, convertible debt, *etc.* will provide a more complete understanding of how the firm signals its private information. This type of extension, in the spirit of some recent work cited in the introduction, will permit an analysis of the choice of optimal signaling instrument and may also provide insight into other outstanding puzzles.

Appendix.

We begin by providing a definition of the equilibrium and then proceed to prove the claims made in the text.

As in the text, let the manager's strategy be a function, σ , from project types, R , to the decision set $D = \{d, (e, p), f\}$, which stands for the choice of debt financing, equity financing and the issuing price or foregoing the project respectively. Thus, $\sigma : [R_\ell, R_h] \rightarrow D$, and the manager's strategy space is the set of maps from $[R_\ell, R_h]$ to D . Since all of the investors have the same priors, we will represent them as one player. Having the same priors means that they will have the same posterior, conditional on observing some $x \in D$. In turn, this implies that either they all are willing to acquire the new shares or none are. Therefore, we can simplify the game by solving as if there is one investor. This investor's strategy is a function from the manager's decision set to a decision to buy or not buy. Let $B = \{buy, not\ buy\}$ and let $s : D \rightarrow B$.

With these conventions, an equilibrium is a pair of strategies, one for the manager and one for the investor, $\sigma^*(R), s^*(x)$, and a belief function, $\mu(R | x)$ that satisfy the following properties:

- (1) given $s^*(x)$ and $\mu(R | x)$, $\sigma^*(R)$ maximizes the manager's objective function, the value of a share, for $R \in [R_\ell, R_h]$,
- (2) given σ^* and $\mu(R | x)$, $s^*(x)$ maximizes the investor's objective function, and
- (3) given σ^* , $\mu(R | x)$ satisfies Bayes' rule whenever possible.

To interpret the last restriction, let $\sigma^{*-1}(x)$ be the set of R 's for which σ^* says "choose decision x ." Then, the last restriction means that if $\sigma^{*-1}(x)$ is not empty, then the investor's probability that $R \leq r$ is the conditional probability that $R \leq r$ given that $R \in \sigma^{*-1}(x)$. More formally, if $R \in \sigma^{*-1}(x)$, where we intend this set to be non-empty, then

$$\mu(R | x) = \frac{F(R+) - F(R-)}{\int_{r \in \sigma^{*-1}(x)} F(dr)}$$

What this means is that if the observation of the manager's choice is one that should arise from the use of the manager's equilibrium strategy, then the investor should believe that the probability that the value of the project is R is simply the conditional probability that it is R given the set of project values that would have induced the manager to make the same decision.

As mentioned in the text, we will restrict attention to the set of sensible equilibria as determined by Kreps' Intuitive Criterion. Kreps' criterion is a restriction on the off-the-equilibrium

path beliefs that one may use to support an equilibrium. The idea is to consider some unsent message x' and ask whether it could have been used to break the equilibrium. The answer is yes if the following conditions hold. First, one must be able to find a subset of the types (R 's) such that if the value of the project is an element of this subset, then the manager does not wish to deviate to this unsent message no matter how the investor interprets the message. Second, for the complementary set, it must be true that if the investor concentrates his beliefs on this complementary set and chooses a best action given this restriction, the manager with a project in this set must prefer to deviate to the unsent message regardless of which best action the investor chooses.⁴⁶

Having defined what will constitute an equilibrium, we turn to proving the statements in the text.

Lemma 1: *In equilibrium, $R^*(p) \geq I + C$.*

Proof: First consider the case in which there is equity financing and suppose that $R^*(p) < I + C$. We immediately have a contradiction because if $R^*(p) < I + C$ then

$$E[R \mid R \in [R_*(p), R^*(p)]] < I + C.$$

Since $\Phi(R)$ is declining for $R < I + C$, there is an R , $I + C > R > R^*(p^e)$, such that $\Phi(R) < \Phi(R^*(p^e))$. Since this firm's minimum issuing price is smaller than $R^*(p^e)$'s, it prefers equity financing to foregoing. Further, since $R < I + C$, it prefers foregoing to debt financing. Hence, we have a contradiction: the R firm has an incentive to deviate and equity finance the project.

