Adverse Selection, Public Information, and Underpricing in New Issues

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Abstract

This paper shows that favorable public information ahead of the IPO reduces investor heterogeneity and hence reduces the adverse selection problem facing lesser-informed investors, and that this induces the issuer to price the issue more conservatively in the sense of pricing it so that the quality of the marginal investor is lower. As a result, initial returns may be higher in issues preceded by favorable public information than in issues preceded by unfavorable information. This implication is consistent with empirical evidence that issuers only partially incorporate public information into the IPO price. The model is also consistent with recent empirical evidence of zero excess returns to uninformed investors in issues preceded by favorable public information and negative excess returns in issues preceded by unfavorable public information.

JEL Classification: G10, G32.

1 Introduction

Empirical evidence on underpricing in initial public offerings (IPOs) shows that initial returns are higher in issues preceded by favorable public information than in issues preceded by unfavorable information, suggesting that issuers fail to fully adjust IPO prices to publicly available information.[1] The present paper offers an explanation for this evidence based on

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[1] See Logue (1973), Loughran and Ritter (2002), Bradley and Jordan (2002), Lowry and Schwert (2003), Amihud, Hauser, and Kirsh (2003), Edelen and Kadlec (2003), and Derrien and Womack (2003).

the adverse selection argument of Rock (1986), which explains IPO underpricing as a compensation to uninformed investors for being allocated a disproportionately large fraction of overpriced issues.

The argument goes as follows. The issuer prices the issue to maximize expected proceeds, facing a pool of heterogeneously informed investors. A lower price induces investors with less precise private information to submit bids in the offering. This implies that a lower price decreases the quality of the marginal investor, but increases the set of investors who potentially submit bids in the offering, and hence increases the probability that the offering will succeed. Favorable public information reduces differences in reservation values among investors who hold favorable private information about the IPO firm, which defines the set of investors who potentially submit bids in the offering. As a result, investors are less heterogeneous—and hence adverse selection is less pervasive—in issues preceded by favorable public information compared to issues preceded by unfavorable public information (all else the same). Less investor heterogeneity induces the issuer to price the issue more conservatively in the sense of pricing it so that investors with less precise information will find it optimal to ask for allocations. The model thus predicts that the quality of the marginal investor will be lower—and hence that initial returns may be higher—in issues preceded by favorable information than in issues preceded by unfavorable information, which is consistent with the evidence of partial adjustment to public information.

Loughran and Ritter (2002) explain the evidence on partial adjustment to public information using prospect theory, which implies that the issuer cares about the change in wealth rather than its level. Ljungqvist, Nanda, and Singh (2003) and Derrien (2003) offer explanations based on the presence of sentiment investors to understand short-term underpricing and long-term overpricing. Although the present model assumes rational investors, the public signal may be viewed as sentiment and thus a rational investor calculating expectations over allocations and short-term returns must take into account the role of sentiment in aftermarket prices of IPO shares. In other words, there is no inconsistency between adverse selection as a source of short-term underpricing and sentiment as a cause of long-term overpricing. Edelen and Kadlec (2003) develop a model in which the issuer's potential surplus from going public is increasing in market valuations observed prior to the IPO. The issuer maximizing the expected surplus in the offering trades off the probability of issue success against the size of the surplus, and end up not adjusting fully to increases in market valuations. In the present paper, favorable public information (which may be viewed a favorable market sentiment consistent with Ljungqvist et al.) reduces the degree of investor heterogeneity in the pool of potential bidders. This induces the issuer to price the issue towards a higher probability of success, and potentially a higher initial return.

The main empirical implication of the basic adverse selection argument is that excess returns to uninformed investors will be zero once the probability of being allocated shares is taken into account. The present model suggests that the marginal investor may be informed, and this implies that the expected excess return to uninformed participation must be negative. Furthermore, if the marginal investor in issues preceded by unfavorable public information is better informed than the marginal investor in issues preceded by favorable information, then the expected loss to uninformed participation in issues preceded by unfavorable public information will be greater than that in issues preceded by favorable public information. This prediction is consistent with the empirical evidence of Amihud, Hauser, and Kirsh (2003) who document zero excess returns on a strategy of submitting bids in issues preceded by favorable market information, and negative excess returns on submitting bids in IPOs preceded by unfavorable market information in a sample of IPOs from the Tel Aviv Stock Exchange. In other words, the present paper suggests that evidence of Amihud et al.(2003) is consistent with the Rock explanation for underpricing, which is in contrast to their conclusion that their results "cast doubt on Rock's (1986) explanation of underpricing."

The rest of the paper is organized as follows. The basic model is presented in Section 2. Section 3 examines how public information relates to underpricing. Section 4 discusses the results. Section 5 concludes the paper. All proofs in the Appendix.

2 The Model

Consider the following two period setting. A firm is sold in an Initial Public Offering (IPO) on date zero, and a market value of this firm is established on date one. The true value of the firm is denoted v, where $v = v_H$ with probability α, $v = v_L$ with probability $1 - \alpha$, and $v_H > v_L = 0$. Its expected value is thus $E(v) := \alpha v_H$. All agents are risk neutral, and the riskless interest rate is zero.

There are $N \geq 2$ investors in the offering. Each investor n observes a private signal $s_n \in S_n = \{b_n, g_n\}$, where $s_n = g_n$ ($s_n = b_n$) represents favorable (unfavorable) information. The precision in s_n is given by $\gamma_n := p(g_n|v_H) = p(b_n|v_L) \geq 1/2$.[2] A key aspect of the model is that investors differ in the precision of their signals, which is captured by the ordering

[2] Let $p(x|y)$ denote the conditional probability of x given y. Furthermore, let $p(x)$ denote unconditional probability, and $p(x, y)$ and $p(x, y, z)$ joint probabilities.

