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Journal of Financial Intermediation 13 (2004) 359–377

Journal of Financial Intermediation

www.elsevier.com/locate/jfi

Excess initial returns in IPOs

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Received 1 December 2000

Available online 14 January 2004

Abstract

The empirical evidence on initial returns in IPOs reveals average overpricing as well as underpricing, depending on the type of security offered for sale. Consistent with this evidence, the present paper develops a model in which an IPO may be overpriced in equilibrium relative to its expected (or average) aftermarket price. Overpricing disappears, however, once the offer price is compared to a 'float-weighted' expectation, where the weights are given by the extent to which the number of securities that are floated in the offering (at the posted price) is positively related to the demand for allocations. Empirically, the model implies that equally-weighted returns underestimate initial returns in IPOs, and hence that inferences based on equally-weighted returns may be misleading.

JEL classification: D82; G24; G32

Keywords: Initial public offerings; Excess initial returns; Float-weighted returns; Equally-weighted returns; Stabilization

1. Introduction

The empirical evidence on initial returns in Initial Public Offerings (IPOs) reveals average overpricing as well as underpricing, depending on the type of security offered for sale.[1] However, while the underpricing phenomenon is relatively well understood, it is less

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[1] See, e.g., Ritter (1998) for a review of the literature on underpricing. With respect to overpricing, Wang et al. (1992) find overpricing (at the 5% level) in a sample of Real Estate Investment Trusts (REITs) IPOs. (Ling and Ryngaert (1997) document underpricing in a more recent sample of REIT IPOs, and find this change to be consistent with the adverse selection argument, and hence the present model.) More recently, Datta et al. (1997) find overpricing (at the 1% level) in the case of IPOs of investment grade bonds and bonds issued by firms

1042-9573/$ – see front matter
doi:10.1016/j.jfi.2003.09.004

clear what generates overpricing. Indeed, why would rational investors want to buy securities that on average drop in price during their first day of trading? Is it possible that the measurement of mispricing in previous work was somehow inappropriate, leading to the wrong conclusion?

My goal in this paper is to address this question theoretically. Consistent with the empirical evidence, I show that overpricing in the sense that the IPO, in equilibrium, is priced above its expected (or average) aftermarket value is indeed possible.[2] However, while the expected aftermarket value of the IPO security is the benchmark that is assumed, at least implicitly, in empirical investigations, its use requires that the size of the issue is unrelated to the demand for allocations, which generally is not the case. Instead, issuers typically adjust the issue size according to the state of demand by floating a greater number of securities (at the posted price) when the demand for allocations is higher.[3] This creates a positive correlation between the supply of securities in the offering and the demand for allocations, and hence a positive correlation between the supply of securities and initial returns. As as result, states with higher demand for allocations should be given greater weights in return calculations than states with lower demand, suggesting that the expected (or average) aftermarket value of the IPO security is inappropriate as benchmark whenever the size of the issue is correlated with the demand for allocations.

Indeed, I show that even though an IPO may be overpriced in equilibrium relative to an equally-weighted average of aftermarket prices, it can never be overpriced relative to a 'float-weighted' benchmark, where the weights are given by the extent to which the size of the issue is increased relative to a pre-stated minimum. I thus ascribe the empirical evidence on overpricing to the use of equally-weighted returns when float-weighted returns should be used instead. On a more general level, the analysis implies that equally-weighted returns

listed on NYSE/AMEX. Peavy (1990) find overpricing (at the 1% level) for IPOs of closed-end stock funds. (Relatedly, Hanley et al. (1996) find no initial overpricing in the sample of IPOs of closed-end funds, but "sharp price declines" once the initial price stabilization period has ended.) Muscarella (1988) finds overpricing (at the 10% level) in the case of MPL IPOs in some of his sub-samples. Finally, testing for adverse selection in IPOs on the Tel Aviv Stock Exchange, Amihud et al. (2003) find evidence of negative excess returns for uninformed investors.

[2] There are other examples of overpricing in the literature. In Hughes and Thakor (1992) myopic issuers knowingly float overpriced securities. However, in their model there is no overpricing *in expectation*, which is what the empirical evidence on overpricing seems to suggest there is. In Chemmanur (1993) there may be overpricing in expectation relative to ex-ante expected *true* value (or the average value of firms coming to the market). This definition of overpricing differs from the one employed here of overpricing relative to the ex-ante expected (or average) *aftermarket* value of the securities that are floated in the IPO, which is consistent with the empirical evidence of overpricing relative to the average aftermarket value of IPO securities. In any case, Chemmanur (1993) does not pursue the overpricing aspect of his model, and the type of overpricing that obtains in his model does not generate the type of empirical implications that are derived in the present paper (see Appendix B for a closer comparison).

[3] In firm commitment offerings this obtains from the commitment made by underwriters to absorb unsold shares at the IPO stage, along with the use of the over-allotment option and the general stabilization activities undertaken by underwriters (see, e.g., Aggarwal (2000) and Ellis et al. (1999) for descriptions and analysis of underwriters' stabilization activities). In best effort offerings it obtains essentially by definition, since these are sold with a prespecified minimum and maximum number of shares. Not all fixed-price offerings across the world are sold with a best effort feature though, as noted by Sherman (2002).

underestimate initial returns in IPOs, and thus that inferences based on equally-weighted returns may be misleading.