Next, consider the case in which no equity is issued. In this case, the manager with $R = I + C$ is foregoing the project because of the additional cost of debt C . Further, since C is strictly positive, there is a $\delta > 0$ such that $\forall R \in [I + C, I + C + \delta]$, the manager is also choosing to forego the project. However, if the manager with a project of this type chooses to issue equity at $\frac{V}{n}$, the value of an existing share will increase. This follows because the investors will purchase such shares because the issue price indicates that $R \geq I$ since any firm with $R < I$ would forego the project rather than fund a negative net present value project by issuing shares at this price. Further, if $R > I$, the manager is strictly better off issuing new shares and accepting the positive net present value project than foregoing it. Hence, we have a contradiction and together with the argument in the previous paragraph, this shows that $R^*(p) \geq I + C$. ■

Lemma 2: *In equilibrium, $R_*(p) < I + C$.*

⁴⁶ For the details, see Kreps [1984].

Proof: Again, the proof is by contradiction. So, suppose that $R_*(p) \geq I + C$. First note that the smallest of the minimum acceptable issuing price is $\frac{IV}{n(I+C)}$. Second, since $R^*(p) \geq I + C$, the investor must, in equilibrium, expect that the firm is choosing a non-negative NPV project and, as a result, be willing to pay more than $\frac{V}{n}$ for a newly issued share. So, the only way to support an equilibrium in which the firm issues at a lower price than the largest that is acceptable to the investor is to choose off-the-equilibrium path beliefs such that a deviation to a larger issuing price is not profitable. In this case, this is possible only if the investor chooses not to buy the issued shares at the larger price. However, these beliefs are not sensible.

They are not sensible because the conditional expectation function is continuous. That is, if the larger price is $p + \delta$ for some $\delta > 0$, there is an $\epsilon > 0$ such that $E[\rho(R) | p + \delta] - E[\rho(R) | p] < \epsilon$. Since $E[\rho(R) | p] > p$, there is a $\delta > 0$ such that if the investor concentrates his beliefs on the set of project values for which the deviation to $p + \delta$ is profitable, the investor's best response is to buy the shares. Since this means that the shares are issued at a higher price, the presumed deviating types are better off. Thus, we need only show that no other type would prefer to deviate if the investor chooses a best response to this deviation for any beliefs about who might be deviating. This is straightforward if one chooses as the original deviating set the set of firms for whom the minimum acceptable issuing price is not larger than $p + \delta$. Then, for any project value not in this set, selling newly issued shares at $p + \delta$ is strictly worse than their next best alternative if the investor purchases the shares and is strictly worse for firms that would have debt financed the project if the investor does not purchase the shares. If the firm would have foregone the project otherwise, then if the investor chooses not to buy the shares, then the manager is worse off for having spent the resources to issue equity. ■

Proposition 1: *There are no equilibria in which the value of an undertaken project is revealed.*

Proof: Again, suppose not. The first two lemmas show that, in equilibrium, the set of firms that issue equity include firms with $R < I + C$ and firms with $R \geq I + C$. Hence, in a separating equilibrium, there is a set of firms choosing to equity finance the project. Since we have supposed a separating equilibrium, it must be the case that for this set of firms, the issuing price reveals the project's value. That is, the issuing price must be a monotonic function of R for R is the set of R 's which are equity financed. Since it is a monotonic function and since there are, at least, two firms issuing equity (by lemmas 1 and 2), there are at least two distinct issuing prices. Label then so that $p_1 > p_2$. For this to be an equilibrium, no firm type must wish to deviate from its equilibrium

action. In particular, the R associated with issuing shares at p_2 , say R_2 , must not wish to deviate. In addition, if we consider deviations to actions that are observable in equilibrium, that is actions that can be generated by the manager's equilibrium strategy for some $R \in [R_\ell, R_h]$, then we need not worry about off-the-equilibrium path beliefs. So let R_2 contemplate deviating to p_1 . Doing so allows this firm to issue equity at a higher price. It is purchased because the investor purchases the issued shares by the firm that is supposed to issue at p_1 . Hence, the R_2 firm is strictly better off. ■