$\gamma_1 \leq \gamma_2 \leq \cdots \leq \gamma_N$. In addition to the private signal, each investor (along with the issuer) observes a public signal $s \in S = \{b, g\}$, which has precision $\gamma := p(g|v_H) = p(b|v_L)$. The public signal is revealed before the issuer sets the IPO price.

The public signal may be correlated with market wide information, it may be firm specific, or it may be a combination. In the first case, the public signal is given by market returns observed prior to the issue. As such, the public signal may represent investor sentiment which in the short-term will affect the market value of IPO shares. In other words, the present model is consistent with that of Ljungqvist, Nanda, and Singh (2003), who study the effect of investor sentiment on short-term and long-term IPO returns.

Let V_n^s denote the reservation value of investor n as a function of the public signal s. Let P_0 denote the IPO price. By definition, an investor n will not request shares in the offering unless his reservation value exceeds the IPO price; that is, unless $V_n^s \geq P_0$. The reservation value V_n^s of investor n is a function of the realization of his private signal, and is higher if the private signal is favorable. The issuer is unable to observe the private signals observed by investors, but will price the issue so that an investor will request shares in the offering only if his signal is favorable.[3] This implies that relevant reservation values from the viewpoint of the issuer are investors' reservation values given favorable private information. Unless otherwise stated, I will let V_n^s denote the reservation value of investor n based on $s_n = g_n$. Thus, given $\gamma_1 \leq \gamma_2 \leq \cdots \leq \gamma_N$, reservation values are ordered $V_1^s \leq V_2^s \leq \cdots \leq V_N^s$. I will refer to an investor with more precise information as a higher quality investor. A higher quality investor has a higher reservation value in the offering since he expects to be allocated a higher fraction of underpriced issues than a lower quality investor.[4]

Let $m \in [1, \ldots, N]$ index the marginal investor in the offering. The pool of IPO investors may be partitioned into sets $B = [m, N]$ and $B^c = [1, m)$, where B represents the set of investors for which $V_n^s \geq V_m^s$. Among the investors in the set B only those with favorable

[3] This is an implicit assumption on the precision in the private signals observed by investors. Specifically, if the precision in the signal observed by investor $n = 1$ is sufficiently low, and the precision in the signals observed by investors $n > 1$ is not too high, then it may be optimal for the issuer to price the issue so that investor $n = 1$ will submit a bid in the offering regardless of his signal. In this case, the marginal investor is effectively uninformed since his bid strategy is independent of his signal. It will never be optimal, however, to price the issue so that any investor $n > 1$ ignores his signal.

[4] With no loss in insight, the private signals are assumed to be costless. The idea is that the issuer, facing a pool of heterogeneously informed investors at the pricing stage, prices the issue to maximize expected proceeds. The cost of becoming informed will affect the size of the investor pool at the pricing stage, as will the issuer's pricing strategy, which in turn is affected by the degree of investor heterogeneity and the size of the investor pool. It may be shown that the necessary conditions for equilibrium are (i) that the relative ranking of investors in terms of signal precision is uncertain at the information acquisition stage, and (i) the cost of acquiring information are not too high.

signals will ask for allocations. Investors in the set B^c do not submit bids in the offering regardless of the precision in their signals. The identity of the marginal investor will be a function of the public signal. This is captured by letting $m = m(s)$.

A higher issue price implies higher proceeds if the offering succeeds, but it also implies a reduction in the set B of potential bidders, and hence a lower probability that the offering will succeed. Also, a higher IPO price implies an increase in the quality of the marginal investor.

It is assumed that the issuer sells the entire firm in the offering. The number of shares that is issued is normalized to one, and allocations are pro-rata. Each investor requests either one share in the offering, or none. If no bids are submitted, then no shares are allocated and the issue is withdrawn.[5]

Let $\#g$ denote the number of investors who submit bids in the offering. This is a random variable with support $[0, \ldots, N - m]$. The issue is allocated pro-rata, and thus each bidder is allocated a fraction $\#g^{-1}$of the issue. The aftermarket value of the IPO firm is denoted $v(s_1, \ldots, s_N, s)$, which represents the expected true value of the firm as a function of the private signals observed by investors as well as the public signal. This implicitly assumes that the private signals of investors are revealed once shares start trading in the aftermarket.

To determine whether the issue is underpriced or not, we need a benchmark against which to compare the IPO price. A natural candidate is the expected aftermarket value of the IPO firm, as given by

$$\overline{v}' = \frac{\sum_{S_1 \times \cdots \setminus \{b_m, \ldots, b_N\}} p(s_1, \ldots, s_N, s) v(s_1, \ldots, s_N, s)}{\sum_{S_1 \times \cdots \setminus \{b_m, \ldots, b_N\}} p(s_1, \ldots, s_N, s)}, \tag{1}$$

where the expectation is taken over all states for which the issue succeeds. Empirically, $\overline{v}'$ corresponds to the average aftermarket value of completed issues.

