Underpricing of Venture and Non Venture Capital IPOs: An Empirical Investigation

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Abstract

In this paper we examine the premarket underpricing phenomenon within a group of venture-backed and a group of non venture-backed initial public offerings (IPOs) using a stochastic frontier approach. Consistent with previous research, we find that venture-backed IPOs are managed by more reputable underwriters and are generally associated with less underwriter compensation. However, unlike other papers in the literature, we find that the initial day returns of venture-backed IPOs are, on average, higher than the non venture-backed group. We also observe a significantly higher degree of pre-market pricing inefficiency in the initial offer price of venture-backed IPOs. Further, our results show that a significant portion of the initial day returns is due to deliberate underpricing in the premarket. We also observe that for both venture and non-venture issuers, there is a positive relationship between deliberate underpricing and the probability that underwriters provide support for the issue. This evidence is consistent with the notion that underwriters deliberately underprice the offering to reduce costs of price stabilization in the after-market.

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1. Introduction

One of the most widely investigated phenomena in the finance literature is the price performance of initial public offerings (IPOs) of common stock. [See, e.g., Ibbotson (1975), Ibbotson, Sindelar and Ritter (1988), Ritter (1991) and Brav and Gompers (1997), among others]. These studies document the presence of significant average underpricing defined as the percent difference between the closing day bid price and the initial offer price over the first day of trading. Work by Barry et al. (1990), Meggison and Weiss (1991) and Brav and Gompers (1997), to name a few, indicates that the degree of underpricing depends on whether or not an IPO is backed by venture capitalists (VC). Specifically, they show that non VC-backed IPOs are more severely underpriced than VC-backed IPOs. The authors contend that this difference in the degree of underpricing is primarily due to the certification role of venture capitalists. An important implication of this is that VC-backed IPOs are characterized by less deliberate underpricing in the pre-market in comparison to non VC-backed IPOs, rather than other factors in the after-market which may contribute to underpricing such as underwriter price support [see, e.g. Rudd (1993) and Hanley, Kumar and Seguin (1993)].[1]

Our purpose here is twofold. First, we investigate whether the difference in underpricing between VC-backed IPOs and non VC-backed IPOs is due to deliberate underpricing in the pre-market or to other factors such as underwriter price support in the after market.[2] Second, we examine the role deliberate underpricing plays in the IPO process as it relates to initial day returns and price stabilization.

Following Hunt-McCool, Koh and Francis (1996), we measure underpricing using information available only in the pre-market period. The stochastic frontier estimator [Aigner, Lovell, Schmidt 1977 (ALS)] is the method used to ascertain whether the difference in underpricing between VC- and non VC-backed issuers is due to the difference in pre market underpricing. In effect, the stochastic frontier assumes that a maximum price exists, and that actual prices fall below the maximum for some systematic reason such as "economic inefficiency." This deviation from the maximum price can be measured by a one-sided error term. The degree of underpricing can be

computed for each stock in question or for groups of stocks. Effectively, the "efficient" frontier is the equivalent of the full information price frontier whose unbiased expectation is the efficient frontier, the maximum price that would prevail if all trading parties had complete information about the underlying value of the firm going public. The expectation is made explicit through a random two-sided disturbance term that completes the error structure. If no systematic underpricing exists, the one-sided error will not appear, and the frontier will be equivalent to the ordinary least square (OLS) estimation of prices [see e.g., Jondrow, Lovell, Materov, and Schmidt (1982)].

As shown by Hunt-McCool et al. (1996), the stochastic frontier estimator is well suited for the IPO underpricing problem. In contrast to traditional approaches, the stochastic frontier estimation allows investors, investment bankers, and financial officers of firms going public to estimate a maximum offer price prior to price setting by investment bankers and prior to the first day of trading. Financial officers can therefore evaluate the expected discount associated with an offer price proposed by underwriters. In turn, underwriters have an upper bound that can be incorporated in their decision-making.

In this application, the frontier estimator is used to compare the estimated price discount of both VC-backed and non VC-backed IPOs in the pre market with the initial after market return. In doing so, evidence can be obtained as to whether the source(s) of the difference in underpricing is due to deliberate under-pricing in the pre-market or to forces in the after-market. For example, suppose the two sets of hypotheses are mutually exclusive, competing explanations of an observed pricing anomaly. Once an adjustment is made for deliberate underpricing, measured differences in under-pricing between VC-backed and non VC-backed IPOs should largely disappear. On the other hand, if both phenomena exist independently, the correlation between the discount and after-market return may be close to zero. The IPOs that are discounted need not be the IPOs that are then supported in the after market.

The evidence we present indicates the existence of both phenomena. Underpricing, at least as we measure it, explains a portion of the after-market returns for both VC-backed and non VC-backed IPOs. However, in contrast to prior studies, we find that VC-backed IPOs are more severely underpriced than non VC-backed IPOs. Further, Our results indicate that the degree of pre-market underpricing is significantly higher for VC-backed IPOs

than non VC-backed IPOs. Thus, our results suggest that the documented difference in underpricing between VC-backed and non VC-backed IPOs cannot be fully attributed to post-market phenomena. Rather, a significant portion may be due to deliberate underpricing as a means of compensating investors. In addition, our results indicate that for both VC- and non VC-backed IPOs deliberate underpricing in the pre-market leads to a higher probability of price stabilization in the after-market. However, there is a higher likelihood of price support for non VC-backed IPOs.

The paper is organized as follows. In Section 2 we briefly review the existing research on the phenomenon of IPO pricing. Section 3 explains the concept of a full-information IPO price frontier and the associated estimator capturing systematic departures from the pricing frontier (deliberate underpricing). Section 4 contains a description of the data and model specifications and univariate analyses. Section 5 reports the relationship between deliberate underpricing and price support. Section 6 provides empirical results of the stochastic frontier estimation and the initial returns regressions. Additional evidence on the robustness of our results is provided in Section 7. Our conclusions are presented in Section 8.

