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Firm Value and the Choice of Offering Method in Initial Public Offerings

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ABSTRACT

A firm raising capital in an initial public offering faces the problems of choosing between a firm-commitment and a best-efforts offering and of how to convey information about its value to potential investors. The offering method chosen affects both the firm's cost of obtaining capital and investors' perceptions about firm value. A partially pooling, partially separating equilibrium is found where high-valued firms have information about their values revealed in a firm-commitment offering, while low-valued firms use best-efforts offerings and are unable to distinguish themselves from other firms.

WHEN A FIRM GOES public with an initial equity offering, it has two options on how to issue the stock. Using an investment banker, the firm can issue stock to the public with either a firm-commitment or a best-efforts agreement.[1] In both types of offerings the investment banker distributes the new shares, but in a firm-commitment agreement he or she performs the additional function of insuring the proceeds to the issuer. In addition, a firm-commitment agreement uses the reputational capital of the investment banker to certify the value of the issue to a greater degree than in a best-efforts offering. The offering method chosen affects both the firm's cost of obtaining capital and investors' perceptions about the value of the offering itself. This paper examines the factors affecting a firm's choice of offering method and to what extent information about firm value is revealed to investors by that choice.

There are two types of mispricing inherent in initial public offerings. The first is the observed short-term underpricing of initial offerings.[2] Several papers have used asymmetric information to generate initial underpricing. In Baron (1982), the investment banker is better informed about market demand than the issuing firm. In Rock (1986), investors can be either informed or uninformed about the value of new issues. Others, such as Grinblatt and Hwang (1988) and Allen and Faulhaber (1988), consider the extent to which underpricing generates informa-

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[1] In the period from 1977 to 1982, Ritter (1987) found that, for firms using investment bankers, 664, or 64.6%, used firm-commitment offerings while 364, or 35.4%, used best-efforts offerings. A third, but less frequently used, possibility is a direct offering without any use of an investment banker.

[2] Initial underpricing of unseasoned issues has been widely documented by Reilly and Hatfield (1969), Stoll and Curley (1970), Logue (1973), Ibbotson (1975), and many others.

tion about the firm's value. Bower (1989) treats initial underpricing as a short-term phenomenon that relates to the risk premium that a risk-averse investment banker demands for insuring a new issue.

The second type of mispricing is a longer term effect that relates to lack of publicly available information about the firm. Firm value is not likely to be revealed immediately, but rather investors' expectations about firm value improve over a long period of time as more information is revealed about the firm. This paper focuses on the long-term mispricing of new issues using an asymmetric information approach.

The model in this paper considers many firms, each of which needs capital to finance a positive net present value project and has chosen to issue equity rather than debt. The manager/entrepreneur knows the value of the project, while potential investors know only the distribution of project values. The manager wishes to maximize the value of his or her shares where the value of the firm equals the project value less the issue costs. The firm can issue equity using an underwriter in a firm-commitment agreement, who, for a fee, determines the value of the firm and certifies this value to investors. Thus, a firm that employs an underwriter has its value revealed, so the firm earns the present value of the project less the underwriter's fee and the share to investors.

A firm can also issue equity using an investment banker for selling purposes only in a best-efforts agreement. Investors can no longer distinguish between firms, so the highest price they would pay for shares is their expected present value, which equals the endogenously determined mean value of firms using best-efforts offerings. Because investors cannot distinguish between firms, each firm using a best-efforts offering sells the same proportion of shares and saves the underwriter's fee. In present value terms, the portion of proceeds paid to investors may be greater or less than the amount obtained from investors, depending on whether the firm is of higher or lower value than the mean value of firms using best efforts.

In my model a partially separating, partially pooling equilibrium results, as some firms find it profitable to pay the certification costs to have their true value revealed, while others find the certification costs too high and realize a greater value of retained shares by not distinguishing themselves from the other firms. This mixed equilibrium is similar to that described by Viscusi (1978), in which signalling occurs only for the most valuable firms that find the costs worthwhile.

Section I describes the model, while the solution is provided in Section II. Section III examines the effects of changing the parameters of the model. Section IV concludes and discusses implications for further research.

I. The Model

I assume that a privately held firm needs to raise capital to finance an investment project. Having chosen to issue stock in an initial public offering, a firm must then decide whether to use a best-efforts offering or a firm-commitment offering. The offering method chosen affects the cost of obtaining the capital and investors' perceptions about the value of the project being financed.

Assume that there are many firms making initial equity offerings to finance investment projects. Each firm has an initial value of assets in place, which is assumed to be zero.[3] Hence, the firm's value is the value of the investment project. Firms draw an investment project from a pool of projects, each with an investment cost of I.[4] The present values of the projects range from $\underline{X}$ to $\bar{X}$, where $\underline{X}$ is at least as large as I, so that a firm accepts only positive net present value projects. The present value calculations assume a rate of return consistent with the return on investments of similar risk. The realized present value of the project is X, drawn from a distribution with probability-density function $f(X)$.[5] The firm, having chosen the project, knows the present value X, but potential investors know only the distribution of project values and cannot observe the actual value of the project chosen.