It is important to note here that it is not issue size per se that matters, but issue size relative to some pre-stated minimum as revealed, for example, in the offering prospectus. The idea is that investors, when computing expectations over allocations and aftermarket values, will take into account the possibility that the number of securities that are floated in the offering will be higher in hot offerings than in cold ones. This leads to a higher equilibrium offering price and, all else the same, less money on the table for investors. However, for a given offering price, allowing the size of the issue to adjust to the demand for allocations implies more money on the table for investors, since a strong demand for allocations generally means high ex-post underpricing. When initial returns are calculated by taking the percentage change from the initial offer price to the first closing price in the aftermarket and then taking an equally-weighted average across the sample to arrive at the sample mean, then this second effect is ignored and thus only the price effect is counted. The result is that estimated returns will understate the returns that are available to investors, and hence understate initial returns in IPOs.[4]

The model is based on the adverse selection argument of Rock (1986). As such, underpricing represents a compensation to the marginal investor in the offering for being allocated a disproportionately small fraction of high-value issues relative to the fraction of high-value issues in the pool of completed IPOs. By analogy, the condition for overpricing must be that the marginal investor in the offering is allocated a disproportionately large fraction of high-value issues compared to the fraction of high-value issues in the pool of completed IPOs. This is possible, but only if the number of completed offerings is left unadjusted for the fact that the number of securities that are floated in the offering is contingent on the state of the demand. Once this adjustment is made, the IPO is shown unambiguously to be underpriced in equilibrium, as long as investors differ in the precision of their information, consistent with the adverse selection argument.

Note that although the model is based on the adverse selection argument, its central insight does not depend on the particular friction that is assumed for underpricing, and neither does it depend on whether the IPO is sold as a fixed price offer or through book-building. It will become clear, for example, that the book-building framework of Benveniste and Spindt (1989) will yield similar results as long as the underwriter is able to promise investors allocations in future issues in return for accepting overpriced securities in states with weak demand. A good reason for using the adverse selection friction, however, is that the empirical evidence on overpricing (as well as that on overpricing versus underpricing) is typically interpreted in terms of adverse selection, and the present model is consistent with this evidence.

The rest of the paper is organized as follows. Section 2 presents the basic model. Section 3 derives and examines the main results. Section 4 discusses empirical impli-

[4] The use of equally-weighted returns is very common in the literature. For example, all the IPO articles referenced by Ritter (1998) use equally-weighted returns. There are exceptions in the literature but these involve the use of proceeds-weighted returns, which decrease estimated returns by increasing the relative weights of large firms, which are less underpriced than small firms (see Lowry and Schwert, 2002).

cations and relate them to the evidence. Section 5 concludes the paper. All proofs are in Appendix A.

2. The model

2.1. The setup

Consider the following three date setting. An issuer is selling unseasoned securities to public investors in an initial public offering (IPO) on date 0. A market value for these securities is established on date 1, and their true value is revealed on date 2. True value (per security) is given by v_k; $k = G, B$; where $v_G > v_B \geqslant 0$, $k = G$ with probability α, and $k = B$ with probability $1 - \alpha$. This gives an expected value of $Ev \equiv \alpha v_G + (1 - \alpha)v_B$. An issue will be referred to as *high-value* if $k = G$, and *low-value* if $k = B$. All agents are risk neutral, and the riskless interest rate is zero.

There is one informed investor (I) and one less-informed investor (investor L) in the offering. Each investor observes a costless private signal $s_k^i \in \{s_B^i, s_G^i\}$; $i = I, L$ about the issue. The conditional probability of s_k^i given v_k is denoted $P(s_k^i \mid v_k)$. It is assumed that $\gamma_i \equiv P(s_G^i \mid v_G) = P(s_B^i \mid v_B)$, where $\gamma_I, \gamma_L \geqslant 1/2$ and $\gamma_I \geqslant \gamma_L$. The latter inequality says that the signal observed by investor I is more precise than that observed by investor L.

The price in the aftermarket (date 1) is denoted $V(.,.)$, and is determined as a function of the signals observed by investors. Specifically, $V(s_k^L, s_k^I)$ represents the expected true value of the IPO security given signals s_k^L and s_k^I. This implies that $V(s_L^G, s_I^G) > V(s_L^B, s_I^G) > V(s_L^G, s_I^B) > V(s_L^B, s_I^B)$, whenever $\gamma_I > \gamma_L$.

The issuer has no private information in the offering. This assumption simplifies the model without altering its main insights. The issuer determines the IPO price, denoted P_0, before investors ask for allocations, and hence before their signals are revealed. Although this resembles the fixed-price method, the basic argument applies to a book-building setting as well, as discussed in Section 3.3.

It is assumed that an investor will request an allocation in the offering only after observing a positive signal.[5] Hence, if both investors observe unfavorable signals, there is zero demand and thus the issue is withdrawn. This specification implies that the IPO will fail with a positive probability, which is the case in practice.[6] This probability can, in any case,

[5] This comes from an implicit assumption that the issuer prices the issue so that only investors with favorable information will want to request allocations in it. Although we may imagine other pricing strategies, whose optimality would depend on the issuer's objective function (which is left unspecified in the present setting), such as pricing the issue so that only the informed investor will request an allocation (upon observing a good signal), the one considered here is the one that yields interesting results for the current purpose. In any case, if the issuer maximizes a combination of her expected proceeds in the issue and the value of her remaining stake in the firm, then the present pricing strategy can be shown to be optimal if the cost of a failed issue is sufficiently large, and investors are not too different in the precision of their information.

[6] For example, Dunbar (1998) finds failure rates (for firm commitment offerings and best effort offerings combined) to be around 30%. Benveniste et al. (2001) detect a failure rate (for firm commitment offerings) of 14%, which they find is large enough to affect the sign as well as the significance of their parameter estimates.

be made arbitrarily small by letting a sufficiently large number of investors participate in the offering.