1. Related Literature

2.1. Underpricing of IPOs

The IPO literature generally ascribes the underpricing of IPOs to the existence of pre-market information asymmetry and views the abnormal initial return as an effort to compensate investors. Baron (1982) explains IPO underpricing as an effort by the issuing firm to compensate underwriters for their holding of superior security-related information. Rock (1986) derived a model in which IPO offering prices are reduced so that investors earn a positive return even if they are less informed about the issue. Grinblatt and Hwang (1989) view the underpricing phenomenon as a signal by the issuing firm to the market concerning the quality of their securities. Welch (1989) and Allen and Faulhaber (1989) claim that IPO underpricing is intended for high proceeds in future sales of seasoned equity issues for high-quality firms. Booth and Chua (1996) claim that issuer's preference for a broad ownership base and liquidity entice them to reduce the offering price as compensation for investors to find new information about the firm. Hunt-McCool et al. (1996) examine pre-market underpricing using a sample of 1,035

firm commitment IPOs of common stock during 1975 and 1984 and find evidence consistent with deliberate underpricing of IPOs in the pre-market.

In general, the underpricing of IPOs is regarded as deliberate underpricing in the pre-market by the issuing firms. However, Ritter (1991) evaluated a sample of 1,526 IPOs that went public in the U.S. market during the 1975-84 period and, found that IPOs are overpriced in the after market. In a three-year period subsequent to going public, IPOs are outperformed by a set of comparable firms. In replicating Ritter's (1991) work within a venture versus non-venture issuer framework, Brav and Gompers (1997) find that the observed after-market under performance is fully attributed to non-venture backed IPOs. That is, venture-backed IPOs do not under perform a portfolio of comparable sized firms.

The unique characteristics of venture funds give us the opportunity to study the role deliberate underpricing plays in the going public process. Venture capitalists represent a group of investors with significant experience in organizing funds, evaluating the prospect of new projects and monitoring future developments of venture projects. They also possess strong ties to top-tier underwriters and commercial banks. These characteristics enable venture capitalists to provide pre-market certification to firms being taken public, thus presumably leading to a lower level of underpricing. Megginson and Weiss (1991) present evidence indicating that VC-backed IPOs are associated with higher underwriter prestige, higher institutional holdings, and lower level of underpricing than non VC-backed IPOs. Lerner (1994) examine the timing of initial public offerings and find that venture capitalists take firms public at market peaks and rely on private financing when the market valuation of equity is low. Further, the more experienced the venture capitalists, the more proficient they are in the timing of taking firms public, thus reducing the level of underpricing.

However, venture funds are generally associated with higher levels of risk. Carleton (1986) shows that capital projects of venture capitalists are investments in new, small, and risky companies especially those based on commercial application of technological innovations. The level of riskiness associated with venture investment is reflected in the relatively long period of time between initial investment and final repayment (usually 10 or more years), and in the 20-30% return to venture capitalists. According to Meggison and Weiss (1991), VC-backed

IPOs go public at a significantly earlier stage than non VC-backed IPOs, with little information disclosure before the going public date.

The foregoing suggests that there is less public information available concerning venture investments. Thus pre-market information asymmetry, if any, may be more severe for VC-backed offers compared to non VC-backed IPOs. Therefore, it is an empirical issue as to whether the certification role of venture capitalists dominates the effect of the fact that VC- backed IPOs tend to be younger and riskier than non VC-backed IPOs. If the latter effect dominates, then VC-backed IPOs should be characterized by more deliberate underpricing (i.e., larger systematic deviations from the efficient frontier) than non VC-backed IPOs.

2.1 Price Stabilization

Recently, the issue of price stabilization of IPOs in the after market has received much attention [see, e.g., Rudd (1993); Hanley et al. (1993); Prabhala and Puri (1998); and Aggarwal (1999)]. Although stabilization of IPOs is a form of price manipulation, it is exempted from the provisions of the 1934 Securities Act, if it is carried out within certain guidelines. Price stabilization has existed since the 1930s, nevertheless not much is understood about its impact on the going public process and the factors that determine whether a particular issue is stabilized in the after market.

Prabhala and Puri (1998) argue that price stabilization has an effect on the IPO process by changing the ex-ante uncertainty of the offering. Specifically, they contend that underwriters in offering price support in the after-market, are, in effect, providing investors with a put option on the IPO being supported. Thus, it is within an underwriter's best interest to reduce the ex-ante price uncertainty and thereby the value of the put-option to investors.[3]

To reduce the ex-ante price uncertainty, and thus the cost of the put option, underwriters can deliberately under-price the IPO. If underwriters use this method, then we would expect a positive relationship between deliberate underpricing in the pre-market and the

likelihood of price support. It should be noted that if the conjecture of Prabhala and Puri (1998) were supported, we would expect a negative relationship between deliberate underpricing and ex-ante risk.

3. Methodology

3.1. The Stochastic Frontier

A point on the stochastic frontier represents the maximum price that would prevail for a given IPO if all parties in the trade had full information. The difference between any given offer price and the maximum price under full information would be the result of random error alone. There would be no systematic underpricing, and the frontier price could be computed by using ordinary least squares to estimate the expected price given the observable variables.

If, however, there is deliberate underpricing (a systematic negative bias) the offer price will fall below the maximum potential by an amount or fraction represented by the one-sided error. In this case, there is both a stochastic error and a systematic, one-sided error. Under the stochastic frontier maximum likelihood estimation, any systematic error, if it exists, will appear in the form of skewness in the residuals and can be separately computed for each IPO. The average deviation from the full information price can also be computed for each type of IPO.

By contrast, under OLS, the systematic error component is incorporated into the intercept and is unidentifiable. The OLS intercept will lie below the frontier, and OLS would not predict the full information price, but the average of the actual set of initial offer

prices.