Each firm has S shares available to issue or to hold, which can be normalized to one share. The firm sells a percentage p of its share to the public to raise the necessary capital for the investment project and retains the remaining proportion of its share. Thus, the new shareholders have a claim on the fraction p of the firm's earnings. Since the firm is raising a fixed amount of capital, the price of the share varies inversely with the percentage of the firm sold. A percentage of the firm, p, is sold for an amount, I, making the total price of the share equal to I/p.

The entrepreneur/manager is assumed to maximize his or her own wealth. Thus, firms maximize retained share value, that is, the present value of the project and the proceeds from issuing net of investment cost, issuing cost, and the proportion of proceeds that goes to investors. The firm's retained present value is the proportion of the present value of the project, X, less the cost of issuing, C_i, where i indicates the issuing method, remaining after deduction of the proportion held by investors. The proceeds from issuing increase firm value by I, while the cost of investment decreases it by I as well, so these terms do not enter into the firm's retained present value. Therefore, the firm or entrepreneur's problem is

$$\max[X - C_i][1 - p], \tag{1}$$

where

$$C_i = \text{issuing cost of issue method } i$$

and

$$i = \begin{cases} B = \text{best efforts offering,} \\ F = \text{firm commitment offering.} \end{cases}$$

[3] If the initial firm value is known, the offering method decision becomes dependent on the initial value. The solution is essentially the same as in the case with no initial value, but each firm solves for a different value at which it is indifferent between offering methods. An unknown initial value can be combined with the value of the new project to create a new value and distribution for X and not change the problem.

[4] The model does not preclude firms from bringing projects to market requiring different levels of investment. Initial investment, I, can be considered to be the lowest common denominator of investment size, and firms can make equity offerings consisting of integer multiples of I.

[5] Project value, X, could also be considered to be the expected value of the project.

The issuing costs are determined by the issuing method. All issues involve costs related to registration, advertisement, printing, and mailing. The major cost difference between a best-efforts offering and a firm-commitment offering is the inclusion of the underwriter's fee in the latter. The investment banker charges a fee to the issuing firm to cover investigation, insurance, and bonding costs. In a firm-commitment agreement, the investment banker functions as an underwriter and thus incurs the costs of investigating the firm and must also be compensated for the risks involved in underwriting the issue. Underwriters participate in public offerings frequently and maintain their reputations through a bonding agreement as in Booth and Smith (1986).[6] To highlight the effect of asymmetric information, the underwriter is assumed to determine the exact value of the project through investigation of the firm and to certify that value to investors.[7] The bond serves as a guarantee to investors so that they view the underwriter's valuation as credible.

For clarity, the issuing costs in common to both methods will be included in the investment costs, and the issuing costs will refer to the additional costs of using a firm-commitment agreement. Thus, the cost of a best-efforts offering, C_B, will be zero, while the cost of a firm-commitment offering, C_F, will be C.

I assume that the number of investors is large relative to the number of new issues to ensure a market for the issues. Investors maximize wealth and know the distribution $f(X)$ of possible firm values X. The investor learns the firm value, X, with a firm-commitment offering since he or she knows how the underwriter behaves. I assume that investors are risk neutral.[8]

II. Solution

To determine the solution to the manager's problem, I first examine the net present value a manager receives from using a firm-commitment offering. I then determine which firms benefit from using a best-efforts offering.

The net present value accruing to the manager/entrepreneur with a firm-commitment offering is the unsold share of the present value of the project less the underwriting cost:

$$NPV_F = [X - C](1 - p). \tag{2}$$

The underwriter reveals the true value of the firm to investors so they pay the investment cost, I, for a portion of the firm worth I. Thus, investors require that $p[X-C] \geq I$. This leads to a net present value of the manager's shares equal to

[6] In Gilson and Kraakman (1984) and Booth and Smith (1986), underwriters are frequent participants in capital markets and, as such, maintain their reputations. As part of the underwriting agreement, the underwriter leases his or her reputation to the firm, which does not have a maintained reputation in the capital markets. Those papers, as well as this one, assume that there are many homogeneous and competitive underwriters.

[7] This assumption eliminates any initial underpricing of firm-commitment offerings since a risk premium need not be offered to investors to induce them to purchase the issue.

[8] The assumption of risk neutrality eliminates initial underpricing of best-efforts offerings due to risk over return of new issues. This allows the model to isolate the effect of firm value on the choice of offering method.