Proposition 2: *The equilibrium issue price satisfies $p = E[\rho(R) | p]$.*

Proof: First, notice that $p \leq E[\rho(R) | p]$. This follows from the observation that were it false, the investor would not purchase the newly issued shares as they are being sold for more than he expects them to be worth. Second, by an argument analogous to that used to prove the previous proposition, if $p < E[\rho(R) | p]$, it is supported by beliefs that are not sensible. ■

Lemma 3: *For all $p > p^e$, $p > E[\rho(R) | p]$.*

Proof: Suppose not. Then for some $p > p^e$, $E[\rho(R) | p] \geq p$. It is immediate from the definition of p^e that this inequality must be strict for all $p > p^e$. (Otherwise, since the conditional expectation is continuous, there would be another $p > p^e$ such that $E[\rho(R) | p] = p$ which is inconsistent with the definition of p^e .) But this cannot be because there is a p sufficiently large, say \tilde{p} , such that for all $p > \tilde{p}$, $E[\rho(R) | p]$ is constant. This follows from the fact that the support of the distribution function F is closed. Thus, simply compute the minimum issuing price acceptable to a firm with $R = R_\ell$ and with $R = R_h$. Choose the larger of these minimum issuing prices and identify it with \tilde{p} . At this issuing price, all firms prefer to issue equity rather than their next best alternative. Hence, $E[\rho(R) | \tilde{p}] = E[\rho(R)]$, a constant. ■

Proposition 3: *There is a $p > \frac{IV}{n(I+C)}$ such that $p = E[\rho(R) | p]$.*

Proof: In lemma 2, we showed that if $p = \frac{IV}{n(I+C)}$, then $p < E[\rho(R) | p]$. In lemma 3, we showed that there was a p , labelled \tilde{p} , such that for all $p > \tilde{p}$, $E[\rho(R) | p] = E[\rho(R)]$. Since the conditional expectation function is continuous, there exists a p , say p' such that $p' = E[\rho(R) | p']$. ■

Theorem 1: *The unique sensible equilibrium has*

$$\sigma^*(R) = \begin{cases} d & R \in (R^*(p^e), R_h] \\ (e, p^e) & R \in [R_*(p^e), R^*(p^e)] \\ f & R \in [R_\ell, R_*(p^e)), \end{cases}$$

where p^e is the largest issuing price such that $p^e = E[\rho(R) | p^e]$ and the investor purchases the

issued debt and equity. Finally, the investor's beliefs are that (e, p) implies that $R \in [R_*(p), R^*(p)]$, f implies that $R \in [R_\ell, R_*(p^e)]$ and that d implies that $R \in (R^*(p^e), R_h]$.

Proof: For p^e to define an equilibrium a number of things must be true. First, if $R < R_*(p^e)$ then the manager must prefer to forego the project rather than equity or debt finance it. Second, if $R \in [R_*(p^e), R^*(p^e)]$ then the manager must prefer to issue equity at p^e rather than either of the other options. Third, if $R > R^*(p^e)$, then the manager must prefer to debt finance the project.

Taking each in turn, the first is satisfied because $R_*(p^e) < I + C$. In other words, because the manager's next best alternative is to forego the project and the issuing price is smaller than the minimum issuing price that increases the current stockholders' wealth: if $R < R_*(p^e)$, then the minimum issuing price that is acceptable to the manager is larger than the equilibrium issuing price. Thus, in this situation, the manager prefers to forego the project rather than issue equity at p^e . By the same reasoning, the manager would prefer to forego the project rather than issue equity at any lower price.⁴⁷ However, this is not sufficient to show that a manager in this situation would choose to forego the project. The reason is that we must ensure that he does not prefer to issue equity at some other price.