It will be helpful to use the following alternative specification of $\overline{v}'$:

$$\overline{v} = \frac{\sum_{S_m \times \cdots \setminus \{b_m, \ldots, b_N\}} p(s_m, \ldots, s_N, s) v(s_m, \ldots, s_N, s)}{\sum_{S_m \times \cdots \setminus \{b_m, \ldots, b_N\}} p(s_m, \ldots, s_N, s)} \tag{2}$$

The difference between $\overline{v}'$ and $\overline{v}$ is that the latter does not explicitly take into account signals observed by investors in the set B^c. However, the two expressions for expected aftermarket

[5] IPOs do fail. Dunbar (1996) finds a failure rate for best-effort (fixed-price) offerings as high as 32.5%. For bookbuilt IPOs, Benveniste, Busaba, and Gou (2001) find failure rates to be sufficiently high to affect the signs as well as the significance of their parameter estimates.

value are equivalent, as shown next.

Lemma 1 $\overline{v} = \overline{v}'$

Although the information observed by investors in the set B^c does affect the realization of the firm's aftermarket value, these investors do not submit bids in the offering and hence they do not affect the outcome of the IPO. As a result, their information will not affect expected aftermarket value.

The IPO is said to be underpriced if $\overline{v} \geq P_0$, which says that the issue is underpriced if it is priced below its expected market value. This closely correspond to the empirical definition of underpricing. The excess initial return is defined by $r_s := \overline{v}/P_0 - 1; s \in \{b, g\}$, and thus underpricing is associated with a positive excess initial return.

As noted, an investor $n \in B$ will submit a bid in the offering only if his signal is favorable. By definition, the reservation value V_n^s of such an investor exceeds the IPO price P_0. For the marginal investor it is the case that $V_m^s = P_0$. The expected pay-off to investor n given $s_n = g_n$ equals

$$EV_n^s = \sum_{S_m \cdots \times S_N \setminus S_n} p(s_m, \ldots, s_N | g_n, s) \# g^{-1} [v(s_m, \ldots, g_n, \ldots, s_N, s) - P_0] \tag{3}$$

The reservation value V_n^s of investor n is the IPO price for which $EV_n^s = 0$.[6] Solving for $P_0 = V_n^s$ with $EV_n^s = 0$, we have

$$V_n^s = \Sigma_n^s v / \Sigma_n^s, \tag{4}$$

where

$$\Sigma_n^s := \sum_{S_m \cdots \times S_N \setminus S_n} p(s_m, \ldots, s_N | g_n, s) \# g^{-1}, \tag{5}$$

and

$$\Sigma_n^s v := \sum_{S_m \cdots \times S_N \setminus S_n} p(s_m, \ldots, s_N | g_n, s) \# g^{-1} v(s_m, \ldots, g_n, \ldots, s_N, s). \tag{6}$$

In other words, the reservation value V_n^s of investor n may be expressed as an allocation-weighted expectation over aftermarket values, where the expectation is taken with respect to the allocation-weighted probability distribution of investor n, conditioned on the probability

[6] In analogy with Lemma 1, investors in the set B^c has no effect on EV_n since they do not submit bids, and hence have no effect on allocation probabilities.

Σ_n^s of receiving an allocation. The expression for the reservation value of the marginal investor is given analogously. By definition, $P_0 = V_m^s$, while $V_n^s \geq P_0$ for $n \geq m$.

Proposition 1 *(Underpricing) $V_m^s \leq \overline{v}$, where the inequality is strict if $V_n^s < V_{n+1}^s$ for at least one $n, n+1 \in B$*

By definition, the IPO price is equal to the reservation value of the marginal investor. An investor with less precise information than that of the marginal investor will refrain from asking for an allocation, and obtains a zero payoff in the offering. An investor with more precise information compared to the marginal investor will ask for shares if his signal is favorable, and will expect a positive payoff. Empirically, this positive expected payoff is observed as underpricing.

3 Public Information and Underpricing

The issuer chooses the IPO price to maximize expected proceeds, which are given by:

$$E(R|s,m) := P_0\Sigma(s,m) = V_m^s\Sigma(s,m), \tag{7}$$

where $\Sigma(s,m) := \Sigma_m^s + \cdots + \Sigma_N^s$ represents the probability that the offering will succeed. This assumes that the value of the firm is zero if the offering fails. This is an extreme assumption, but it has no effect on the basic trade-off facing the issuer, and it has no effect on any of the results.

The IPO price implicitly defines the quality of the marginal investor. A lower IPO price decreases the quality of the marginal investor and increases the set of investors who potentially submit bids in the offering. A lower IPO price increases expected proceeds as long as the resulting increase in the success probability of the issue is sufficient to compensate for the lower price. A key insight of the model is that the public signal will affect this trade-off, and thus indirectly affect the initial return.

As a benchmark case, Proposition 2 examines the initial return r_s as a function of the public signal under the assumption that the quality of the marginal investor does not depend on the public signal.

Proposition 2 *Suppose that the issue be priced so that quality of the marginal investor does not depend on the public signal, then the initial return will be higher in issues preceded by* *unfavorable public information than in issues preceded by favorable public information; i.e.* $r_b > r_g$

Thus, when the quality of the marginal investor is independent of the public signal, initial returns are lower in issues preceded by favorable public information than in issues preceded by unfavorable information. The reason is that investors (in the relevant set) are less heterogeneous, and hence adverse selection is less pervasive, when the public signal is favorable. To understand this result observe that the initial return given the public signal may be expressed as follows

$$r_s = \Sigma'^s_{N-1} + (1 - \Sigma'^s_{N-1}) \frac{V^s_N}{V^s_{N-1}} - 1, \tag{8}$$

where $\Sigma'^s_{N-1} = \frac{\Sigma'^s_{N-1}}{\Sigma'^s_{N-1} + \Sigma'^s_N}$ and where investor $N-1$ is the marginal investor. Recalling that the firm's expected aftermarket value $\overline{v}$ may be represented as a weighted average of investors' reservation values, Σ'^s_{N-1}represents the weight of the reservation value of investor $N-1$.