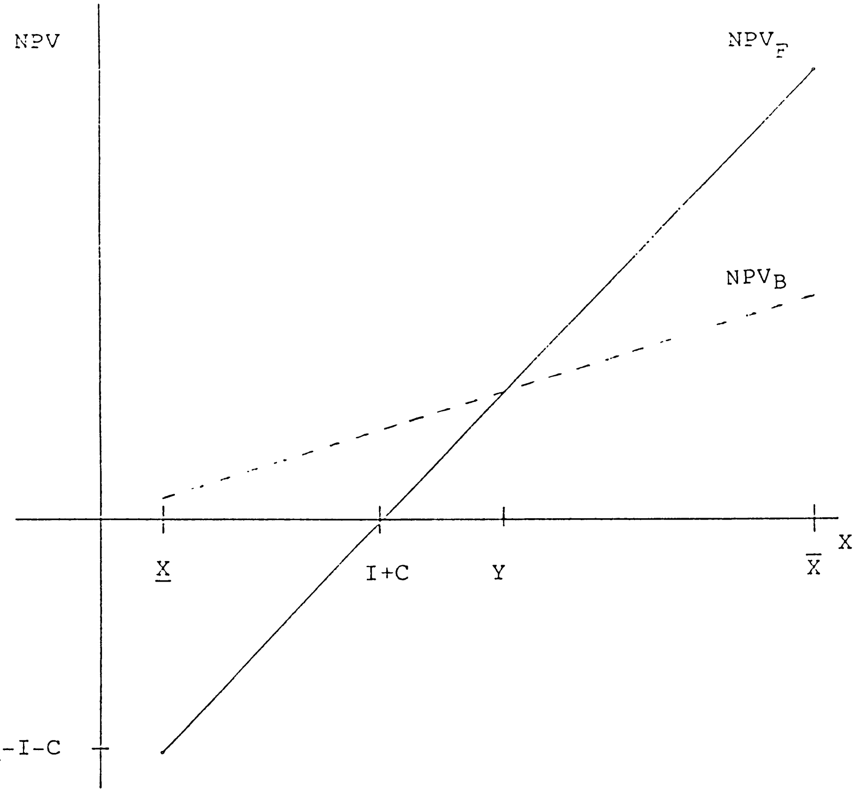

Figure 1. Net present value to a firm of using a best-efforts or a firm-commitment offering.

the net present value of the project less the investment cost and the underwriting cost:[9]

$$NPV_F = X - I - C. \tag{3}$$

Calculating the net present value to a firm of using a firm-commitment agreement, NPV_F, leads to a schedule of NPV_F's for all X, with negative NPV_F's for values of X less than $I + C$. (See the NPV_F line in Figure 1.) If the lowest valued firm has value $\underline{X}$ less than $I + C$, then the manager's share has a negative net present value if a firm-commitment offering is used. By using a best-efforts offering, the lowest valued firm can save the cost of the underwriter and has nothing to lose from an incorrect public valuation. The net present value from using a best-efforts offering would be $NPV_B = \underline{X} - I > 0$, if the lowest valued firm is the only type to use a best-efforts offering. In order to raise I, the lowest valued firm has to sell $\bar{p} \equiv I/\underline{X}$ of its shares.

Other firms with negative net present values from using a firm-commitment offering have an incentive to switch to a best-efforts offering. If investors value

[9] The firm could also pass the cost of underwriting on to the investors by raising $I + C$ in the offering, rather than I. The resulting net present value to the issuer is the same as in equation (3).

them as the lowest valued firm, they also have to sell $\bar{p}$ of their shares to raise I. This yields a net present value to the manager of $NPV_B = X(1\text{-}I/\underline{X}) > 0$. Any firm which nets a higher present value from a best-efforts offering than from a firm-commitment offering would be better off not using the investment banker as an underwriter. That is, any firm for which $X(1\text{-}I/\underline{X}) > X - I - C$, or $X < (I+C)\underline{X}/I$, should use a best-efforts offering to maximize profits.

As investors see a range of project values for firms using best-efforts offerings, they become willing to pay a higher price for shares, since the net present value of shares they receive will be greater than the price paid on most issues. Competition among investors drives the price up to that of the mean valued firm, since by investing in many firms making best-efforts offerings at this price their investment equals the present value of the shares they receive. The firms want to offer shares at the higher price in order to sell a smaller proportion of the firm and to maintain greater profits for themselves.

As the expected valuation of firms using best-efforts offerings increases, some additional firms have an incentive to switch to a best-efforts offering. Although they have to sell shares at a lower price than they would with a firm-commitment offering because they are perceived as being of lower value, they save the underwriting fee and thus are better off. Some firms, however, are still better off paying the underwriting fee and having their true values revealed.

There is a cutoff value of X, call it Y, where firms are indifferent between using a best-efforts and a firm-commitment agreement. That is, their retained net present value is the same using a firm-commitment offering as it is using a best-efforts offering, given that that is the highest quality firm using best efforts.