This methodology provides a direct test of the existence of deliberate underpricing, thus enabling us to determine whether VC-backed IPOs are characterized by less deliberate underpricing than non VC-backed IPOs. If OLS estimation is equivalent to the maximum likelihood (ML) estimation, no systematic underpricing exists in the pre-market, and the difference in underpricing would be due to forces in the after-market such as price stabilization [see, e.g. Rudd (1993); Hanley et al. (1993)]. It should be noted that if deliberate underpricing in the pre-market is not found, then it would support the notion that non VC-backed IPOs are provided more after-market price support than VC-backed IPOs.

3.2. The Maximum Likelihood Estimator

The stochastic frontier model of ALS is estimated via maximum likelihood (ML) methods. The frontier and distributional assumptions can be expressed as: $P_i = f(\mathbf{C}_i; \mathbf{b}) + e_i, \quad i = 1,2,...,n, \quad (1)$

$$e_i = v_i + u_i,$$

$$v_i \sim N(O , \mathbf{s}_v^2),$$

$$`u_i \sim N[(\ddot{O}2/\ddot{O}\mathbf{p}\ \mathbf{s}_u), \mathbf{s}_u^2],$$

$$u_i = min (`u_i , 0),$$

where, P_i is the observed initial offer price at the time of offering; $\mathbf{C}$ is a vector of firm and offering method characteristics; $\mathbf{b}$ is a vector of coefficients of the IPO pricing frontier; v denotes the symmetric error component; and u is the asymmetric component and is truncated at zero since discounting takes the maximum value of 0 and, by assumption, is independent of v. The composite error term is e. The non-positive error term u_i is interpreted to mean that the actual price must lie on or below the true but unknown frontier, while the two-sided error v_i suggests that observed prices may lie above or below the estimated frontier due to statistical noise.

ALS (1977) estimated the stochastic frontier model by using the distribution function of the sum of a symmetric normal random variable and a truncated random variable, which was derived by Weinstein (1964). The density function is:

$$f(e_i) = (2/\mathbf{s}) f(e_i/\mathbf{s}) [1 - F(e_i \mathbf{l} \mathbf{s}^{-1})], \quad (2)$$

where, $\mathbf{s}^2 = \mathbf{s}_u^2 + \mathbf{s}_v^2$; $\mathbf{l} = \mathbf{s}_u/\mathbf{s}_v$; $-\mathbf{¥} < e_i < +\mathbf{¥}$; and $f(e_i / \mathbf{s})\ a\ F(e_i \mathbf{l} \mathbf{s}^{-1})$ are the standard normal density and distribution functions respectively.

If the P_i's are independently distributed, and the non-stochastic part of P_i is explained by a set of exogenous variables $\mathbf{X}$, the log-likelihood function becomes:

$$\ln L(P,\beta,\lambda,\sigma^2) = N \ln(\sqrt{2/\pi}) + N \ln\sigma^{-1} + \Sigma_i \ln[1-F(e_i\lambda\sigma^{-1})] - (1/2\sigma^2)\Sigma_i e_i^2, \quad (3)$$

where, $e_i = P_i - \beta' C_i$, $\quad i = 1, \ldots, N$.

ALS (1997) provide a means for obtaining the optimal values of σ^2, β, and λ. This approach, in contrast to the conventional OLS approach, enables one to identify the placement of the efficient IPO price frontier. In principle, OLS will provide a best linear unbiased and consistent estimate of the vector of slope coefficients, so conventional hypothesis testing can be carried out. However, the OLS estimator of the intercept is biased and inconsistent, since the mean of the composite error is nonzero. The OLS estimator of slope coefficients in general will also be less statistically efficient than an alternative estimator that incorporates the a-priori information that the composite error is asymmetric.

In this context, the estimate of λ is of particular interest as it allows a comparison of ML to OLS estimates of the frontier. Specifically, λ, the skewness in the error component (u_i) relative to the symmetric random disturbance (v_i), measures gains in statistical efficiency of the frontier estimator over OLS. The estimate of λ has a straight-forward interpretation for inferring deliberate IPO underpricing. If λ goes to zero, deviations in actual prices from the frontier are simply due to statistical noise. This means that the symmetric error, σ_v, dominates the asymmetric error, σ_u, and maximum likelihood estimates are not significantly different from OLS estimates. On the other hand, if λ is greater than zero, deviations from the frontier are characterized by some form of deliberate discounting in the pre-market pricing of IPOs. In this case the half-normal error dominates the symmetric error term and ML estimates of the frontier will be quite different from OLS estimates. Thus, as λ becomes large, deliberate discounting in the pricing of IPOs is indicated.

3.3. Specification of Initial Returns Regression

As in Rudd (1993), we interpret the existence of skewness in the measured returns to suggest excess returns. If after-market returns are randomly distributed around the full information offer price, the mean excess

return will be zero, and the distribution will be symmetric around this mean. In our sample, 593 of the 843 IPOs have a positive return measured by comparing the first day closing price with the pre-market offer price. Of course, the measurement of excess returns remains dependent upon the pre market offer price. If excess returns are an artifact of measurement (resulting from failure of the offer price to correctly indicate the economic value of the firm due to deliberate underpricing), they should disappear once adjustments are made for pre-market underpricing. However, if they exist independent of underpricing, the correlation between the measured returns and measured underpricing may be close to zero. To test for a relationship between after-market returns and pre market underpricing for both VC-backed and non VC-backed IPOs, we first estimate the P_i^*s, the predicted maximum prices for each IPO. Using the modal formula proposed by Jondrow *et al.*, (1982), the level of systematic underpricing for each IPO is computed. The formula is:

$$u_i^* = M(u_i \_ e_i) = -e_i (\sigma_u^2/\sigma^2) \quad if\ e_i \leq 0, \qquad (4)$$

$$= 0 \qquad \text{if } e_i > 0 .$$

The second stage involves a variant of the methodology proposed by Hunt and Warren (1987), where the percentage by which an issue is underpriced u_i^*/P_i^*,[4] is used as an independent variable in a regression in which the dependent variable is the initial day return:

$$RET_i = \alpha + \beta(u_i^*/P_i^*) + \varepsilon_i, \qquad (5)$$

where, RET_i is measured from the offer price to the close (or bid) price at the end of first trading day; α and β are parameters to be estimated; and ε_i is the random error term. Separate OLS regressions are estimated for both VC-backed and non VC-backed IPOs.