It may be shown that

$$\frac{V^b_N}{V^b_{N-1}} \geq \frac{V^g_N}{V^g_{N-1}}, \tag{9}$$

which says that the relative difference between investors' reservation values is less after favorable public information compared to unfavorable information.[7] In other words, investors are less heterogeneous, and hence adverse selection is less pervasive, if the issue is preceded by favorable public information than if it is preceded by unfavorable information.[8] A reduction in the adverse selection problem facing less-informed investors allows the issuer to optimally price the issue to induce investors with less precise signals to submit bids in it. The implication is that the expected initial return may be higher when the public signal is favorable than when it is unfavorable. This is demonstrated next.

[7] Alternatively, condition (9) may be expressed

$$\frac{V^b_N}{V^g_N} \geq \frac{V^b_{N-1}}{V^g_{N-1}},$$

which says that the reservation value of the better-informed investor is less affected by the public signal than the reservation value of the (lesser-informed) marginal investor.

[8] An investor who obtains an unfavorable private signal will refrain from submitting a bid. In the subset of investors with favorable signals, favorable public information will reduce investor heterogeneity, while unfavorable public information will increase it. In the subset of investors with unfavorable private signals, favorable public information will increase investor heterogeneity, while unfavorable public information will reduce it.

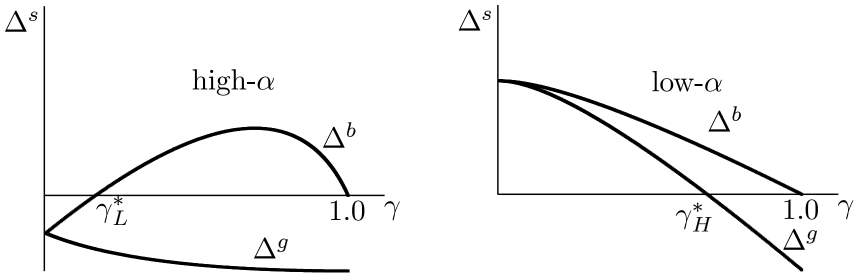

Figure 1: The change Δ^s in expected proceeds from pricing the issue to investor $N-1$ as the marginal investor m rather than investor $N-2$ as a function of the precision γ in the public signal. If $\Delta^s > 0$, then $m = N-1$, and if $\Delta^s < 0$, then $N-2$.

Consider the case in which $m \in \{N-2, N-1\}$.[9] Given the public signal, the issuer prices the issue to maximize expected proceeds $\Sigma(s, m)V_m^s$. Consider the difference

$$\Delta^s = \Sigma(s, N-1)V_{N-1}^s - \Sigma(s, N-2)V_{N-2}^s \tag{10}$$

If $\Delta^s > 0$, then pricing the issue with investor $N-1$ as the marginal investor represents higher expected proceeds than pricing it with investor $N-2$ as the marginal investor. Otherwise, the issue is priced with investor $N-1$ as the marginal investor. Thus, if $\Delta^s > 0$, then $P_0 = V_{N-1}^s$, and if $\Delta^s < 0$, then $P_0 = V_{N-2}^s$.

Favorable public information implies a reduction in investor heterogeneity and therefore a reduction in the adverse selection problem facing less-informed investors, which induces the issuer the price the issue towards less-informed investors. This is illustrated in Figure 1, which depicts Δ^s as a function of the precision in the public signal for low-risk (high-α) firms and high-risk (low-α).

In the low-risk (high-α) case, when $s = g$ adverse selection is modest and the issuer maximizing expected proceeds prices the issue at V_{N-2}^g regardless of the precision in the public signal. For $s = b$, if the precision in the public signal is sufficiently low, then $\Delta^s < 0$ and the issue is priced at V_{N-2}^g. An increase in the precision in the public signal increases investor heterogeneity. At some point $\Delta^s > 0$, and the issue is priced at V_{N-1}^b rather than

[9] By Lemma 1, we may ignore investors with information quality less than that of the marginal investor. Still, the general case for which $m < N-2$ becomes needlessly complex and the basic tradeoffs can be studied in a less complex setting with $m \geq N-2$. Note also that by ignoring the possibility that $m = N$ makes the analysis more accessible, but it has no effect on the analysis. Indeed, in the numerical examples depicted it is never optimal for the issuer to price the issue with investor N as the marginal investor.

V^b_{N-2}.

In the high-risk (low-α) case, for $s = b$ the issue is priced at V^b_{N-1} regardless of the precision in the public signal. For $s = g$, investor heterogeneity is decreasing in the precision in the public signal, and thus for sufficiently high precision the issue is priced at V^g_{N-1} rather than V^g_{N-2}.

When the issue is priced such that the quality of the marginal investor is independent of the public signal, Proposition 2 implies that initial returns will be higher when the public signal is unfavorable than when it is favorable. These are the cases in Figure 1 for which $\gamma \leq \gamma^*$. In the low-risk case, the issue is priced with investor $N-2$ as the marginal investor, and investor $N-1$ in the high-risk case.

When $\gamma > \gamma^*$ the issue is priced to investor $N-1$ as the marginal investor if $s = g$, and to investor $N-2$ as the marginal investor if $s = b$. In this case, since the quality of the marginal investor is lower when the public signal is favorable than when it is unfavorable, a favorable public signal may give a higher initial return than an unfavorable signal.