The retained net present value from a best-efforts offering, NPV_B, is the present value of the project less the share to investors, where the expected value of outside investors' shares equals the investment:

$$NPV_B = X[1 - p], \qquad \text{where} \quad p[E(X \mid X \leq Y)] = I. \tag{4}$$

Solving for p and substituting,

$$NPV_B = X\left[1 - \frac{I}{E(X \mid X \leq Y)}\right]. \tag{5}$$

Since Y is the point of indifference between using a best-efforts and a firm-commitment offering, Y solves $NPV_F(Y) = NPV_B(Y)$:

$$Y - I - C = Y[1 - I/E(X \mid X \leq Y)]$$

or

$$\frac{Y}{I + C} = \frac{E(X \mid X \leq Y)}{I}. \tag{6}$$

The solution, Y, equates the ratio of perceived value to the total cost of the issue and investment for firm-commitment and best-efforts offerings. Figure 1 illustrates the equilibrium. At the indifference point C is the value of information. Higher valued firms gain more than the cost, C, from having their values revealed. Firms with values below the indifference point may lose some from not having their values revealed, but the loss is less than the cost of using the underwriter.

The following propositions provide conditions for the existence and stability of the equilibrium.

PROPOSITION 1: *An equilibrium exists and is characterized by equation (6) if $F(X)$ is continuous, $Xf(X)$ is integrable, and $E(X)/I \leq \bar{X}/[I+C]$.*

Proof: See Appendix 1.

An equilibrium is a point $Y \in [\underline{X}, \bar{X}]$, such that all firms with project values greater than Y prefer to use a firm-commitment agreement while firms with project values less than Y prefer a best-efforts offering. The first two conditions of the equilibrium, continuity of $F(X)$ and integrability of $Xf(X)$, are sufficient for the continuity of the right-hand side of equation (6). The final condition, $E(X)/I < \bar{X}/[I+C]$, forces the range of the function in equation (6) to be within the domain; i.e., it makes the function map the domain, $[\underline{X}, \bar{X}]$, into itself. This third condition states that the expected return on the investment using a best-efforts offering is less than the expected return on the investment using a firm-commitment offering, given that the firm has the highest valued project. In other words, at least the highest valued firm will find it worthwhile to use a firm-commitment agreement, so some separation by issuing method occurs. If this condition does not hold, all firms attain higher net present values by using a best-efforts offering.

PROPOSITION 2: *The equilibrium will not unravel.*

Proof: See Appendix 1.

The equilibrium is said to unravel if all but the lowest valued firm or, in this case, all firms with negative net present values from using a firm-commitment agreement choose not to use an underwriter. This proposition asserts that unraveling will not occur; some firms that have positive net present values when using a firm-commitment offering will choose a best-efforts offering because they achieve higher net present values by using this method of offering.

PROPOSITION 3: *The equilibrium is stable when*

$$\frac{C}{I} < \frac{F(Y)/Y}{f(Y)}. \tag{7}$$

Proof: See Appendix 1.

Stability of the equilibrium implies that, for any arbitrary division point between a firm-commitment and a best-efforts offering, the division point will tend toward the equilibrium value, Y. Stability occurs when the ratio of average cumulative distribution to marginal cumulative distribution at the indifference point is greater than the ratio of cost of underwriting to investment cost.

III. Effects of Changes in Parameters

In this section I explore the effects of changes in each of the variables. This provides an indication of the effect of exogenous changes in the market on firms making initial public offerings. The marker variables of interest are the cost of underwriting, C, and the investment cost, I. I examine the effects changes in these variables have on the net present value to firms using firm-commitment offerings, NPV_F, net present value to firms using best-efforts offerings, NPV_B, and the point of indifference between using a firm-commitment or a best-efforts offering, Y. Proofs of these assertions are found in Appendix 2.

A. Changes in C, the Cost of Underwriting

As the cost of underwriting increases, the net present value to the firm using a firm-commitment offering makes a parallel shift downward equal to the increase in cost. An increase in the cost of underwriting causes the present value at which firms are indifferent between a firm-commitment and a best-efforts offering, Y, and the mean present value of firms using a best-efforts offering, $E(X/X \leq Y)$, both to increase. The net present value to the firm from a best-efforts offering, NPV_B, shifts upward accompanied by an increase in slope as the cost of underwriting increases. In summary, an increase in the cost of underwriting causes some additional firms to select best-efforts offerings over firm-commitment offerings. Figure 2 illustrates the effects of a change in C.