4. Data Selection

4.1. Description of Variables

Our sample consists of firm commitment IPOs that went public during the 1990-93 period. IPO prospectuses (where available), Investment Dealers Digest (IDD), various issues of Venture Capital Journal were the key data-sources. Additionally, underwriter rankings were obtained from Carter, Dark, and Singh (1998). Most of the companies in the sample went public in the NYSE or over-the-counter. We kept the penny stock offerings out of our sample by taking a minimum of $5. First day stock prices of all companies were obtained from the CRSP tapes and the Standard & Poor's daily stock price record. . We dropped companies that had missing values for stock prices or other variables that are used in our estimations. The final sample contains 843 IPOs of which 415 are VC-backed.

To examine the degree of pre-market pricing inefficiency associated with VC - and non-VC-backed IPOs, we use information available prior to the commencement of trading. Following Hunt-McCool et al. (1996), the dependent variable we use is the natural log of the initial offer price. The choice of independent variables is motivated by the underlying theory and by the existing literature.

According to the signaling model [Grinblatt and Hwang (1989)], insider fraction of ownership (INSFR) signals to the market the amount of private information possessed by insiders. The better information insiders have the larger the fraction of shares they will retain. Thus a positive relation between insider fraction and offer price is expected. Further, because of the direct participation of venture capitalists in monitoring and managing these firms, the relation should be stronger for VC-backed firms.

Underwriters convey firm-related information to the public during a firm going-public process. In fact, underwriters are compensated for reducing the information asymmetry between the issuing firm and the market. The larger the information asymmetry, the more important the underwriter's role, and the greater the level of compensation. Thus we should observe a negative relation between the IPO's offer price and the underwriter compensation (COM). The natural log of the total proceeds from the issue (LPROC) (measured in millions of

dollars) is included to control for the level of asymmetry. Tinic (1988) points out that smaller, riskier firms often make small offerings. And according to Barry and Brown (1984), firm size conveys additional information to outsiders. Thus we expect a positive relation between the IPO offer price and issue size.

Underwriter ranking (UWRANK) has long being recognized as an important factor in determining the degree of underpricing and therefore the offer price. Megginson and Weiss (1991), Booth and Chua (1996), and Carter et al. (1998), among others, document a negative relation between underwriter ranking and IPO underpricing. These authors also show that the more reputable the underwriter, the lower the degree of underpricing and thus the higher the offer price relative to the full information offer price.

Following Beatty and Ritter (1986) and Tinic (1998), we utilize the reciprocal of the initial offer price (INVP0) as a proxy for the riskiness of the offerings. We expect that securities that are riskier, with a higher degree of information asymmetry, to be priced below the frontier.

Table I lists the distribution of IPOs for each year. VC-backed IPOs account for approximately half of the IPOs in each year, with the number of IPOs generally increasing over the four-year sample period.

Table II provides summary statistics for the IPOs contained in the sample. The average initial offer price for VC-backed issues is $11.70, whereas for non VC-backed IPOs it is $13.18. The difference is significant at the 0.01 level. The average initial return for the full sample is 11.38%. For VC-backed IPOs the average initial day return is 13.26%, while for non VC-backed IPOs the average initial day return is 9.60%. The difference is significant at the 0.01 level. This finding is significantly different from those reported by Meggison and Weiss (1990) and by Brav and Gompers (1997). However these results support the theoretical work of Allen and Faulhaber (1989), Welch (1988), and Chemmanur (1988), which predict that high-quality IPOs are more underpriced so that follow-up seasoned equity offers are more favorably received by investors.

On average, non VC-backed issues are larger than those of VC-backed firms. Non VC-backed firms also issue more shares to the public than VC-backed firms. Both differences are highly significant. But the fraction held by insiders is not significantly different between the two subgroups, which indicates that the market reacts favorably to non VC-backed IPOs.

The statistics in Table II show that, on average, VC-backed IPOs are significantly smaller than non VC-backed IPOs, which is inconsistent with Megginson and Weiss (1991) and Brav and Gompers (1997). But this is consistent with Carleton's (1986) argument that venture capitalists generally bring firms to the market at a relatively earlier stage of development. The results also show that on average VC-backed firms hire more prestigious underwriters and pay significantly less compensation as well as secondary compensation for underwriters' services. This is consistent with the notion that VC-backed firms because of the certification provided by venture capitalists can attract more reputable underwriters, thereby reducing the costs of going public.

In summary, the univariate results contained in Table II indicate that VC-backed IPOs are smaller, more underpriced, and use more reputable underwriters. These results are strikingly different from previous results on several accounts. First, previous studies [see, e.g., Meggison and Weiss (1991) and Brav and Gompers (1997)] show that VC-backed IPOs are significantly less underpriced than non VC-backed IPOs. Second, VC-backed IPOs are significantly larger. Finally, IPOs that use more reputable underwriters are usually less underpriced.

It has been suggested [Meggison and Weiss (1991)] that a contributing factor to this lower level of underpricing is the certification role played by the more reputable underwriters used by these IPOs. However, our results show that although our sample of VC-backed IPOs use more reputable underwriters, they still display a higher level of underpricing. This suggests that the lower level of underpricing of VC-backed IPOs documented in previous studies may not be due to the certification role of underwriters.