So, consider the possibility that the manager issues equity at some larger price p' . Notice that by construction, this is an off-the-equilibrium path signal and thus the investors' off-the-equilibrium path beliefs come in to play.⁴⁸ We employ the following off-the-equilibrium path beliefs. As we show below, these are the beliefs which are consistent with Kreps' Intuitive criterion and result in a unique sensible equilibrium. The investor's beliefs are that any off-the-equilibrium path issuing price would be used by the manager for every R such that the new issuing price makes the original owners of the firm at least as well off as the equilibrium action. That is, the investor computes the set of R 's such that if R is a member of this set, then issuing at the off-the-equilibrium path issuing price is at least as good as the equilibrium action. From above, we know that for a larger issuing price, the set of R 's that prefer to issue at this price rather than undertake their next best alternative strictly contains $[R_*(p^e), R^*(p^e)]$. However, we have p^e equal to the largest issuing price at which $E[\rho(R) \mid R \in [R_*(p^e), R^*(p^e)]] = p^e$. Hence, at this higher issuing price, p' , the investors will not purchase the shares which will immediately imply that if

⁴⁷ This preference is independent of the investors' best reply to the deviation because the reply to issuing at this price that makes the manager's payoff largest (to purchase the issued shares) is insufficient to induce the manager to issue the shares at this price.

⁴⁸ It is these types of situations that cause the off-the-equilibrium path beliefs to play such a large role in determining what is or is not an equilibrium.

the manager's project has $R < R_*(p^e)$ then he will prefer to forego the project.

To explain why p^e is the largest issuing price such that the issue price is equal to the conditional expectation of $\rho(R)$, we need to recall a couple of facts. First, $\Phi(R)$ is increasing in R for $R \geq I + C$ and is decreasing in R for $R < I + C$. Further, there is a large enough issuing price such that the manager prefers to issue equity and such that increasing the issuing price does not change the manager's decision, regardless of the value of R . This immediately implies that if, regardless of the value of R , the manager issues equity at the issuing price, then the issuing price does not reveal any information. Together, these imply that there is an issuing price, \hat{p} , such that $E[\rho(R) \mid R \in [R_*(\hat{p}), R^*(\hat{p})]] = E[\rho(R)]$ for all $p \geq \hat{p}$. Second, our assumptions about the distribution function of R as well as the fact that both $R_*(p)$ and $R^*(p)$ are continuous ensure that $E[\rho(R) \mid R \in [R_*(p^e), R^*(p^e)]]$ is a continuous function of p . Next, we combine this with the obvious fact that either $p^e \geq \hat{p}$ or not. If $p^e \geq \hat{p}$ then for all $p > p^e$, $p > E[\rho(R) \mid p] = E[\rho(R) \mid R \in [R_*(p), R^*(p)]] = E[\rho(R)]$. That is, if the equilibrium issuing price is not smaller than the issuing price that induces equity financing for all values of R , then increases in the issuing price cannot change $E[\rho(R) \mid R \in [R_*(p), R^*(p)]]$. Thus, since p^e is the largest price such that $p = E[\rho(R) \mid R \in [R_*(p), R^*(p)]]$, any increase in the issuing price causes $p > E[\rho(R) \mid R \in [R_*(p), R^*(p)]]$. Since the investors would refuse to purchase shares issued at a price such that $p > E[\rho(R) \mid R \in [R_*(p), R^*(p)]]$, this deviation is unprofitable. In the other case, $p^e < \hat{p}$, we know that for all $p > p^e$, $p > E[\rho(R) \mid R \in [R_*(p), R^*(p)]]$. Again, deviations to such an issuing price results in the investors refusing to purchase the issued shares. If they do not buy the issued shares, the manager prefers not to deviate. Thus, we have shown that when $R < R_*(p^e)$, the manager's best choice is to forego the project.