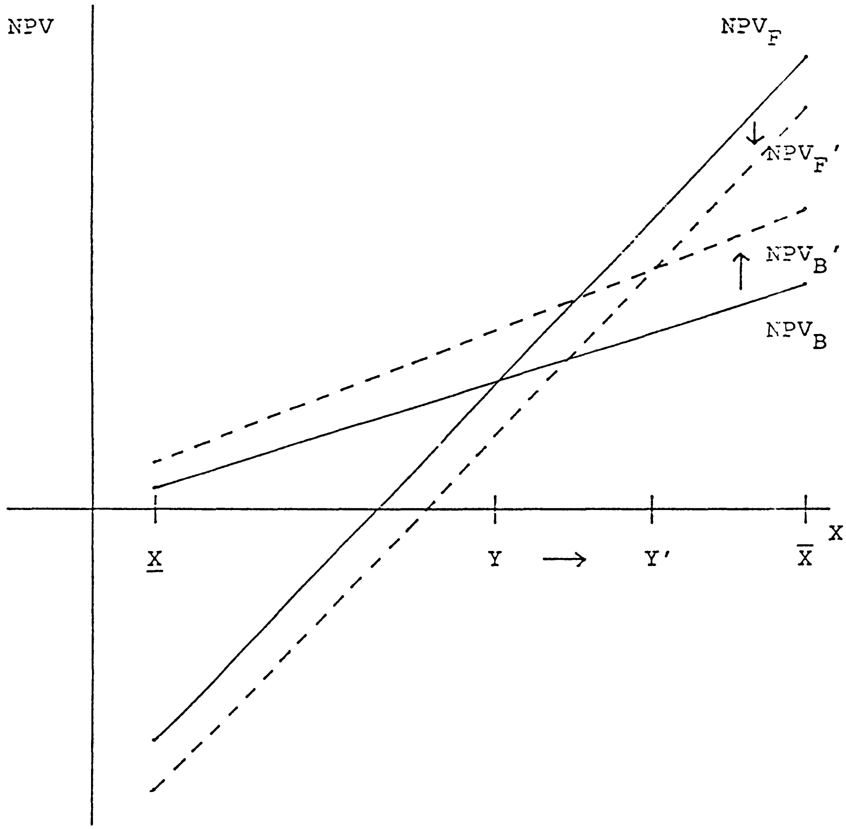

Figure 2. The effect on net present value to a firm of an increase in the cost of underwriting.

B. Changes in I, the Cost of Investment

An increase in the cost of investment shifts the net present value curves for both firm-commitment and best-efforts offerings, as well as changing the cutoff value between offering types. The net present value to the firm of using a firm-commitment offering decreases, causing a parallel downward shift in the NPV_F curve equal to the change in investment. The present value at which firms are indifferent between a firm-commitment and a best-efforts offering, Y, and the mean present value of firms using a best-efforts offering, $E(X/X \leq Y)$, both decrease. The net present value to the firm from a best-efforts offering, NPV_B, shifts downward. The shift is accompanied by a decrease in slope. For firms near the cutoff point, the loss in net present value from an increase in investment cost will be larger for firms using best-efforts offerings than for those using firm-commitment offerings, causing an increase in firms choosing firm-commitment over best-efforts offerings. Figure 3 summarizes these effects.

The effects of changes in underwriting and investment costs conform to expectations. With an increase in the cost of underwriting, we would expect to see fewer firms choosing to pay the cost in a firm-commitment offering. Ritter (1987) documents that, as gross proceeds from an issue increase, the proportion

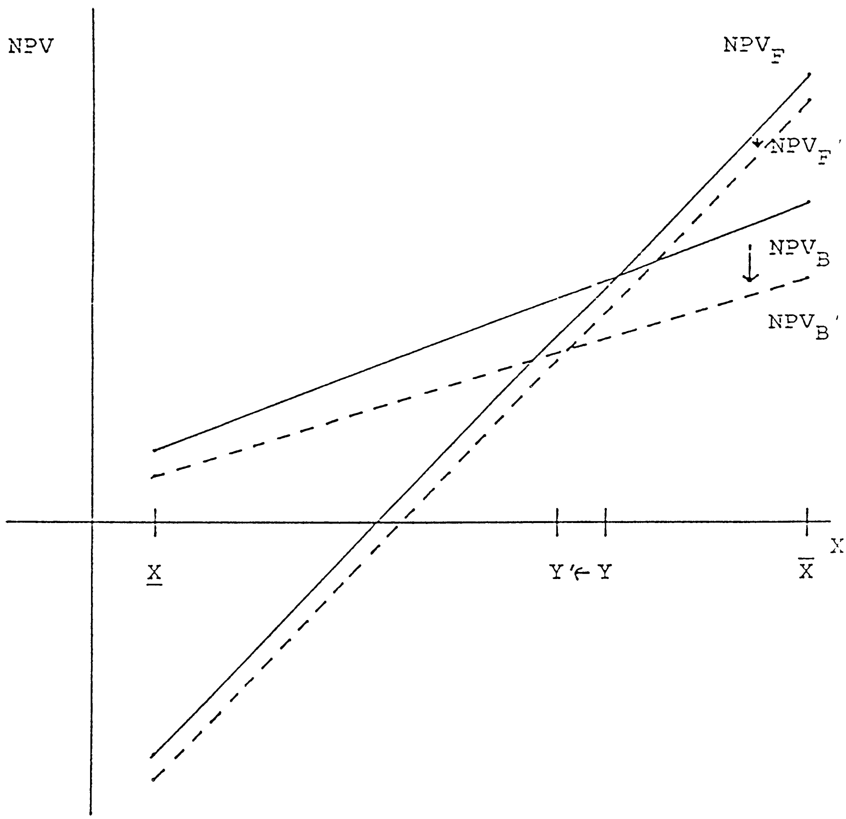

Figure 3. The effect on net present value to a firm of an increase in investment costs.

of firms using best-efforts offerings decreases. Since, in this model, investment costs are equivalent to the proceeds of the issue (less underwriting costs), these observations support the conclusions about changes in investment costs.