5. Empirical Results

5.1. Estimates of Stochastic Frontier

Table III presents the results of the estimates of the price frontier conditioned on pre-market information. Almost all of the coefficients are statistically significant and have the expected signs. INVP0 has a negative impact on the maximum potential offer price, implying that the higher the risks of IPOs, the lower the offer price. A positive association is found between the underwriter ranking (UWRANK) and the offer price. This supports the

certification role of underwriters, which contends that more prestigious underwriters provide more certification to the market about the quality of the IPOs and thus lessens the pre-market information asymmetry.

The signaling and asymmetric information hypotheses predict that, IPOs with more pre-market information asymmetry are more severely underpriced as a means of signaling their true quality and as compensation to investors. If these hypotheses are correct, the additional certification function provided by underwriters should be less important for high quality issues. Hence they would require less compensation for underwriting the securities, or the marginal certification role of underwriters would decrease with the offer price. Our regression results indicate a negative relation between the maximum offer price and total compensation, and are thus consistent with the above hypotheses.

The coefficient representing the presence of systematic deviations from the maximum potential offer price, $\boldsymbol{l}$, is highly significant. This finding is consistent with that of Hunt-McCool et al. (1996) and Koop and Li (1998) that the offer prices for IPOs are priced below the maximum potential offer price and that IPOs are characterized by deliberate underpricing.

Next, we investigate whether the level of deliberate underpricing is different for VC- and non VC-backed IPOs. Descriptive statistics are provided in Table IV. On separating our sample in to VC-backed and non VC-backed IPOs, the results indicate that the deliberate underpricing embodied in the offer price of VC-backed IPOs is significantly higher than that of non VC-backed IPOs. This finding is consistent with our earlier findings that VC-backed IPOs are characterized by a greater level of underpricing, and thus supports the notion that, at least for the IPOs in our sample, VC-backed IPOs are more deliberately underpriced than the non VC-backed group. Again, this finding is not consistent with those of previous studies, which indicate that VC-backed IPOs are less underpriced than non VC-backed ones.

5.2 Relation between Underpricing and Initial Returns

The above analysis establishes the empirical fact that IPOs are deliberately underpriced in the pre market and that the level of underpricing is significantly higher for VC-backed than for non VC-backed IPOs. Earlier we suggested that the initial day return might be due to deliberate underpricing in the pre market. To test this

hypothesis, we ran OLS regressions using the initial day returns as the dependent variable, with the level of deliberate underpricing as the independent variable. A positive relation between the initial day returns and the level of deliberate underpricing would be consistent with the notion that a portion of the documented IPO underpricing is due to the deliberate underpricing in the pre-market. This would also indicate that the level of deliberate underpricing is greater for the VC-backed IPOs.

Regression results are presented in Table V. Evidence indicates a positive and significant relationship between initial day returns and our pre-market measure of underpricing for the sample. The results indicate that a 1% increase in deliberate underpricing will result in about a 2.6% increase in initial day returns. On separating the sample into VC-backed and non VC- backed groups, we find results consistent with those of the full sample. For VC- backed IPOs, the impact of our measure of pre-market underpricing becomes stronger with statistical significance at the 99% confidence level. For the non VC-backed group the coefficient is positive, but is significant only at the 10% level. For the non VC-backed IPOs, the results show that a 1% increase in deliberate underpricing leads to a 4.6% increase in initial day returns.

5.3. Deliberate Underpricing and Size

Brav and Gompers (1997) show that based on size there is a difference between the long-run performance of VC-backed and non VC-backed IPOs. To investigate whether there is a relationship between pre-market underpricing and size we separate our sample first into VC- and non VC-backed IPOs and then, using each group, form four portfolios. Table VI shows mean and median efficiency scores by quartile size (proceeds) using the measure of underpricing obtained from our frontier estimates; the data show an interesting trend. Based on both mean and median estimates of VC- and non-VC backed IPOs, we observe a decrease in pre-market underpricing as size increases. For the VC-backed sub-sample, the mean level of deliberate underpricing in the first (smallest) quartile is 0.347 and 0.262 in the fourth (largest) size group. The median estimates also reveal a similar trend where inefficiency declines from a first quarter high of 0.333 to a fourth quarter low of 0.250. Similar results are observed for the non-VC sub-sample. Consistent with our earlier findings, the VC-backed sub-sample still record a higher degree of pre-market underpricing in both the mean and median estimates for all quartile groups.

However, the differences between the two sub-samples are insignificant when the upper quartile groups are compared, which indicates that pre-market underpricing differences are more prominent among the smaller issuers. To the extent that there is more ex-ante pricing uncertainty associated with smaller firms, this finding supports our earlier results that deliberate underpricing is undertaken to reduce ex-ante pricing uncertainty.

To provide additional evidence on the role of size, we re-estimate Equation 5 for our sample classified by size quartiles; the results are reported in Table VII. Once again we find evidence similar to our findings that the impact of pre-market underpricing is positively and significantly related to initial returns. Consistent with the descriptive analyses, this paper portrays a stronger relationship between inefficiency and return for the smaller issuers. However, the coefficient in the largest quartile group is not significantly different from zero.

6. Deliberate Underpricing and Price Support

We examine whether deliberate underpricing plays a role in determining the underwriters' decision to provide price support for IPOs. We earlier suggested that by deliberately underpricing the IPOs in the pre-market, investment bankers are reducing the price risk of IPOs brought to the market. That is, by deliberately underpricing the IPOs, underwriters are reducing the value of the put option given to investors. To test this conjecture we estimate a logit model with the dependent variable taking a value of 1 for IPOs that are supported and 0 otherwise. This is regressed against our estimated measure of deliberate underpricing. Deliberate underpricing in the pre-market is expected to have a positive effect on the probability that the IPO will be price-supported.