This prediction is generated in Table 1. When the public signal is favorable ($s = g$), the issue is priced optimally to investor $N-2$ as the marginal investor. This gives expected proceeds of .91 and an initial return of 10.55%. The alternative is to price the issue to investor $N-1$ as the marginal investor. However, although this implies a lower initial return (of 4.32%), it implies lower expected proceeds and is therefore not optimal. When the public signal is unfavorable ($s = b$), the issue is priced optimally with investor $N-1$ as the marginal investor. This implies expected proceeds of .79 and an initial return of 5.93%. The alternative is to price the issue with investor $N-2$ as the marginal investor. However, this gives expected proceeds of .78 and hence is not optimal.[10]

Let $E(v|s)$ denote the expected value of the IPO firm as a function of the public signal. In a first-best world, the issuer will be able to raise an amount equal to $E(v|s)$. In a first-best world, investors are uninformed, the issuer prices the issue at $E(v|s)$, and the issue succeeds with probability one. Actual proceeds, on the other hand, are given by $E(R_{m(s)}|s) = \Sigma(s, m)V^s_{m(s)}$. Thus the total loss to the issuer, normalized by the first-best amount, is given

[10] Holding the quality of the marginal investor constant it may be shown that higher ex ante uncertainty increases adverse selection and hence increases the initial return, consistent with Beatty and Ritter (1986). However, a negative correlation between ex ante uncertainty and initial returns may obtain as well when allowing the issuer to price the issue optimally to maximize expected proceeds, suggesting that the adverse selection argument need not imply a positive correlation between ex ante uncertainty and initial returns. Although the empirical evidence does support a positive correlation, some of this evidence is weak, and some of it is even contrary to the standard prediction (see Jenkinson and Ljungqvist (2001) for a summary). In addition, ex ante uncertainty is not directly observable and must therefore be estimated from proxies.

m	$s=g$	V_m^g	$\Sigma(g,m)$	$E(R\|g)$	r_g	$s=b$	V_m^b	$\Sigma(b,m)$	$E(R\|b)$	r_b
$N-2$		1.01	.90	**.91**	**10.55**		.88	.88	.78	14.22
$N-1$		1.12	.80	.89	4.32		1.01	.78	**.79**	**5.93**

Table 1: The table shows the optimal choice of the issuer and the associated initial return r_s for $\gamma = 0.55$, $\alpha = 0.7$, $E(v) = 1$, $\gamma_{N-2} = 0.55$, $\gamma_{N-1} = 0.625$, and $\gamma_N = 0.70$.

by:

$$M_s(m) := \frac{E(v|s) - E(R_{m(s)}|s)}{E(v|s)}.$$

This amount is increasing in investor heterogeneity since expected proceeds $E(R_m|s)$ are decreasing in investor heterogeneity. The next result considers the effect on M_s of the public signal.

Proposition 3 $M_g < M_b$

Proposition 3 says that expected proceeds to the issuer are closer to first-best in issues preceded favorable public information than in issues preceded by unfavorable public information. The reason is that favorable public information reduces investor heterogeneity. This reduces the adverse selection problem facing less-informed investors, and in turn reduces the wedge between expected proceeds and first-best. The proposition holds even if the quality of the marginal investor is independent of the public signal. If the issuer, in maximizing expected proceeds, prices the issue to a lower quality investor after a favorable public signal, then expected proceeds increase and the cost of going public decreases. Yet, the initial return increases.

The public signal affects expected proceeds in the offering in two ways. A favorable signal increases the expected value of the firm, and it decreases adverse selection by reducing the extent of investor heterogeneity. Both effects increase expected proceeds and hence make it more desirable for the firm to go public. The fact that investor heterogeneity and adverse selection costs are negatively correlated with the public signal implies that the number of firms coming to the market in periods of favorable public information will be excessively large relative to what one would predict from fundamental values, and that the number of firms coming to the market in periods of unfavorable public information will be excessively small. This implication is consistent with observations of hot issue periods (Ibbotson and Jaffe (1975) and Ritter (1984)).

Consider the numerical example from Table 1. First-best as a function of the public signal is given by $E(v|g) = 1.06$ and $E(v|b) = 0.94$. The expected loss relative to first-best equals

$M_g = 13.96\%$ and $M_b = 15.73\%$. The initial return, however, is given by 10.55% when the public signal is favorable and 5.93% when the public signal is unfavorable. In other words, the initial return is inversely related to the cost of going public, suggesting that the initial return may be a misleading measure of the cost of going public. This result is related to Habib and Ljungqvist (2001) who suggest that issuers balance the amount of underpricing against direct costs of going public, and thus that issuers who float a smaller fraction of the firm will care less about underpricing. In the present setting, although a positive expected excess return reflects the presence of adverse selection, and hence reflects an indirect cost of going public, the issuer prices the issue to maximize expected proceeds and its expected initial return is only of indirect relevance.

The expected initial return r_s does not coincide with the (normalized) loss associated with adverse selection, given by $M_s(m)$. One reason for this is that the initial return implicitly normalizes the total loss using the expected proceeds $E(R_{m(s)}|s)$ rather than expected firm value $E(v|s)$. To see this, note that the initial return may be expressed

$$r_s = \frac{\Sigma(s,m)\overline{v} - E(R_{m(s)}|s)}{E(R_{m(s)}|s)},$$

which, if the probability of failure is (near) zero, may be expressed as

$$r_s = \frac{E(v|s) - E(R_{m(s)}|s)}{E(R_{m(s)}|s)}$$

In other words, the initial return as a measure of indirect cost of going public normalizes the total expected loss $E(v|s)-E(R_{m(s)}|s)$ by expected proceeds $E(R_{m(s)}|s)$ rather than expected firm value $E(v|s)$. Since $E(v|s) \geq E(R_{m(s)}|s)$, the initial return thus over-estimates the loss associated with the IPO. This is not a general implication, however. Allowing for a positive probability of failure, the initial return may actually underestimate the loss associated with the IPO. To see this, note that $\Sigma(s,m)\overline{v} \leq E(v|s)$, which suggests that if the probability of failure $1-\Sigma(s,m)$ is sufficiently large, the expected initial return may underestimate the loss associated with going public.