Next, consider the case in which the manager's project's quality is $R \in [R_*(p^e), R^*(p^e)]$. Obviously, this manager prefers to equity finance the project rather than his next best alternative, regardless of which alternative is best. However, we must again show that there is no alternative issuing price which he prefers. As above, he clearly will not prefer a lower issuing price because, at best, he would be throwing money away. To show that he does not prefer a higher issuing price, we simply use the argument above to show that for all larger issuing prices, $p > E[\rho(R) \mid R \in [R_*(p), R^*(p)]]$. Again, this implies that the investors would refuse to purchase the issued shares and this means that the manager's optimal choice is to issue equity at p^e .

Lastly, we must show that the manager will choose to debt finance a project if $R > R^*(p^e)$. Since

this manager's minimum acceptable issuing price exceeds p^e , he would not prefer to issue equity at a lower price. The above argument shows that the investors will not purchase equity issued at a higher price thus making this manager prefer to debt finance the project rather than attempt to issue equity at a price that exceeds p^e . Finally, since $R > I + C$, the manager prefers to debt finance the project rather than forego it. Consequently, the manager will choose to debt finance the project if $R > R^*(p^e)$. Thus, we need only show that the beliefs are sensible and that the equilibrium is unique.

To see that the beliefs are sensible, notice that we have concentrated the investor's beliefs on the set of firm types, say Z , that would prefer to deviate if the investor purchases the shares. This immediately implies that the beliefs are sensible for downward deviations because no firm prefers to deviate because such a firm would simply be issuing shares for a lower price. If there is a deviation to a higher issuing price, then if the investor chooses to respond to the deviation by purchasing no shares, no firm type wishes to deviate. Hence, the equilibrium involves beliefs that are not sensible only if the investor would purchase the shares, after concentrating his beliefs on the set Z . However, the investor will not purchase these shares in this event. This follows because p^e is the largest price such that $p = E[\rho(R) | p]$. Thus, concentrating his beliefs on Z , which is equal to $[R_*(p'), R^*(p')]$ if p' is the deviation, results in $p' > E[\rho(R) | R \in [R_*(p'), R^*(p')]]$ as shown in lemma 3. This implies that the investor would not purchase the shares.

Thus, we are left with showing that the equilibrium is unique. Our analysis of the manager's optimal decision immediately implies that a change in either the set of firms issuing debt or foregoing the project requires a larger issuing price. Proposition 2 showed that the set of issuing prices that we need consider are only those that satisfy $p = E[\rho(R) | p]$, and the definition of p^e made it the largest issuing price satisfying this equation. Finally, recall that Proposition 1 showed that we could not have a separating equilibrium. As a result, we need only consider the possibility that we get an equilibrium of the type described in Theorem 1 with a different issuing price. So, consider an equilibrium of that type except that the issuing price is $p < p^e$.

We proceed by showing that such an equilibrium must be supported by beliefs that are not sensible thereby proving uniqueness. To see this, simply consider a deviation to a larger issuing price, in particular, p^e . We know that at this larger issuing price, more firms are issuing equity and less are debt financing or foregoing the project. Obviously, those firms that had been foregoing the project in the conjectured equilibrium are better off equity financing it because their minimum acceptable

issuing price is no larger than p^e . Second, note that every firm that had been issuing equity, and still is, is better off because the shares are issued at a higher price. Third, note that the firms that switch from debt to equity financing are better off because the issuing price is at least as large as their minimum acceptable issuing price. Finally, note that any firm that was, and still is, either foregoing the project or debt financing it is indifferent to the change, but strictly prefers its choice to equity financing the project at p^e . This completes the proof because these facts imply that we can break the conjectured equilibrium.

To see this, simply consider the deviation to p^e . If the investor responds by purchasing the shares, then the set of firms that prefer to deviate to this issuing price is exactly $[R_*(p^e), R^*(p^e)]$. Further, given that the investor concentrates his probability on this set, the investor is willing to purchase the shares (by the definition of p^e). Hence, if we can show that there is a set of firms that prefer not to deviate, we are done. We identified such a set above. These are the firms that do not switch from either foregoing the project or debt financing it.