There is no data indicating which IPOs are price supported. In keeping with the literature [see, e.g., Rudd (1993); Hanley et al. (1993); Prabhala and Puri (1998)], we assume that price-supported IPOs have an initial day return of zero. Evidence provided by Asquith, Jones and Kieschnick (1998) and Prabhala and Puri (1998) is consistent with this assumption.

Table VIII reports the correlation between our measure of deliberate underpricing and several characteristics of our data. Panel A contains the correlation of the VC-backed sample and Panel B that of the non VC-backed sample. In general, the results for both sub-samples are consistent with our conjecture of the relationship between ex-ante pricing uncertainty and deliberate underpricing. Specifically, Table VIII shows that

there is a positive relationship between deliberate underpricing and INVP0. Note that except for LPROCEED, the expected negative relationship persists, with the remaining variables available to investors in the pre-market. Thus to the extent that deliberate underpricing is used to reduce risk and thus to reduce the value of the put option, our results are consistent with the findings of Prabhala and Puri (1998).

The logit estimates are reported in Table IX. Consistent with our conjecture, the results indicate that IPOs that are deliberately underpriced in the pre-market are price-stabilized. This finding applies to the full sample and also to the sample when it is separated into VC- and non VC-backed IPOs. The results indicate that although deliberate underpricing is higher for VC-backed IPOs, it has a higher explanatory power foe non VC-backed IPOs. A possible explanation is that the certification role of venture capitalists helps to reduce the pre-market pricing uncertainty. In summary, to the extent that deliberate underpricing reduces price uncertainty in the pre-market, our results are consistent with the hypothesis that underwriters provide price support for IPOs that are characterized by less ex-ante pricing uncertainty.

V. Additional Evidence

So far our results indicate that VC-backed IPOs are different from non VC-backed IPOs. As a result it is possible that VC- and non VC-backed IPOs are characterized by different pricing frontiers.[3] To examine the robustness of our results we estimate additional stochastic frontier regressions allowing the pricing technology and error structure to differ between the VC-backed and non VC-backed IPOs.

Table X presents results of additional estimates of the price frontier for VC- and non VC-backed IPO sub-samples based on the assumption that the two groups are characterized by different pricing technologies. The magnitude, strength, and significance of the coefficients are similar to the findings reported in Table 3. However, in some cases the statistical significance is found to be even more robust in VC-backed sub-samples. Underwriter ranking is negatively correlated with the maximum potential offer price in both sub-samples as is the compensation variable. λ - which represents systematic deviations from the maximum potential offer price - is

[3] In examining financial institutions, Mester (1993) used a similar estimating approach that focused on the

significant in both cases, with its significance being stronger for the VC-backed IPOs. These results are consistent with our earlier findings of deliberate underpricing for our entire sample and provides evidence indicating that the pricing technology is different according to whether they are VC- or non VC-backed.

Using the inefficiency scores from the separate estimations for the two groups, we also attempt to confirm previous findings that deliberate underpricing affects the initial day returns. The results are documented in Table XI. Irrespective of the sub-sample considered, we find a positive and significant impact of pre-market deliberate underpricing on initial returns in all regressions. Moreover, we find (Table XII) that the significance of pre-market coefficients for the VC-backed IPO sub-sample is stronger for the estimates obtained based on the assumption of different pricing technologies. Thus, there is additional support for the hypothesis that IPO underpricing can be partly explained by deliberate underpricing in the pre-market. Apparently, VC-backed IPOs play a stronger role in deliberate underpricing then their non VC-backed counterparts.

VI. Conclusion

In this paper we reexamined the underpricing phenomenon of IPOs by using a group of VC-backed and non VC-backed IPOs. Our finding suggests that the underpricing of IPOs is determined not only by factors such as third party certification and public information about the new offerings, but is also influenced by factors that lead to pre-market deliberate underpricing. The regression results indicate that our measure of pre-market underpricing is higher for VC-backed than for non VC-backed IPOs. In addition, initial day returns are higher for VC-backed IPOs than for non VC-backed IPOs. We attribute such phenomena to the greater pre-market deliberate underpricing that characterizes IPOs brought to the market by venture capitalists.

We also find that there is a positive relationship between deliberate underpricing and the probability that underwriters provide support for the issue. This evidence is consistent with the notion that underwriters deliberately under price the offering to reduce the costs of price stabilization in the after-market.

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different production technologies among a group of financial institutions based on their organizational forms.

Although we have presented evidence that price support plays an important role in the deliberate underpricing of IPOs, it is clear that there are other factors. The existing literature suggests that factors such as investor sentiment and hot issue periods, among others, may be important in explaining the deliberate underpricing phenomenon. Nevertheless, we believe that in addition to the observed factors, pre-market inefficiency provides an additional explanation for the underpricing of IPOs.

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TABLE I

Distribution of IPOs by Year:
VC-backed versus Non VC-backed

YEAR	VC-backed	Percent of All IPOs in the year	Non VC-backed	Percent of All IPOs in the year	Total
1990	40	48.2%	43	51.8%	83
1991	113	57.1%	85	42.9%	198
1992	139	74.3%	48	25.7%	187
1993	123	32.8%	252	67.2%	375

Venture capital backed IPOs account for approximately one-half of the IPOs in each year, with the number of IPOs generally increasing over the 4-year sample period.