Each investor requests either one security in the offering (if $s_i^k = s_i^G$), or none (if $s_i^k = s_i^B$). The total number of securities requested is therefore zero (and the offering is withdrawn), one (in the *low-demand state* where only one investor obtains a positive signal), or two (in the *high-demand state* where both investors obtain positive signals). The issuer seeks to float at least one security in the offering, but may float as many as $1+a$, where $a \in [0,1)$. In the low-demand states only one security is requested, so only one security is floated. In the high-demand state, the issuer responds to the greater demand by selling $1+a$ securities at the posted price, and allocates $(1+a)/2$ securities to each investor.[7] Thus, $a > 0$ implies that the supply of securities in the offering is positively related to the demand for allocations,[8] and $a < 1$ ensures that the issue is rationed in the high-demand state.

2.2. The IPO price

As noted, the issue is priced so that only investors with favorable information ask for allocations. The signal observed by investor L is less precise than that observed by investor I. This implies that investor L is allocated a disproportionately large fraction of low-value issues compared to investor I, and hence that investor L is the marginal investor in the offering (more on this below).

The offering is priced from investor L's participation constraint

$$P\left(s_B^I \mid s_G^L\right)\left[V\left(s_G^L, s_B^I\right) - P_0\right] + \frac{1}{2}(1+a)P\left(s_G^I \mid s_G^L\right)\left[V\left(s_G^L, s_G^I\right) - P_0\right] = 0 \tag{1}$$

where $P(s_k^I \mid s_G^L)$ denotes the probability of s_k^I conditional on $s_k^L = s_G^L$. Solving (1) with respect to the IPO price gives

$$P_0 = \frac{P\left(s_B^I \mid s_G^L\right)V\left(s_G^L, s_B^I\right) + \frac{1}{2}(1+a)P\left(s_G^I \mid s_G^L\right)V\left(s_G^L, s_G^I\right)}{P\left(s_B^I \mid s_G^L\right) + \frac{1}{2}(1+a)P\left(s_G^I \mid s_G^L\right)}. \tag{2}$$

The right-hand side of (2) represents the expected aftermarket value of the IPO security, conditioned on $s_k^L = s_G^L$ and adjusted for the expected amount of rationing facing the marginal investor.

It will be convenient to express the IPO price in terms of the true value of the IPO security rather than its aftermarket value. By Bayes' Rule we have

$$P_0 = \alpha_L v_G + (1-\alpha_L)v_B, \tag{3}$$

[7] An alternative interpretation is that the issuer sells $1+a$ shares in the offering with the underwriter absorbing a shares in the event of low demand. I am grateful to an anonymous referee for pointing out the relevance to the present argument of the commitment of the underwriter in firm commitment offerings to absorb unsold shares.

[8] As noted in the introduction, this is the case in best efforts by the fact that these are sold with a pre-stated maximum and minimum quantity of securities to be sold, and in firm commitment offerings through the use of the over-allotment option, the commitment by underwriters to absorb usold shares, along with general stabilization activities.

where

$$\alpha_L \equiv \frac{[2-(1-a)\gamma_I]\gamma_L\alpha}{[2-(1-a)\gamma_I]\gamma_L\alpha + [1+\gamma_I + a(1-\gamma_I)](1-\gamma_L)(1-\alpha)} \tag{4}$$

represents the fraction of high-value issues in the pool of securities allocated to investor L. In other words, α_L represents the probability from the perspective of investor I of being allocated a high-value issue. It is straightforward to show that the corresponding probability for investor I is greater (since $\gamma_I \geqslant \gamma_L$), which makes investor L the marginal investor in the offering.[9]

3. Overpricing and underpricing

To determine whether the IPO is overpriced or underpriced in equilibrium, we need a benchmark against which to compare the offer price. There are two benchmarks of relevance. The first is the expected aftermarket value of the IPO security, which I will refer to as the *equally-weighted* benchmark. This is the benchmark that is assumed, at least implicitly, in empirical investigations when the average initial return is calculated as an equally-weighted average across the sample. The alternative benchmark, which I will refer to as the *float-weighted* benchmark, is given by the expected aftermarket value of the IPO security, with the probability of each state adjusted by the relative size of the issue for that state.[10] That is, the probability distribution over aftermarket value is adjusted for the relative number of securities floated in each state.

3.1. The equally-weighted benchmark

The equally-weighted benchmark is given by the expected aftermarket value of the IPO security, as follows:

$$\bar{v} = \frac{P\left(s_G^L, s_B^I\right)V\left(s_G^L, s_B^I\right) + P\left(s_B^L, s_G^I\right)V\left(s_B^L, s_G^I\right) + P\left(s_G^L, s_G^I\right)V\left(s_G^L, s_G^I\right)}{P\left(s_G^L, s_B^I\right) + P\left(s_B^L, s_G^I\right) + P\left(s_G^L, s_G^I\right)}, \tag{5}$$

where $P(s_k^L, s_k^I)$; $k = G, B$ denotes the joint probability of signals s_k^L and s_k^I. The expectation $\bar{v}$ represents the expected true value of the IPO security, conditional on the offering being completed successfully. Using Bayes' Rule, the expression for $\bar{v}$ may be written

$$\bar{v} = \alpha_v v_G + (1-\alpha_v)v_B, \tag{6}$$

[9] Since the probability $P(s_G^L \mid s_G^I)$ from investor I's perspective of the high-demand state occurring is larger than the corresponding probability $P(s_G^I \mid s_G^L)$ of investor L only if $\alpha > 1/2$, it is not all that obvious that investor L should be the marginal investor in the offering. However, the securities that are allocated to investor I in the low-demand state are less overpriced than those allocated to investor L, which in turn ensures that investor L is allocated a disproportionately large fraction of low value issues compared to investor I.