The initial return r_s represents the expected amount of money left on the table $\Sigma(s,m)(\overline{v}-V_m^s)$ normalized by the payment $\Sigma(s,m)V_m^s$. A higher initial return clearly implies more money on the table for investors, but a higher initial return may be accompanied by greater expected proceeds to the issuer and hence need not be associated with a higher cost of going public.

4 Discussion

4.1 Fixed-Price vs Bookbuilt

The setting studied in the present paper most closely resembles that of a fixed-price offering. However, the results apply to bookbuilt offerings as well. Specifically, empirical evidence shows that retail investors do receive allocations in bookbuilt IPOs even though they do not participate in the bookbuilding process, and it shows that retail investors earn a positive excess return on these allocations.[11] The fact that retail investors do not participate in the bookbuilding process, the positive excess return that they earn is hard to explain as a compensation for revealing valuable information. Indeed, the fact that retail investors do not participate in the bookbuilding process suggests that bookbuilt issues are fixed-price from the viewpoint of retail investors, and hence that the positive excess return to retail investors represents compensation for adverse selection, as suggested by the analysis of Benveniste and Wilhelm (1990). The issuer must price the issue to induce sufficient demand from retail investors to fill the retail tranche, which is essentially the problem studied in the present paper.

If the bookbuilding process works as hypothesized, then the IPO price will reflect the information observed by institutional investors (Benveniste and Spindt (1989); see Cornelli and Goldreich (2001) for empirical support). Aggarwal et al. (2002), however, find that the return to institutional investors is too large to be explained by bookbuilding alone, suggesting that institutional investors are allocated underpriced issues at the expense of retail investors. This evidence also suggests that institutional investors may not reveal fully reveal their information during the bookbuilding process and hence that there may be adverse selection among institutional investors as well.

4.2 Empirical Evidence

The model shows that initial returns may be higher in issues preceded by favorable public information than in issues preceded by unfavorable public information. This result is consistent with the empirical evidence on partial adjustment of IPO prices to public information

[11] See Aggarwal, Prabbala, and Puri (2002) and Ljungqvist and Wilhelm (2002) for evidence on allocations across retail and institutional investors in bookbuilt offers. With respect to returns, Aggarwal et al. document a first day return of 13.9% to retail investors, and 15.7% to institutional investors. Although the return to institutional investors is higher than that to retail investors, the return retail investors is clearly in excess of any risk adjusted rate of return.

(see Introduction). The present model accounts for this evidence as an optimal (and rational) response by the issuer to publicly available information. Specifically, unfavorable public information has the effect of increasing differences in investors' reservation values. This implies an increase in investor heterogeneity, to which the issuer responds by floating the issue to better-informed investors. The result is that the quality of the marginal investor will be higher in issues preceded by unfavorable public information than in issues preceded by favorable information, and hence that initial returns may be lower.

The main empirical implication of the Rock argument is that the excess return to uninformed bidding will be zero. This implication relies an assumption that the marginal investor in the offering is uninformed. Since uninformed investors presumably submit bids randomly in IPOs, when the marginal investor is uninformed the bid strategy of the marginal investor in the offering is easily simulated with proper allocation data. As such, the assumption of an uninformed marginal investor offers a convenient benchmark. Indeed, if the marginal investor is informed, as suggested by the present model, then the adverse selection argument implies that the expected excess return to uninformed bidding will be negative. Furthermore, it implies that the expected excess return to uninformed bidding will be lower the more precise is the private information observed by the marginal investor. Also, holding the quality of the marginal investor constant, the excess return to uninformed participation in issues preceded by unfavorable information will be lower than that to uninformed participation in issues preceded by favorable information, since investor heterogeneity is higher in the first case. Both factors pull towards a prediction that the return to uninformed participation is lower in issues preceded by unfavorable public information than in issues preceded by favorable public information.

These implications are consistent with the recent empirical evidence of Amihud et al., who test the Rock prediction of a zero allocation-weighted excess return to uninformed investors in a sample of IPOs from the Tel Aviv Stock Exchange. They find that an uninformed strategy of submitting bids in all the IPOs in their sample would have yielded a negative excess return, while a strategy of submitting bids only in IPOs preceded by favorable public information would have yielded a zero excess return. With respect to the present model, their results suggest that the marginal investor in issues preceded by favorable market information is uninformed, and that the marginal investor in the case of unfavorable information is informed.

An alternative way of testing the model is through bid size. The prediction that the quality of the marginal investor is higher in issues preceded by unfavorable public information than in issues preceded by favorable public information implies that the quality range of bidders in issues preceded by favorable public information will be higher than in issues preceded by unfavorable information. In the case of bookbuilt issues, these implications apply to the retail tranche. If higher quality investors submit larger bids than do lower quality investors, then the prediction on bidder quality implies that average bid size will be smaller in issues preceded by unfavorable public information than in issues preceded by favorable public information. However, investors are likely to adjust bid sizes according to the extent of rationing that they expect, submitting larger bids in IPOs preceded by favorable public information. This makes the relationship between bid size, bidder quality, and the public signal ambiguous. One way around this ambiguity may be to consider the variability in bid size across bidder. If the quality range of investors is higher in issues preceded by favorable public information, and bid size is positively correlated with investor quality, then the present argument implies that the variation in bid sizes will be higher in issues preceded by favorable public information than in issues preceded by unfavorable public information.