TABLE II

Comparative Descriptive Statistics

	Full Sample	VC-Backed IPOs	Non VC-Backed IPOs	t-statistics for difference in mean
PRICE0 [Offer Price]	**12.44**	**11.70**	**13.16**	**4.56***
	(4.72)	**(3.73)**	**(15.07)**	
SIZE (in 000) [Proceeds]	**48592.48**	**32245.81**	**64554.86**	**6.58***
	(81515.15)	**(24336.90)**	**(109785.48)**	
INSFR [Insider Fraction]	**0.0122**	**0.0103**	**0.0132**	**2.17****
	(0.019)	**(0.020)**	**(0.019)**	
UC [Underwriter Compensation]	**0.853**	**0.828**	**0.876**	**2.60****
	(0.251)	**(0.247)**	**(0.253)**	
SC [Secondary Compensation]	**0.488**	**0.472**	**0.503**	**2.74****
	(0.155)	**(0.149)**	**(0.157)**	
UWRANK [Underwriter Ranking]	**7.79013**	**8.072**	**7.530**	**4.56***
	(1.745)	**(1.412)**	**(1.983)**	
RETURN [Initial Return]	**11.37854**	**13.50**	**10.06**	**3.00***
	(16.65)	**(17.98)**	**(15.07)**	

*** Significant at .01 level**

**** Significant at .05 level**

TABLE III

Estimated Frontier

Independent Variables	Parameters	Standard Errors
Constant	3.3170	0.1377 *
INVP0	-13.678	0.6409 *
LPROCEED	0.0668	0.48E-2 *
COMP	-0.103E-04	0.47E-5 **
UWRANK	-0.0114	0.19E-2 *
INSFR	-0.995E-03	0.45E-3 **
l	**2.133**	**0.1308 ***
s	0.312	0.167 * 0.168
Log likelihood function	-644.355	
Number of observations	843	

* Significant at .01 level
** Significant at .05 level

TABLE IV

Deliberate Underpricing Differences Between VC-Backed and Non VC-Backed IPOs

Inefficiency score from regression using stochastic frontier estimation. Dependent variable is log of initial offer price. Dependent variable is log of initial offer price. Independent variable includes INVP0, inverse of initial offer price, which serves as a proxy for the risk of the new offer, logarithm of the size of the offering firm LPROCEED, underwriter compensation to offering ratio COMP, underwriter rank UWRANK, insider holding to the total offerings INSFR. Inefficiency is defined as in Section II. We also give the test result for the hypothesis that the inefficiency scores from the two regressions are equal and the t-statistics for the difference in mean scores is provided in the last column.

	Full Sample	VC-Backed IPOs	Non VC-Backed IPOs	t-statistics difference in mean
Inefficiency	0.300	0.325	0.274	5.37*
	(0.134)	(0.134)	(0.129)	

* Significant at .01 level

TABLE V

Initial Returns and Deliberate Underpricing

OLS regressions of initial return on the measure of pre-market deliberate underpricing to initial offer price. Initial return is defined as difference between first trading day closing price and initial offer price divided by initial offer price. Inefficiency is defined as in Section II. Heteroscedasticity corrected t-statistics are reported in the parentheses.

	Full sample	Venture backed IPOs	Non-venture backed IPOs
Constant	**16.886**	**22.050**	**14.958**
	(2.821) **	**(4.654)** *	**(3.435)** *
$\frac{x}{P}$	**2.649**	**4.207**	**2.758**
	(1.834) $^{+}$	**(1.966)** **	**(1.754)** $^{+}$
R^2	**.0688**	**.0664**	**.0629**

TABLE VI

Deliberate Pre-Market Underpricing and Size

Descriptive inefficiency score by quartiles of offering size from regression using stochastic frontier estimation. Dependent variable is log of initial offer price. Dependent variable is log of initial offer price. Independent variable includes INVP0, inverse of initial offer, which serves as a proxy for the risk of the new offer, log of the size of the offering firm LPROCEED, underwriter compensation to offering ratio COMP, underwriter rank UWRANK, insider holding to the total offerings INSFR.Inefficiency is defined as in Section II.

	Deliberate Underpricing VC-Backed IPOs				Deliberate Underpricing of Non VC-Backed IPOs			
	Quartiles by Size				Quartiles by Size			
	1	2	3	4	1	2	3	4
Mean	**0.347***	**0.320***	**0.280***	**0.262**	**0.326**	**0.299**	**0.265**	**0.258**
Median	**0.333***	**0.306***	**0.272**	**0.250**	**0.324**	**0.279**	**0.271**	**0.247**

* Significantly different from the Non VC-Backed IPOs in the same quartile category.

TABLE VII

Initial Return and Deliberate Underpricing By Quartiles

The relationship between initial return and inefficiency score investigated for each quartiles of sample based on offering size. Dependent variable is initial return and independent variable is the deliberate underpricing or price inefficiency in the pre-market.

	Quartiles Based on Size			
	Quartile 1	**Quartile 2**	**Quartile 3**	**Quartile 4**
Constant	10.52	15.04	13.78	9.46
	(3.93)*	(2.77)**	(2.361)**	(4.041)*
$\frac{x}{P}$	1.34	1.81	2.056	3.701
	(1.74)+	(1.98)**	(1.72)+	(1.61)
R^2	.0389	.0505	.0492	.0267

Note: *, **, + means significant at 1, 5, and 10 percent level respectively.

TABLE VIII
Correlation Coefficients of the Independent Variables

IPO sample in the U.S. capital market during the 1990-1993 period. The sample contains 415 VC-Backed IPOs and 428 non VC-backed IPOs. Variables used in the correlation coefficient estimates include PRICE0, the offering price, INVP0, inverse of initial offer price, which serves as a proxy for the risk of the new offer, the natural logarithm of the size of the offering firm LPROCEED, insider holding to the total offerings INSFR, underwriter compensation to offering ratio COMP, underwriter rank UWRANK, initial return, RETURN, is the difference between first trading day closing price and initial offer price divided by initial offer price and Inefficiency is pre-market deliberate underpricing defined as in Section II.