[10] In earlier versions of the paper, I referred to this benchmark as *allocation-weighted*. I am grateful to Jeffrey Wurgler for suggesting the more appropriate term *float-weighted*.

where

$$\alpha_v \equiv \frac{(\gamma_I + \gamma_L - \gamma_I\gamma_L)\alpha}{(\gamma_I + \gamma_L - \gamma_I\gamma_L)\alpha + (1-\gamma_I\gamma_L)(1-\alpha)} \tag{7}$$

represents the fraction of high-value issues in the pool of completed offerings.[11] The offering is now overpriced (or else underpriced) relative to $\bar{v}$ if $P_0 > \bar{v}$, and hence if $\alpha_L > \alpha_v$. Thus, the offering is overpriced in equilibrium relative to $\bar{v}$ if the fraction of high-value issues in the pool of securities that are allocated to investor L exceeds the fraction of high-value issues in the pool of completed IPOs.

Since P_0 is increasing in a, while the equally-weighted benchmark $\bar{v}$ is unrelated to a, it is clear that the offering will be overpriced relative to $\bar{v}$ for sufficiently large a. It is less clear, however, that there will be overpricing relative to $\bar{v}$ for $a < 1$, in which case the issue is rationed in the high-demand state. This is indeed the interesting case, and henceforth I refer to overpricing as a situation under which $P_0 > \bar{v}$ for $a < 1$.

Proposition 1. *There exists a critical value for the issuer's demand response parameter, a, such that the IPO will be overpriced relative to the equally-weighted benchmark $\bar{v}$ if a exceeds this critical value, and will be underpriced otherwise.*

The critical value of a has the following properties:

(i) *it equals zero if the precision in the signals observed by investors is equal* (*i.e.*, $\gamma_I = \gamma_L$),
(ii) *it is strictly greater than one if either the signal observed by the informed investor is without noise* ($\gamma_I = 1$), *or the signal observed by the less-informed investor is uninformative* ($\gamma_L = 1/2$),
(iii) *it is decreasing in the precision γ_I of the signal observed by the informed investor, and increasing in the precision γ_L in the signal observed by the less-informed investor, and*
(iv) *it lies in the interval* $[0, 1)$ *for γ_I and γ_L sufficiently close.*

The proposition establishes that overpricing relative to the equally-weighted benchmark $\bar{v}$ is possible. In fact, it shows that if investors are homogeneous in the precision of their information, in which case there is no adverse selection, then the offering will be strictly overpriced in equilibrium for any $a > 0$. Furthermore, it shows that overpricing is less likely to arise the more investors differ in the precision of their information, and hence the more extensive is the adverse selection problem facing the marginal investor. Indeed, overpricing does not obtain if investors are sufficiently different in the precision in their signals, and hence if the adverse selection problem facing the marginal investor is sufficiently severe.

Intuitively, overpricing in the sense of Proposition 1 obtains when the fraction α_L of high-value issues in the pool of securities allocated to the less-informed investor exceeds the fraction α_v of high-value issues in the pool of completed IPOs. That is, overpricing in the sense of Proposition 1 arises when the less-informed investor is allocated a disproportionately large fraction of high-value issues relative to the fraction of high-value issues

[11] Note that $\alpha_v \geqslant \alpha$ and hence that $\bar{v} \geqslant Ev$.

in the pool of completed IPOs. The problem with this comparison, however, is that while α_L is adjusted for the possibility that a greater number of securities will be floated when the demand for allocations is higher, α_v is not. Hence, the comparison between α_L and α_v is not appropriate unless $a = 0$, and thus using $\bar{v}$ as benchmark is not appropriate unless $a = 0$. In the next section, I consider a float-weighted benchmark which specifically allows $a \geqslant 0$.

3.2. *The float-weighted benchmark*

If $a > 0$, then the equally-weighted benchmark $\bar{v}$ understates the true expected after-market value of the IPO security by understating the true probability of drawing a security from the high-demand state, and thus understating the true probability of drawing a high-value issue from the pool of completed IPOs. The following float-weighted benchmark avoids this problem. It is given by

$$\bar{v}_a = \frac{P\left(s_G^L, s_B^I\right)V\left(s_G^L, s_B^I\right) + P\left(s_B^L, s_G^I\right)V\left(s_B^L, s_G^I\right) + (1+a)P\left(s_G^L, s_G^I\right)V\left(s_G^L, s_G^I\right)}{P\left(s_G^L, s_B^I\right) + P\left(s_B^L, s_G^I\right) + (1+a)P\left(s_G^L, s_G^I\right)}. \tag{8}$$

The expression for $\bar{v}_a$ may be written in terms of true value as follows:

$$\bar{v}_a = \alpha_{va} v_G + (1 - \alpha_{va}) v_B, \tag{9}$$

where

$$a_{va} \equiv \frac{(\gamma_I + \gamma_L - (1-a)\gamma_I\gamma_L)\alpha}{(\gamma_I + \gamma_L - (1-a)\gamma_I\gamma_L)\alpha + (1 - \gamma_I\gamma_L + a(1-\gamma_L)(1-\gamma_I))(1-\alpha)}, \tag{10}$$

which represents the fraction of high-value issues among the securities in the pool of completed IPOs. From the earlier discussion, it is clear that $\alpha_{va} \geqslant \alpha_v$, and hence that $\bar{v}_a \geqslant \bar{v}$. The inequalities are strict for $a > 0$.