Consequently, we have shown that the equilibrium is unique. ■

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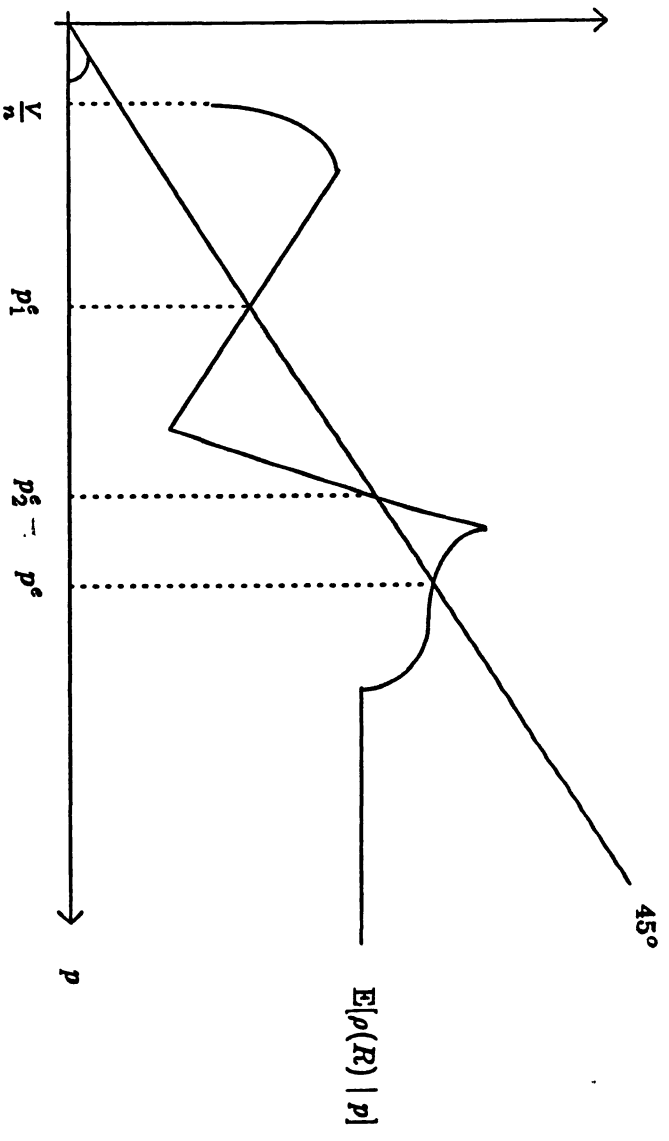