PANEL - A [VC-BACKED IPOs]

Variables	1	2	3	4	5	6	7	8
1. PRICE0	1.00							
2. INVP0	-0.92	1.00						
3. LPROCEED	0.74*	-0.74*	1.00					
4. INSFER	-0.04	0.05	-0.04	1.00				
5. COMP	0.98*	-0.90	0.69*	-0.10	1.00			
6. UWRANK	0.32*	-0.35	0.33*	0.07	0.26	1.00		
7. RETURNS	0.37*	-0.34*	0.18*	0.07	0.39*	0.11*	1.00	
8. UNDERPRICING	-0.05	0.07	0.002	-0.06	-0.07	-0.03	0.11*	1.00

PANEL - B [NON VC-BACKED IPOs]

Variables	1	2	3	4	5	6	7	8
1.PRICE0	1.00							
2. INVP0	-0.82	1.00						
3. LPROCEED	0.77*	-0.77*	1.00					
4. INSFR	0.02	-0.08	0.12*	1.00				
5. COMP	0.88*	-0.82*	0.59*	0.05	1.00			
6. UWRANK	0.49*	-0.64*	0.60*	0.15*	0.43*	1.00		
7. RETURNS	0.03	-0.06	-0.03	-0.01	0.20*	-0.03	1.00	
8. UNDERPRICING	-0.08	0.04	0.01	-0.01	-0.04	-0.04	0.05	1.00

Note: * means statistically significant at least at the 5 percent significance level.

Table IX

Likelihood of Receiving Price Support from the Underwriters
[Logistic Regression Analysis of Price Support]

The dependent variable is the price support dummy variable which takes a value of 1 if the initial day return is zero and 0 otherwise. Independent variable is the pre-market pricing inefficiency (deliberate underpricing). Inefficiency scores are based on estimates that assumes all IPOs (VC and non-VC backed samples) have a similar price technology. Chi-square statistics are reported in the parentheses.

	Combined Sample	VC-Backed IPOs	Non VC-Backed IPOs
Variables	**Parameters (Chi-square Statistics)**	**Parameters (Chi-square Statistics)**	**Parameters (Chi-square Statistics)**
Constant	**-1.02 (4.56) ****	**-1.29 (3.88) ****	**-1.87 (130.46)***
Deliberate Underpricing	**0.008 (1.98)#**	**0.002 (1.76)#**	**0.006 (1.95)#**
Model Statistics			
-2 Log Likelihood	**705.51**	**288.40**	**310.29**
Model Chi-square	**108.42***	**110.68***	**92.35***
Number of Observations	**843**	**428**	**415**

Note: *, **, # indicates significant at 1, 5, and 10 percent significance level.

TABLE X

Estimated Frontier

Regression results on VC- and Non VC-backed sub-samples using stochastic frontier estimation. Dependent variable is log of initial offer price. Independent variable includes INVP0, inverse of initial offer, which serves as a proxy for the risk of the new offer, log of the size of the offering firm LPROCEED, underwriter compensation to offering ratio COMP, underwriter rank UWRANK, insider holding to the total offerings INSFR. *l* indicates whether inefficiency exists or not. Inefficiency is defined as in Section II. Inefficiency estimates here are based on separate estimates of VC and non-VC backed samples, i.e. assuming a different pricing frontier.

Independent Variables	Parameters	
	VC-Backed	Non VC-Backed
Constant	2.83*	3.41*
INVP0	-10.78*	-14.08*
LPROCEED	0.056*	0.0422**
COMP	-0.156E-04**	-0.086E-05**
UWRANK	-0.0261*	-0.0168**
INSFR	-0.821E-03**	-0.835E-05
λ	1.82*	2.56**
σ	0.461*	0.183*
Log Likelihood Function	-689.731	-565.82
Number of Observations	415	428

* Significant at .01 level

** Significant at .05 level

TABLE XI

Relative Importance of Pre-market Deliberate Underpricing and Price Supports in Determining Initial Returns: Assuming Different Pricing Technology between VC- and Non-VC Backed IPOs

The relationship between initial return, inefficiency score and price support binary variable is investigated the total sample and the sub-samples of VC-backed and non-VC backed IPOs. Dependent variable is initial return and independent variables are inefficiency in the pre-market and price support dummy variable. The price support dummy variable takes a value of 1 for all IPOs that have an initial return of zero at the end of the first day of trading in the capital market. Inefficiency scores are based on separate estimates of VC and non-VC backed samples i.e assuming a different pricing technology for each group. t-statistics are reported in the parentheses.

	Venture backed IPOs	Non-Venture backed IPOs
Constant	**18.682**	**12.056**
	(5.450) *	**(4.065)** *
$\frac{x}{P}$	**1.350**	**2.758**
	(2.634) **	**(1.90)** +
R^2	**.0703**	**.0673**

Note: *, **, + means significant at 1, 5, and 10 percent level respectively.

Table XII

Likelihood of Receiving Price Support from the Underwriters
[Logistic Regression Analysis of Price Support]
[Different Pricing Technology for VC and Non-VC Sub-samples]

The dependent variable is the price support dummy variable which takes a value of 1 if the initial day return is zero and 0 otherwise. Independent variable is the pre-market pricing inefficiency (deliberate underpricing). Inefficiency scores are based on estimates that assumes VC and non-VC backed samples have a different pricing technology. Chi-square statistics are reported in the parentheses.

	VC-Backed IPOs	Non VC-Backed IPOs
Variables	**Parameters (Chi-square Statistic)**	**Parameters (Chi-square Statistic)**
Constant	**-1.29 (3.88) ****	**-1.87 (130.46)***
Deliberate Underpricing [Pre-market Inefficiency]	**0.003 (3.03) ****	**0.007 (2.75) ****
Model Statistics		
-2 Log Likelihood	**345.36**	**358.83**
Model Chi-square	**114.02***	**107.25***
Number of Observations	**428**	**423**

Note: *, **, # indicates significant at 1, 5, and 10 percent significance level.

Endnotes

[1] Here we use the term pre-market to indicate the time before the IPO is actually issued. And the after market to indicate the time once trading commences.

[2] Here we use the term pre-market to indicate the time before the IPO is actually issued. And the after market to indicate the time once trading commences.

[3] Recently Cantale (1999)shows that the empirical regularity of underpricing could be solved