The offering is underpriced relative to $\bar{v}_a$ if $P_0 < \bar{v}_a$, and hence if $\alpha_L < \alpha_{va}$. In other words, the offering is underpriced relative to $\bar{v}_a$ if the fraction of high-value issues among the securities that are allocated to the less-informed investor is less than the fraction of high-value issues among the securities in the pool of completed IPOs.

Proposition 2. *The IPO is strictly underpriced in equilibrium relative to the float-weighted benchmark $\bar{v}_a$ whenever investors differ in the precision of their information. Otherwise, i.e. if investors are homogeneous in the precision of their information, the IPO is priced equal to the float-weighted benchmark.*

Thus, the IPO can never be overpriced in equilibrium relative to the float-weighted benchmark, and will be strictly underpriced relative to this benchmark if investors differ in the precision of their signals. In other words, the IPO will be strictly underpriced in equilibrium in the presence of adverse selection. This result restates Rock (1986) for a setting in which the size of the issue may be correlated with the demand for allocations.[12]

[12] See Appendix B for a closer comparison to Rock (1986).

3.3. The amount of money left on the table

Propositions 1 and 2 are derived by comparing the IPO price P_0 to the two benchmarks $\bar{v}$ and $\bar{v}_a$. It will be useful to take a second look at the two propositions by looking at two alternative expressions for the expected amount of money left on the table in the offering (or the expected rent captured by investors). Consider first the expression for this rent if we incorrectly assume that $a = 0$:

$$U = P\big(s_G^L, s_B^I\big)\big[V\big(s_G^L, s_B^I\big) - P_0\big] + P\big(s_B^L, s_G^I\big)\big[V\big(s_B^L, s_G^I\big) - P_0\big] + P\big(s_G^L, s_G^I\big)\big[V\big(s_G^L, s_G^I\big) - P_0\big], \tag{11}$$

which clearly understates the expected amount left on the table if $a > 0$. Indeed, consistent with Proposition 1, collecting terms and rearranging, it is immediate that $U \geqslant 0$ iff $\bar{v} \geqslant P_0$, and that $U < 0$ iff $\bar{v} < P_0$. Thus, overpricing in the sense of Proposition 1 implies negative expected rents to investors, which is unreasonable.

Consider therefore the expression for the expected rent earned by investors when allowing for the possibility that $a > 0$:

$$U_a = P\big(s_G^L, s_B^I\big)\big[V\big(s_G^L, s_B^I\big) - P_0\big] + P\big(s_B^L, s_G^I\big)\big[V\big(s_B^L, s_G^I\big) - P_0\big] + (1+a)P\big(s_G^L, s_G^I\big)\big[V\big(s_G^L, s_G^I\big) - P_0\big]. \tag{12}$$

Collecting terms and rearranging, it is immediate that $U_a \geqslant 0$ iff $\bar{v}_a \geqslant P_0$. Thus, the expected amount of money left on the table in the IPO is positive if and only if the offering is underpriced in equilibrium in the sense of Proposition 2.[13] This is a reasonable result and suggests that $\bar{v}_a$ is indeed the appropriate benchmark.

Note that although I have used the adverse selection friction to generate underpricing, the central insight of the paper, namely that equally-weighted returns underestimate the returns available to investors and in the extreme may give overpricing, goes beyond adverse selection. This is seen by noticing that overpricing in the sense of Proposition 1 requires that $U < 0$, which in turn requires that the issue, ex-post, is overpriced in at least one state. In the present setting, this occurs in the low-demand state where only one of the two investors requests shares in the offering. In the book-building framework of Benveniste and Spindt (1989) state-by-state overpricing, and hence overpricing relative to an equally-weighted benchmark, requires that the investment banker is able to promise allocations in future issues in return for accepting overpriced shares in states with weak demand. In other words, it requires a multiperiod model.

Finally, how does the amount of money left on the table in the IPO respond to a change in a? That is, does allowing $a > 0$ increase or decrease underpricing? There are two opposing effects. An increase in a increases the IPO price and thus decreases the amount of

[13] Note that investor L earns no rent in the offering and thus that U_a represents the informational rent captured by investor I. To see this, note that the rent earned by investor I is given by

$$P\big(s_B^L, s_G^I\big)\big[V\big(s_B^L, s_G^I\big) - P_0\big] + \frac{1+a}{2} P\big(s_G^L, s_G^I\big)\big[V\big(s_G^L, s_G^I\big) - P_0\big],$$

which can be shown to be identical to U_a if the offering is priced along the participation constraint of investor L.

money that is left on the table in the offering. On the other hand, an increase in a also implies that the issuer must sell more shares in the high-demand state, and this increases the amount of money left on the table. It is not immediate which of these two effects dominate.

Lemma 1. *The expected amount of money that is left on the table in the offering, U_a, is decreasing in the issuer's demand response parameter a, if $P(s_G^L \mid s_G^I) < P(s_G^I \mid s_G^L)$ (i.e., if $\alpha < 1/2$), and increasing in a if $P(s_G^L \mid s_G^I) > P(s_G^I \mid s_G^L)$ (i.e., if $\alpha > 1/2$).*

Recall that U_a represents the informational rent that is captured by investor I (footnote 13). Assume that $P(s_G^L \mid s_G^I) < P(s_G^I \mid s_G^L)$ (and hence that $\alpha < 1/2$). This inequality implies that the (relevant) probability from investor I's perspective of ending up in the high-demand state is less than the corresponding probability of investor L, and thus that investor L will exhibit a greater willingness to substitute a higher IPO price for a greater allocation in the high-demand state. Since the IPO is priced from the participation constraint of investor L, an increase in a will reduce the rent going to investor I and hence reduce the amount of money that is left on the table.