IV. Conclusions

In this study I examine a firm's choice of offering method in an initial public offering. I find that, as long as the highest valued firm benefits from using the investment banker as an underwriter, there exists a partially separating equilibrium. Under this equilibrium, firms with project values above a cutoff value find the bonding and investigation costs of employing an underwriter in a firm-commitment agreement and having their true value revealed worthwhile, while the remaining firms prefer a best-efforts offering where only the average value of such firms is discernible.

My model does not deal with initial underpricing, but rather is concerned with the change in the market price from the immediate aftermarket to the long term. This change represents the change in price from an initial state where the only information investors have about firm value is derived from management's choice of offering method to a later time period when more information about the firm has disseminated into the market. A more complete model would endogenize initial underpricing in addition to the long-term mispricing considered in this paper. Within the context of this model, however, we can treat the short-term underpricing as being an exogenously determined constant, which can differ across offering methods without affecting the conclusions.

The model has several empirical implications. Under a firm-commitment agreement the underwriter certifies the value of a firm to investors, allowing them to perceive the value of the firm more accurately than under a best-efforts agreement. With more accurate initial perceptions, the excess returns in the aftermarket should be close to zero for all firms, with a relatively small variance across firms. In a best-efforts offering investors know only the average value of all best-efforts offerings, so they will perceive each firm as being of average value. On average, their perceptions will be correct, but some firms' shares should experience non-zero excess returns in the aftermarket.

Existing work on the underpricing of initial public offerings shows that the price adjustment to underpricing occurs very quickly; most of the adjustment occurs in the first week after the offering. For this reason, any empirical work on my model should examine changes occurring in the aftermarket.

Firm-commitment offerings, in general, are more correctly valued by investors, and so one would expect to see a low variance of returns across companies. The value of a best-efforts offering, on the other hand, is, in general, incorrectly perceived by investors. During the period following the offering, investors would be expected to learn more information about the firm and revise their price perceptions toward the actual value. The initial inaccurate pricing and revisions during the year will lead to a greater variance in post-offering returns for best-efforts offerings than for firm-commitment offerings.

Additional differences between firm-commitment and best-efforts offerings can be found by looking at the proportion of shares that are retained by insiders in each type of offering. Referring to the model, the proportion of shares that would be sold to outside investors in a firm-commitment offering is equal to the amount of money required for investment divided by the project value less the issue cost of a firm-commitment offering. This proportion, $I/(X - C)$, depends on the value of the project; the higher the firm's project value, the smaller the proportion of the firm that must be sold to achieve the amount required for investment. In other words, insider retention is larger for higher valued projects.

In a best-efforts offering the proportion of shares sold to outsiders equals the amount required for investment divided by the expected value of the project given that a best-efforts offering is being used. Thus, the proportion of shares sold equals $I/E(X/X \leq Y)$. Neither of these quantities depends on the actual value of the project. Thus, for best-efforts offerings, retention levels by insiders should not depend on project value but should be the same for all firms.

Appendix 1: Proofs of Propositions

PROPOSITION 1: *An equilibrium exists and is characterized by equation (6) if $F(X)$ is continuous, $Xf(X)$ is integrable, and $E(X)/I \leq \bar{X}/[I+C]$.*

Proof: An equilibrium is characterized by

$$Y = \frac{I + C}{I} E(X \mid X \leq Y), \qquad Y \in [\underline{X}, \bar{X}].$$

This is a fixed point and so will exist when the conditions of Brouwer's fixed-point theorem hold.

The mapping $\frac{I + C}{I} E(X \mid X \leq Y)$

$$= \begin{cases} \dfrac{I + C}{I} \cdot \dfrac{1}{F(Y)} \displaystyle\int_{\underline{X}}^{Y} Xf(X)\, dX & Y \in (\underline{X}, \bar{X}], \\ \dfrac{I + C}{I} \underline{X} & Y = \underline{X}, \end{cases}$$

is continuous in Y for $X > \underline{X}$, as long as $F(X)$ is continuous and $Xf(X)$ is integrable.

Continuity at $\underline{X}$:

$$\lim_{Y \downarrow \underline{X}} \frac{I + C}{I} E(X \mid X \leq Y)$$
$$= \frac{I + C}{I} E(X \mid X \leq \underline{X})$$
$$= \frac{I + C}{I} \underline{X}.$$

The set $[\underline{X}, \bar{X}]$ is closed, bounded, and convex.
$[(I + C)/I]E(X \mid X \leq Y)$ maps $[\underline{X}, \bar{X}]$ into $[\underline{X}, \bar{X}]$ as long as $[(I + C)/I]E(X) \leq \bar{X}$ (since $[(I + C)/I]E(X \mid X \leq Y)$ is nondecreasing, and $[(I + C)/I]\underline{X} > \underline{X}$. If

$f(X)$ is continuous and $[(I + C)/I]E(X) \le \bar{X}$, then, by Brouwer's fixed-point theorem, there exists $Y \in [\underline{X}, \bar{X}]$ such that

$$Y = \frac{I + C}{I} E(X \mid X \le Y)$$

or

$$\frac{Y}{E(X \mid X \le Y)} = \frac{I + C}{I}.$$

Q.E.D.