5 Concluding Remarks

Empirical evidence shows that initial returns are higher in issues preceded by favorable public information than in issues preceded by unfavorable public information, which suggests that IPO prices are only partially adjusted to public information observed prior to the issue date. The present paper develops an IPO model based on the adverse selection argument of Rock (1986) that produces empirical predictions consistent with this evidence. Specifically, it shows that favorable public information reduces the degree of heterogeneity among potential bidders in the offering, and that this induces the issuer to price the issue more conservatively when the public signal is favorable in the sense of pricing it to induce investors with less precise private signals to submit bids in it, and thereby increase the probability that the offering will succeed. The model thus predicts that the quality of the information observed by the marginal investor will be lower—and hence initial returns may be higher—in issues preceded by favorable information than in issues preceded by unfavorable information.

In the standard adverse selection argument the marginal investor is uninformed, which implies that the expected excess return to uninformed participation in the IPO market must be zero. The present paper, however, suggests that the marginal investor in the offering will be informed, and hence that the expected excess return to uninformed participation will be negative. Furthermore, it shows that investor heterogeneity and the quality of the marginal investor are both lower in issues preceded by favorable public information than in issues preceded by unfavorable information. As a result, the expected excess return to uninformed participation will be less in issues preceded by unfavorable public information. These predictions are consistent with recent evidence of Amihud et al. (2003), who document negative excess returns to uninformed participation in issues preceded by unfavorable information and a zero excess return in issues preceded by favorable public information.

Favorable public information increases the fundamental value of the firm, and it decreases adverse selection costs. Both effects increase expected proceeds, and so both effects make it more desirable for the firm to go public. Since the adverse selection cost is negatively correlated with the public signal, the model implies that the number of firms that are coming to the market in periods of favorable public information will be excessively large relative to what may be predicted from fundamental values, and that the number of firms coming to the market in periods of unfavorable public information will be excessively small. Such a prediction is consistent with the observation of hot issue markets.

6 Appendix

Proof of Lemma 1. If $m = 1$, the lemma is trivial. Consider the case for which $m > 1$, and consider within the summation in $\sum_{S_1 \times \cdots \setminus \{b_m, \ldots, b_N\}} p(s_1, \ldots, s_N)$ from $\overline{v}'$ the element

$$p(\ldots, g_{m-h}, \ldots, g_m, \ldots) + p(\ldots, b_{m-h}, \ldots, g_m, \ldots),$$

where $1 \leq h < m$. Now, since

$$p(\ldots, g_{m-h}, \ldots, s_m, \ldots) + p(\ldots, b_{m-h}, \ldots, s_m, \ldots) = p(\ldots, s_m, \ldots) \quad \text{for all} \quad h \in B^c$$

it follows that

$$\sum_{S_1 \times \cdots \setminus \{b_m \ldots, b_N\}} p(s_1, \ldots, s_N, s) = \sum_{S_m \times \cdots \setminus \{b_m, \ldots, b_N\}} p(s_m, \ldots, s_N, s)$$

where the summation on the right hand side is from $\overline{v}$.

Consider then the summation

$$\sum_{S_1 \times \cdots \setminus \{b_m, \ldots, b_N\}} p(s_1, \ldots, s_N, s) v(s_1, \ldots, s_N, s)$$

and the element

$$\begin{aligned} & p(\ldots, g_{m-h}, \ldots, s_m, \ldots)v(\ldots, g_{m-h}, \ldots, s_m, \ldots) \\ & + p(\ldots, b_{m-h}, \ldots, s_m, \ldots)v(\ldots, b_{m-h}, \ldots, s_m, \ldots) \\ = \ & p(\ldots, s_m, \ldots)v(\ldots, s_m, \ldots) \end{aligned}$$

and thus

$$\begin{aligned} & \sum_{S_1 \times \cdots \setminus \{b_m, \ldots, b_N\}} p(s_1, \ldots, s_N, s)v(s_1, \ldots, s_N, s) \\ = & \sum_{S_m \times \cdots \setminus \{b_m, \ldots, b_N\}} p(s_m, \ldots, s_N, s)v(s_m, \ldots, s_N, s) \end{aligned}$$

■

Proof of Proposition 1. The proof of uses an observation that the expected after-market value of the firm may be expressed as a weighted average of the reservation values of each investor in the set B, as follows

$$\overline{v} = \frac{V_m \Sigma_m + V_{m+1} \Sigma_{m+1} + \ldots + V_N \Sigma_N}{\Sigma_m + \Sigma_{m+1} + \ldots + \Sigma_N},$$

where the notation for the public signal s is suppressed throughout. This most easily seen in the case where $m = N - 1$. The reservation values of investors $N - 1$ and N are given by

$$\begin{aligned} V_{N-1} &= \frac{p(b_N|g_{N-1})v(g_{N-1}, b_N) + p(g_N|g_{N-1})\frac{1}{2}v(g_{N-1}, g_N)}{p(b_N|g_{N-1}) + \frac{1}{2}p(g_N|g_{N-1})} \\ &= \frac{p(g_{N-1}, b_N)v(g_{N-1}, b_N) + p(g_{N-1}, g_N)\frac{1}{2}v(g_{N-1}, g_N)}{p(g_{N-1}, b_N) + \frac{1}{2}p(g_{N-1}, g_N)}, \end{aligned}$$