Ritter (1987) suggests that allowing the size of the issue to be increased in the event of high demand ameliorates the adverse selection problem in IPOs and thus decreases underpricing, by increasing the IPO price. Lemma 1 extends this insight by showing that there is also a cost involved, and that this cost may outweigh the benefit. Chowdry and Nanda (1996) study ex-post stabilization activities by underwriters, showing that stabilization reduces the adverse selection problem facing uninformed investors and thereby increases the proceeds that can be raised in the offering. Lemma 1 indicates, in contrast, that stabilization may not be all favorable. Indeed, associating a lower α with greater ex-ante uncertainty, the lemma implies that riskier issues will benefit from stabilization, while safer issues will be hurt by it.[14]

4. Empirical implications and evidence

4.1. Average initial returns

The theoretical analysis implies an equally-weighted initial return equal to $\bar{r} \equiv \bar{v}/P_0 - 1$, and a float-weighted initial equal to $\bar{r}_a \equiv \bar{v}_a/P_0 - 1$. I now consider their empirical counterparts.

The equally-weighted average typically used in empirical investigations is the following:

$$r \equiv \sum_{i=1}^{n} \frac{r_i}{n}, \tag{13}$$

[14] There is some evidence in support of this contention. Specifically, Hansen et al. (1987) find that riskier issues are more likely to be floated using an over-allotment option.

where n is the sample size and r_i is the return on the ith offering, computed as the percentage change from the initial offer price to the first closing price in the aftermarket. The present argument suggests that r underestimates actual IPO returns, since it ignores the possibility that the issue size is positively correlated with the demand for allocations.

Consider therefore the following float-weighted average:

$$r_a \equiv \sum_{i=1}^{n} \frac{(1+a_i)r_i}{n+\sum_{i=1}^{n} a_i}, \tag{14}$$

where a_i is the percentage change in the number of securities that are floated relative to a pre-stated minimum.[15] The present model implies that the float-weighted average r_a is positive (Proposition 2), while the equally-weighted average r may be positive or negative depending on parameter values (Proposition 1).

And it implies that r gives biased estimates for initial returns in IPOs, while r_a does not. This bias may depend on the type of offering method that is used, the type of security that is floated, and on the particular time period that is considered. With respect to the latter, it is likely that equally-weighted returns are relatively accurate in hot issue periods, since during these periods the over-allotment option is generally fully exercised, and few (if any) offerings are under-subscribed.

A well-known implication of the adverse selection argument is that returns weighted by the probability of obtaining an allocation in the offering should be zero for the marginal (or *uninformed*) investor.[16] The present analysis complements this implication by suggesting that returns should also be weighted by the extent to which the size of the issue correlates with investors' demand for allocations. Thus, to appropriately test the Rock prediction of zero (excess) returns for the uninformed investor, probability-weighted returns should be generated from float-weighted returns rather than from equally-weighted returns.

4.2. Ex-ante uncertainty

A well-known implication of the adverse selection argument is that greater ex-ante uncertainty will increase the adverse selection problem facing the marginal investor, and thus increase underpricing (see Beatty and Ritter, 1986). A common inference from this implication is that overpricing is more likely the lower is ex-ante uncertainty.[17] However, this inference is inconsistent with the present model, as shown next.

[15] Depending on how one defines this minimum, a_i may be negative if the investment banker ends up absorbing unsold securities.

[16] Indeed, as noted by Rock (1986), and recently quoted by Amihud et al. (2003), "weighting the returns by the probabilities of obtaining an allocation should leave the uninformed investor earning the riskless rate."

[17] For example, Wang et al. (1992) predict that "given a higher level of uncertainty [in REIT IPOs compared to industrial firm IPOs] and existing IPO theories, we might expect REIT IPOs to be significantly underpriced." Commenting on their findings of overpricing for investment-grade bonds and underpricing for low-grade bonds, Datta et al. (1997) note that "this finding is also consistent with Beatty and Ritter's (1986) proposition on ex-ante uncertainty." Finally, Ling and Ryngaert (1997) observe that "Under Rock (1986)... this increased uncertainty could result in higher initial-day returns for recent REIT IPOs compared to their predecessors."

Proposition 3. *The equally-weighted return $\bar{r} = \bar{v}/P_0 - 1$ is increasing in ex-ante uncertainty for issues that are underpriced in equilibrium, and decreasing in ex-ante uncertainty for issues that are overpriced in equilibrium.*

Proposition 3 is consistent with the evidence. In particular, Wang et al. (1992) find the amount of overpricing in their sample of REIT IPOs to be increasing in proxies for ex-ante uncertainty, while Beatty and Ritter (1986) and others document a positive relation between ex-ante uncertainty and the amount of underpricing in common stock IPOs.

Datta et al. (1997) find overpricing in IPOs of investment-grade corporate bonds and underpricing in junk-grade bonds. Proposition 3 predicts a positive relation between ex-ante uncertainty and overpricing in investment-grade bonds, and similarly a positive relation between ex-ante uncertainty and underpricing in junk-grade bonds.

The next result considers the relation between ex-ante uncertainty and the float-weighted initial return.