FIGURE 1

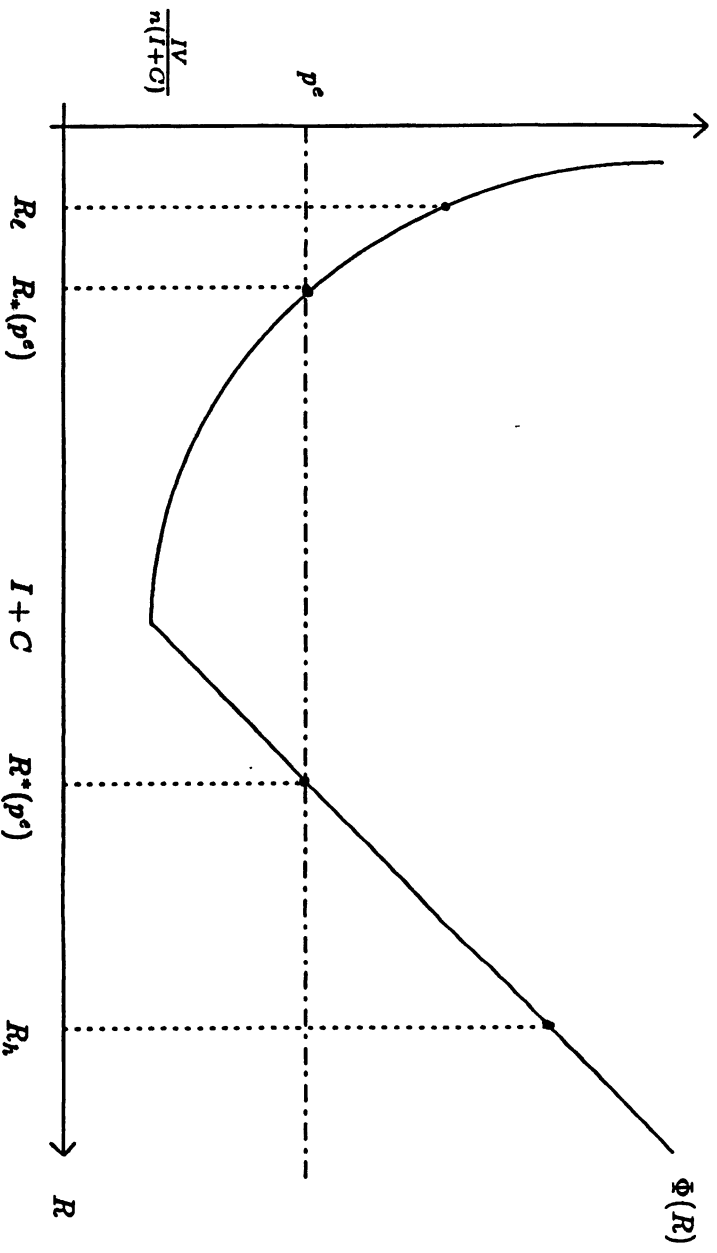


FIGURE 2

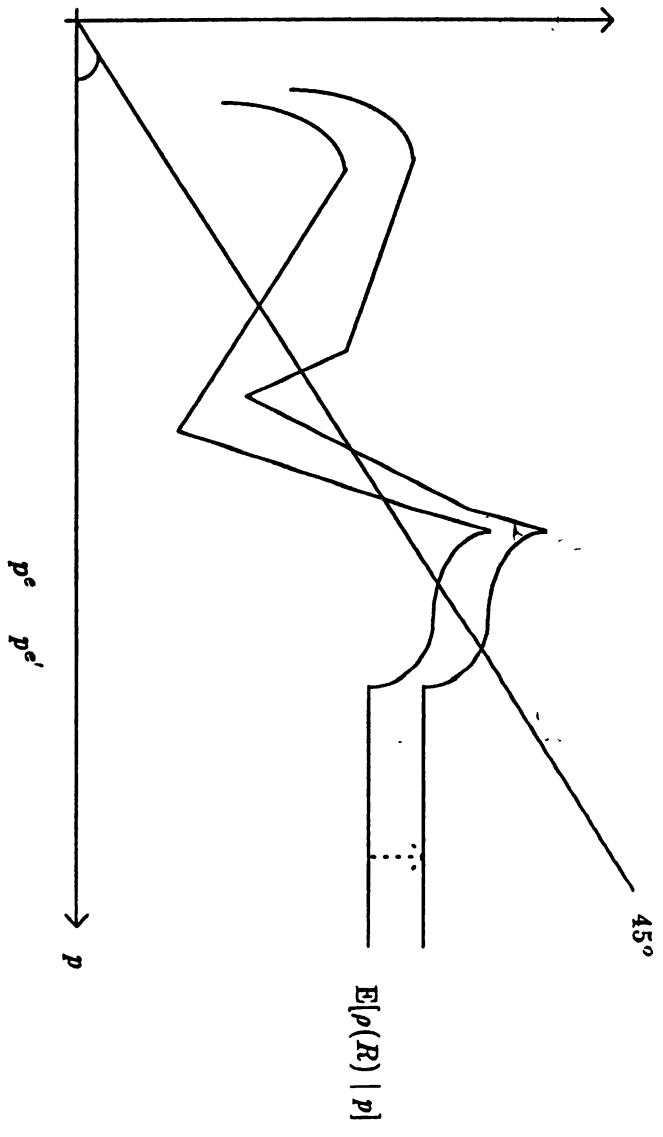