Proposition 2: *The equilibrium will not unravel.*

Proof: $X \in [\underline{X}, \bar{X}]$, where $I \le \underline{X} \le I + C$.
Suppose $I < \underline{X} \le Y \le I + C$;

$$NPV_F(Y) = Y - I - C \le [I + C] - I - C = 0,$$

$$NPV_B(Y) = Y\left[1 - \frac{I}{E(X \mid X \le Y)}\right] > 0,$$

since $E(X \mid X \le Y) > I$. This is a contradiction since Y equates $NPV_F(Y)$ and $NPV_B(Y)$.
Suppose $I = Y = \underline{X}$;

$$NPV_F(Y) = Y - I - C = -C,$$

$$NPV_B(Y) = Y\left[1 - \frac{I}{E(X \mid X \le Y)}\right] = 0.$$

This contradicts $NPV_F(Y) = NPV_B(Y)$. Therefore, $Y > I + C$. Q.E.D.

Proposition 3: *The equilibrium is stable when*

$$\frac{C}{I} < \frac{F(Y)/Y}{f(Y)}.$$

Proof: The equilibrium is defined by a project value, Y, such that firms with project values less than Y prefer a best-efforts offering, firms with project values greater than Y prefer a firm-commitment offering, and firms with project value equal to Y are indifferent between the two methods.

The equilibrium is characterized by equal costs:

$$I + C = \frac{I}{E(X \mid X \le Y)} Y.$$

The equilibrium is stable if, for $Z < Y$, $I + C > \dfrac{I}{E(X \mid X \le Z)} Z$ and a best-efforts offering is preferred and if, for $Z > Y$, $I + C < \dfrac{I}{E(X \mid X \le Z)} Z$ and a firm-commitment offering is preferred.

Rearranging terms, stability occurs when, for $Z < Y$, $\frac{I + C}{I} E(X \mid X \leq Z) > Z$ and, for $Z > Y$, $\frac{I + C}{I} E(X \mid X \leq Z) < Z$.

Equivalently, because of the linearity of Z and monotonicity in Z of $\frac{I + C}{I} E(X \mid X \leq Z)$, at $Z = Y$,

$$\frac{\partial}{\partial Z} \frac{I+C}{I} E(X \mid X \leq Z) < \frac{\partial}{\partial Z} Z,$$

$$\frac{I + C}{I} \frac{\partial}{\partial Z} \frac{1}{F(Z)} \int_{\underline{X}}^{Z} Xf(X)\, dX < 1,$$

$$\frac{I + C}{I} \left[\frac{1}{F(Z)} Zf(Z) - \frac{f(Z)}{F(Z)^2} \int_{\underline{X}}^{Z} Xf(X)\, dX \right] < 1 \text{ at } Z = Y,$$

$$\frac{I + C}{I} \cdot \frac{f(Y)}{F(Y)} [Y - E(X \mid X \leq Y) < 1 \text{ at } Y, E(X \mid X \leq Y) = \frac{IY}{I + C},$$

$$\frac{I + C}{I} \cdot \frac{f(Y)}{F(Y)} \left[\frac{CY}{I + C} \right] < 1,$$

$$\frac{C}{I} \cdot \frac{f(Y)}{F(Y)} Y < 1,$$

$$\frac{C}{I} < \frac{F(Y)/Y}{f(Y)}.$$

Therefore, the equilibrium is stable when $\frac{C}{I} < \frac{F(Y)/Y}{f(Y)}$. Q.E.D.

Appendix 2: Comparative Statics

Changes in C, the Cost of Underwriting

Effect on NPV_F:

$$\frac{\partial NPV_F}{\partial C} = -1 < 0; \qquad NPV_F \text{ shifts downward;}$$

$$\frac{\partial}{\partial C} \frac{\partial NPV_F}{\partial X} = \frac{\partial}{\partial C} (1) = 0; \qquad NPV_F\text{'s slope constant.}$$

Effect on Y:

$$\frac{\partial E(X \mid X \leq Y)}{\partial C} = \frac{f(Y)}{F(Y)} [Y - E(X \mid X \leq Y)] \frac{\partial Y}{\partial C}$$

$$= \frac{f(Y)}{F(Y)}\left[\frac{CY}{I + C}\right]\frac{\partial Y}{\partial C};$$

$$\frac{\partial Y}{\partial C} = \frac{1}{I} E(X \mid X \leq Y) + \frac{I + C}{I}\frac{\partial E(X \mid X \leq Y)}{\partial C}$$

$$= \frac{Y}{I + C} + \frac{I + C}{I} \cdot \frac{f(Y)}{F(Y)}\left[\frac{CY}{I + C}\right]\frac{\partial Y}{\partial C};$$

$$\frac{\partial Y}{\partial C} = \frac{F(Y)/[I + C]}{[F(Y)/Y]I - [\partial F(Y)/\partial X]C} \gtreqless 0, \text{ where } \frac{\partial F(Y)}{\partial X} = f(Y);$$

$\frac{\partial Y}{\partial C}$ will take the same sign as the denominator. Stability requires $\frac{F(Y)/Y}{\partial F(Y)/\partial X} > \frac{C}{I}$, implying that the denominator is positive, $\frac{\partial Y}{\partial C} > 0$, and $\frac{\partial E(X \mid X \leq Y)}{\partial C} > 0$.