Proposition 4. *The float-weighted return $\bar{r}_a = \bar{v}_a/P_0 - 1$ is increasing in ex-ante uncertainty.*

In other words, underpricing generated from float-weighted returns is increasing in ex-ante uncertainty. This result is consistent with the well-known comparative statics implication of the adverse selection argument as identified by Beatty and Ritter (1986). Empirically, it implies that the positive relation between overpricing and ex-uncertainty in the REIT sample of Wang et al. (1992) will switch to a positive relation between underpricing and ex-ante uncertainty once their analysis is based on float-weighted returns.

4.3. Adverse selection

Proposition 1 implies that overpricing is more likely the more homogeneous are investors. This is consistent with the finding of Datta et al. (1997) of overpricing in IPOs of high-grade bonds (where investor heterogeneity is low) and underpricing in IPOs of junk-grade bonds (where investor heterogeneity is higher). Other evidence is Wang et al.'s (1992) finding of overpricing in REIT IPOs, and Ling and Ryngaert's (1997) finding of underpricing in a more recent sample of REIT IPOs.

Ling and Ryngaert ascribe this switch from overpricing to underpricing in more recent REIT IPOs to an increase in adverse selection risk arising from greater valuation uncertainty and higher institutional participation. While the present model is consistent with their hypothesis, it is also able to account for the overpricing evidence of Wang et al. (1992), suggesting (by Propositions 1 and 3) that the switch from overpricing to underpricing in more recent REIT IPOs should be ascribed to greater investor heterogeneity rather than greater uncertainty. This implication also applies to Datta et al.'s (1997) finding of underpricing in speculative-grade bonds and overpricing in investment-grade bonds; that is, the reason for overpricing in investment-grade issues is not because they are less risky than speculative-grade issues, but because investors in high-grade issues are less heterogeneous than investors in speculative-grade issues.[18]

Michaely and Shaw (1994) find zero excess returns in MLP IPOs, which they interpret consistent with the adverse selection argument on account of an absence of institutional investors in these types of issues, and thus an absence of adverse selection. However, since their evidence is based on equally-weighted returns, it is not clear that MLP IPOs are not underpriced and thus it is not clear that there is no adverse selection in these types of IPOs. More generally, the present argument suggests that it may be inappropriate to conclude an absence of pricing frictions based on equally-weighted returns since these underestimate actual IPO returns.

5. Concluding remarks

Average initial returns used in empirical IPO research are typically equally-weighted. The use of equally-weighted returns, however, implicitly assumes that the size of the issue is unrelated to the demand for allocations, which is not generally the case in practice. Indeed, issuers typically adjust the offering size to the state of demand by floating a greater number of securities at the posted price when the demand for allocations is higher. This creates a positive correlation between the size of the issue and the demand for allocations, and thus a positive correlation between the size of the issue and initial returns. The result is that equally-weighted returns underestimate actual IPO returns, and thus inferences based on equally-weighted returns may be misleading.

This potentially has implications for comparisons across offering methods (best efforts versus firm commitments versus auctions), time periods, countries, and security types. Indeed, the paper shows that while an IPO may be overpriced in equilibrium based on equally-weighted returns, it can never be overpriced based on float-weighted returns, where weights are given by the extent to which the number of securities in the offering is increased relative to a pre-stated minimum. As such, the paper offers an explanation for the puzzling evidence of overpricing in some types of IPOs.

To generate underpricing, I used the winner's curse argument of Rock (1986), where underpricing is necessary to compensate uninformed investors for being allocated a disproportionately large fraction of low-value issues. A well-known empirical implication of the winner's curse argument is that average returns to uninformed investors should be zero if properly weighted by the probability of obtaining an allocation in the offering. The present argument complements this adjustment, suggesting that to appropriately test the winner's curse prediction of zero probability-weighted returns to uninformed investors, probability-weighted estimates should be based on float-weighted rather than equally-weighted returns.

An empirical implication of the model is that greater ex-ante uncertainty is associated with greater overpricing (based on equally-weighted returns). This prediction complements

[18] Indeed, this is consistent with Datta et al.'s observation that the investors in the two bond classes are different: "Conversations with investment bankers indicate that the markets for investment grade and junk grade bonds are segmented... where investment houses employ different sales forces for the two broad classes of bonds... Investment grade issues are sold exclusively on bond rating to investors who are interested primarily in safety of the principal and not in appreciation in price. On the other hand, not unlike equity offerings, junk grade issues are sold based on stories that relate to future prospects of the firms."

the well-known implication of the adverse selection argument of a positive correlation between the amount of underpricing and ex-ante uncertainty, and it is consistent with the (puzzling) evidence of Wang et al. (1992). An untested implication of the model is that the amount of underpricing based on float-weighted returns is positively correlated with ex-ante uncertainty.

The central insight of the paper is that equally-weighted initial returns underestimate the returns available to investors in IPOs, and that the type of float-weighted initial returns introduced in the present paper do not. This result is independent of the particular friction assumed for underpricing, and hence independent of whether the issue is sold as a fixed-price offer or using book-building. Future empirical work may determine whether the bias associated with the use of equally-weighted returns rather than float-weighted returns is large enough to matter, and whether it can explain the evidence of average overpricing in some types of IPOs.

Acknowledgments

I thank Frøystein Gjesdal, Hans K. Hvide, Thore Johnsen, Kjell Henry Knivsflå, Tommy Stamland, David Webb, seminar participants at the Norwegian School of Management BI and the FIBE XVI conference in Bergen, several anonymous referees, and especially Anjan V. Thakor (managing editor) for helpful comments. I am particularly indebted to Ernst-Ludwig von Thadden (editor) for many helpful comments, and patience.