and

$$V_N = \frac{p(b_{N-1}, g_N)v(b_{N-1}, g_N) + p(g_{N-1}, g_N)\frac{1}{2}v(g_{N-1}, g_N)}{p(b_{N-1}, g_N) + \frac{1}{2}p(g_{N-1}, g_N)},$$

where $V_N \geq V_{N-1}$ if $\gamma_N \geq \gamma_{N-1}$. Further,

$$\overline{v} = \frac{p(g_{N-1}, b_N)v(g_{N-1}, b_N) + p(b_{N-1}, g_N)v(b_{N-1}, g_N) + p(g_{N-1}, g_N)v(g_{N-1}, g_N)}{p(g_{N-1}, b_N) + p(b_{N-1}, g_N) + p(g_{N-1}, g_N)}$$

and thus

$$\overline{v} = \frac{\Sigma_{N-1} V_{N-1} + \Sigma_N V_N}{\Sigma_{N-1} + \Sigma_N}$$

where

$$\Sigma_{N-1} = p(g_{N-1}, b_N) + \frac{1}{2} p(g_{N-1}, g_N) \quad \text{and} \quad \Sigma_N = p(b_{N-1}, g_N) + \frac{1}{2} p(g_{N-1}, g_N)$$

It is now immediate that $V_{N-1} \leq \overline{v}$ and hence that the IPO is underpriced in equilibrium. Extended to the general case, the expected aftermarket value of the firm may be expressed as follows:

$$\begin{aligned} \overline{v} &= \frac{V_m \Sigma_m + V_{m+1} \Sigma_{m+1} + ... + V_N \Sigma_N}{\Sigma_m + \Sigma_{m+1} + ... + \Sigma_N} \\ &= V_m \Sigma'_m + \cdots + V_N \Sigma'_N. \end{aligned}$$

where $\Sigma'_n := \frac{\Sigma_n}{\Sigma_m + \Sigma_{m+1} + ... + \Sigma_N}$. It is now immediate that $\overline{v} \geq V_m$ and that hence the issue is underpriced if $V_m \leq V_{m+1} \leq \cdots \leq V_N$. It is also immediate that $\overline{v} > V_m$ if $V_n < V_{n+1}$ for at at least one $n, n+1 \in B$. Finally, it is clear that this result is independent of the realization of the public signal. ■

Proof of Proposition 2. Consider the case in which $m = N - 1$. The difference $r_{b_{pre}} - r_{g_{pre}}$ is given by

$$r_{b_{pre}} - r_{g_{pre}} = \frac{A}{B \times C}$$

where

$$A := \alpha(1-\alpha)(2\gamma_P - 1)(\gamma_N - \gamma_{N-1})(1 + \gamma_{N-1}(1-\gamma_N) + \gamma_N(1-\gamma_{N-1}))(\gamma_N + \gamma_{N-1}(1-\gamma_N)),$$

$$B := (1-\alpha)(1-\gamma_P)(1-\gamma_{N-1}\gamma_N) + \alpha\gamma_P[\gamma_N(1-\gamma_{N-1}) + \gamma_{N-1}(1-\gamma_N)] + \gamma_{N-1}\gamma_N\gamma_{P,}$$

and

$$\begin{aligned} C \ : \ &= \alpha\gamma_{N-1}(1-\gamma_P) + (1-\alpha)\gamma_P + \alpha\gamma_N(1-\gamma_{N-1}) \\ &+\gamma_P(1-\gamma_{N-1}\gamma_N) + [2\gamma_{N-1}\gamma_N - \alpha\gamma_P(1-\gamma_{N-1})]. \end{aligned}$$

It is clear that A, $B > 0$. It is straightforward to show that $[2\gamma_{N-1}\gamma_N - \alpha\gamma_P(1-\gamma_{N-1})] \geq 0$

and hence that $C > 0$. Thus, $r_{b_{pre}} - r_{g_{pre}} > 0$. ■

Proof of Proposition 3. Consider the case for which $m(g) = m(b) = N - 1$; if the proposition is satisfied for in this case, then it is satisfied in the case for which the issuer optimally chooses $m(g) = N - 2 > m(b) = N - 1$.[12] Note that $M_g(m) = M_b(m)$ if the public signal is uninformative. The inequality will thus be satisfied if $\frac{\partial M_g}{\partial \gamma} < 0$ and $\frac{\partial M_b}{\partial \gamma} > 0$. Taking the derivatives gives:

$$\frac{\partial M_g}{\partial \gamma} = \frac{-\alpha(1-\alpha)\gamma_{N-1}(2-\gamma_N)(\gamma_N - \gamma_{N-1})(1+\gamma_{N-1}+\gamma_N - 2\gamma_{N-1}\gamma_N)}{[(1-\gamma)(1-\alpha)(\gamma_{N-1}\gamma_N - \gamma_N - 1) + (1-\gamma) + \alpha\gamma_{N-1}(\gamma\gamma_N - (1+\gamma))]^2} < 0,$$

and

$$\frac{\partial M_b}{\partial \gamma} = \frac{\alpha(1-\alpha)\gamma_{N-1}(2-\gamma_N)(\gamma_N - \gamma_{N-1})(1+\gamma_{N-1}+\gamma_N - 2\gamma_{N-1}\gamma_N)}{[\gamma(1-\alpha)(1+\gamma_N(1-\gamma_{N-1}) + \gamma_{N-1}) + (1-\gamma)\alpha\gamma_{N-1}(1-\gamma_N)]^2} > 0.$$

■

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[12] It may also be verified for the case $m(g) = m(b) = N - 2$ as well, but the algebra is very messy.

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