FIGURE 3

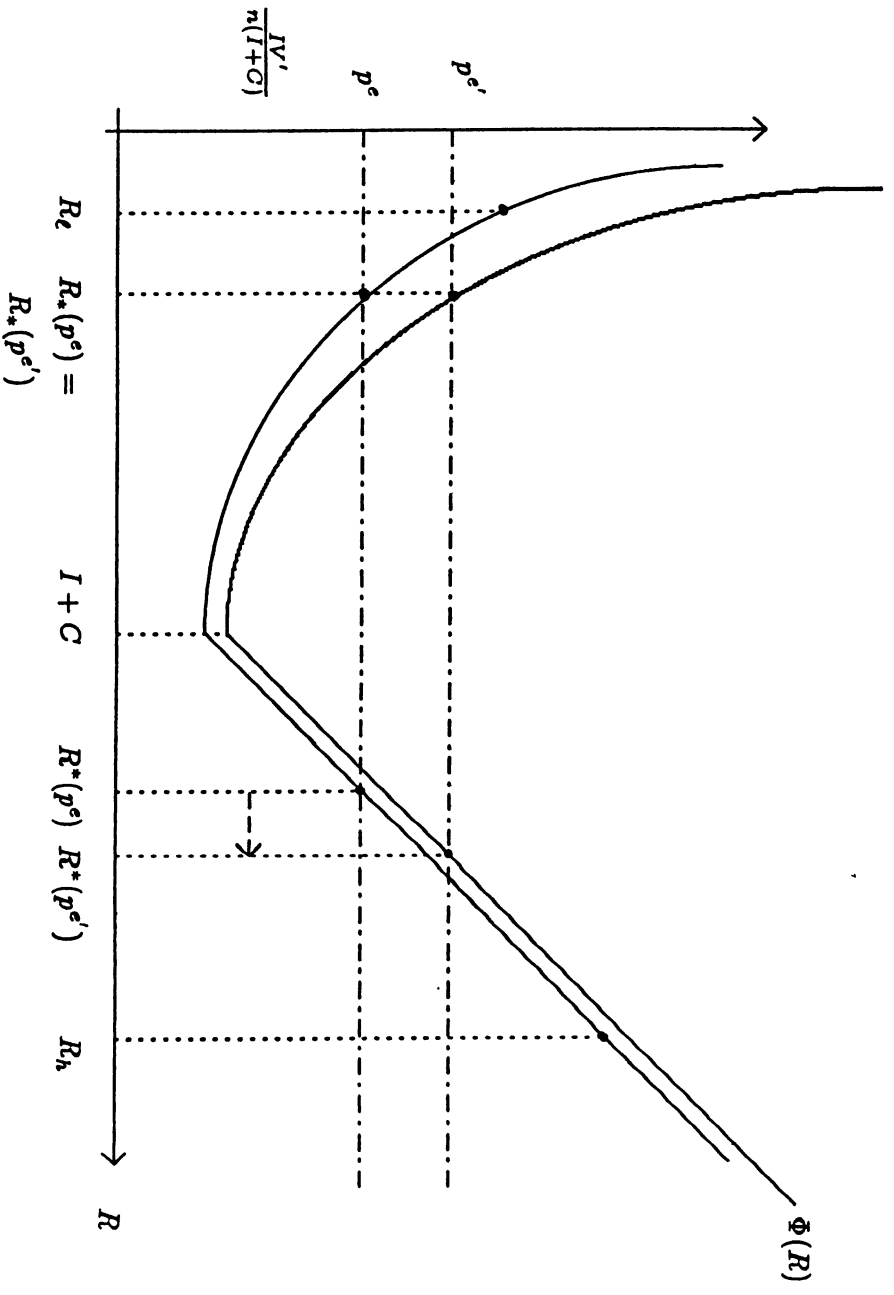


FIGURE 4

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