Effect on NPV_B:

$$\frac{\partial NPV_B}{\partial C} = \frac{IX}{E(X \mid X \leq Y)^2}\frac{\partial E(X \mid X \leq Y)}{\partial C}$$

$$= \frac{XCf(Y)}{YI[I[F(Y)/Y] - [\partial F(Y)/\partial X]C]}; \quad NPV_B \text{ shifts upward;}$$

$$\frac{\partial}{\partial C}\frac{\partial NPV_B}{\partial X} = \frac{\partial}{\partial C}\left[1 - \frac{I}{E(X \mid X \leq Y)}\right] = \frac{I}{E(X \mid X \leq Y)^2}\frac{\partial E(X \mid X \leq Y)}{\partial C}$$

$$= \frac{Cf(Y)}{YI[I[F(Y)/Y] - [\partial F(Y)/\partial X]C]}; \quad NPV_B\text{'s slope increases.}$$

Changes in I, the Cost of Investment

Effect on NPV_F:

$$\frac{\partial NPV_F}{\partial I} = -1 < 0; \qquad NPV_F \text{ shifts downward;}$$

$$\frac{\partial}{\partial I}\frac{\partial NPV_F}{\partial X} = \frac{\partial}{\partial I}(1) = 0; \qquad NPV_F\text{'s slope constant.}$$

Effect on Y:

$$\frac{\partial E(X \mid X \leq Y)}{\partial I} = \frac{f(Y)}{F(Y)}[Y - E(X \mid X \leq Y)]\frac{\partial Y}{\partial I}$$

$$= \frac{f(Y)}{F(Y)}\left[\frac{CY}{I + C}\right]\frac{\partial Y}{\partial I};$$

$$\frac{\partial Y}{\partial I} = -\frac{C}{I^2} E(X \mid X \leq Y) + \frac{C + I}{I}\frac{\partial E(X \mid X \leq Y)}{\partial I}$$

$$= -\frac{CY}{I[I+C]} + \frac{C+I}{I} \cdot \frac{f(Y)}{F(Y)} \left[\frac{CY}{I+C}\right] \frac{\partial Y}{\partial I};$$

$$\frac{\partial Y}{\partial I} = \frac{-CF(Y)/[I+C]}{I[F(Y)/Y] - C[\partial F(Y)/\partial X]} \gtreqless 0.$$

The sign of $\partial Y/\partial I$ will be the opposite of the sign of the denominator. Given stability conditions, $\dfrac{F(Y)/Y}{\partial F(Y)/\partial X} > \dfrac{C}{I}$, $\dfrac{\partial Y}{\partial I} < 0$.

Effect on NPV_B:

$$\frac{\partial NPV_B}{\partial I} = \frac{-X}{E(X \mid X \leq Y)} + \frac{IX}{E(X \mid X \leq Y)^2} \frac{\partial E(X \mid X \leq Y)}{\partial I}$$

$$= \frac{X[I+C]}{IY} \left[\frac{I+C}{Y} \frac{\partial E(X \mid X \leq Y)}{\partial I} - 1\right]$$

$$= \frac{X}{Y} \left[\frac{[\partial F(Y)/\partial X]C - [F(Y)/Y][I+C]}{[F(Y)/Y]I - [\partial F(Y)/\partial X]C}\right];$$

$$\frac{\partial}{\partial I} \frac{\partial NPV_B}{\partial X} = \frac{\partial}{\partial I} \left[1 - \frac{I}{E(X \mid X \leq Y)}\right]$$

$$= \frac{-1}{E(X \mid X \leq Y)} + \frac{I}{E(X \mid X \leq Y)^2} \frac{\partial E(X \mid X \leq Y)}{\partial I}$$

$$= \frac{1}{Y} \left[\frac{[\partial F(Y)/\partial X]C - [F(Y)/Y][I+C]}{[F(Y)/Y]I - [\partial F(Y)/\partial X]C}\right].$$

These derivatives will each take on the sign of the term in brackets. If $\partial Y/\partial I < 0$, then the denominator is positive and the derivatives will take on the same sign as the numerator. Given the stability conditions, $\dfrac{F(Y)/Y}{\partial F(Y)/\partial X} > \dfrac{C}{I}$, the denominator is positive and the numerator is negative, implying $\dfrac{\partial NPV_B}{\partial I} < 0$ and $\dfrac{\partial}{\partial I} \dfrac{\partial NPV_B}{\partial X} < 0$.

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