Appendix A. Proofs

Proof of Proposition 1. Let a^* denote the critical value of a above which $NP_0 > \bar{v}$. To derive the expression for a^*, note that the offering is overpriced (underpriced) relative to $\bar{v}$ if $\alpha_L > (<)\, \alpha_v$. Setting up this inequality and rearranging gives

$$\big(2-(1-a)\gamma_I\big)(1-\gamma_I\gamma_L)\gamma_L > (<)\, (\gamma_I+\gamma_L-\gamma_I\gamma_L)\big(1+\gamma_I+a(1-\gamma_I)\big)(1-\gamma_L).$$

Rearranging further gives

$$a > a^* \equiv \frac{\gamma_I(1+\gamma_I)-2\gamma_I\gamma_L(\gamma_I-\gamma_L)-\gamma_L(1+\gamma_L)}{2\gamma_I\gamma_L(2-\gamma_I-\gamma_L)-\gamma_I(1-\gamma_I)-\gamma_L(1-\gamma_L)}.$$

Consider then the four properties stated for a^*:

(i) $\gamma \equiv \gamma_I = \gamma_L$ gives

$$a^* = \frac{0}{2\gamma(1-\gamma)(2\gamma-1)} = 0;$$

(iia) $\gamma_I = 1$ gives

$$a^* = \frac{2+\gamma_L^2-3\gamma_L}{\gamma_L(1-\gamma_L)} = \frac{2-\gamma_L}{\gamma_L} > 1;$$

(iib) $\gamma_L = 1/2$ gives

$$a^* = \frac{\gamma_I(1+\gamma_I) - 3/4 - \gamma_I(1-1/2)}{\gamma_I(3/2-\gamma_I) - \gamma_I(1-\gamma_I) - 1/4} = 3;$$

(iii) Taking the derivative with respect to γ_L yields

$$\frac{\partial a^*}{\partial \gamma_L} = -\frac{2(2\gamma_I - 1)(\gamma_I + \gamma_L^2 + 2\gamma_I^2\gamma_L^2 - 2\gamma_I^2\gamma_L - 2\gamma_I\gamma_L^2)}{[\gamma_I(1-\gamma_I) + \gamma_L(1-\gamma_L) - 2\gamma_I\gamma_L(2-\gamma_I-\gamma_L)]^2},$$

which is negative if

$$\gamma_I + \gamma_L^2 + 2\gamma_I^2\gamma_L^2 \geqslant 2\gamma_I^2\gamma_L + 2\gamma_I\gamma_L^2,$$

or if

$$\gamma_I + \gamma_L^2 \geqslant 2\gamma_I\gamma_L(\gamma_I + \gamma_L - \gamma_L\gamma_I).$$

This inequality holds if

$$\text{(i)} \quad \gamma_I + \gamma_L^2 \geqslant 2\gamma_I\gamma_L \quad \text{and} \quad \text{(ii)} \quad \gamma_I + \gamma_L - \gamma_L\gamma_I \leqslant 1.$$

To see that (i) is satisfied, note that since $\gamma_I + \gamma_L^2 \geqslant \gamma_I^2 + \gamma_L^2$, so that if $\gamma_I^2 + \gamma_L^2 \geqslant 2\gamma_I\gamma_L$, then clearly (i) must hold as well. To see that $\gamma_I^2 + \gamma_L^2 \geqslant 2\gamma_I\gamma_L$ is satisfied, note that it is equivalent to $\gamma_I^2 - 2\gamma_I\gamma_L + \gamma_L^2 \geqslant 0$ and hence to $(\gamma_I - \gamma_L)^2$.

Now to see that (ii) is satisfied, note that it can be rearranged to $\gamma_I(1-\gamma_L) \leqslant 1 - \gamma_L$, which is satisfied since $\gamma_I \leqslant 1$.

Consider then

$$\frac{\partial a^*}{\partial \gamma_I} = \frac{2(2\gamma_L - 1)(\gamma_L + \gamma_I^2 + 2\gamma_I^2\gamma_L^2 - 2\gamma_I^2\gamma_L - 2\gamma_I\gamma_L^2)}{[\gamma_I(1-\gamma_I) + \gamma_L(1-\gamma_L) - 2\gamma_I\gamma_L(2-\gamma_I-\gamma_L)]^2},$$

which is positive if $\gamma_L + \gamma_I^2 + 2\gamma_I^2\gamma_L^2 \geqslant \gamma_I + \gamma_L^2 + 2\gamma_I^2\gamma_L^2$ or if $\gamma_L(1-\gamma_L) > \gamma_I(1-\gamma_I)$. This latter inequality is satisfied since $\gamma_I > \gamma_L \geqslant 1/2$ and since $\gamma_i(1-\gamma_i)$; $i = I, L$ is maximized at $\gamma_i = 1/2$.

(iv) Property (iv) follows from (i), (ii), and (iii). □

Proof of Proposition 2. $P_0 \leqslant \bar{v}_a$ iff $\alpha_L \leqslant \alpha_{va}$, where we recall that

$$\alpha_L = \frac{[2-(1-a)\gamma_I]\gamma_L\alpha}{[2-(1-a)\gamma_I]\gamma_L\alpha + [1+\gamma_I + a(1-\gamma_I)](1-\gamma_L)(1-\alpha)}$$

and

$$a_{va} = \frac{(\gamma_I + \gamma_L - (1-a)\gamma_I\gamma_L)\alpha}{(\gamma_I + \gamma_L - (1-a)\gamma_I\gamma_L)\alpha + (1 - \gamma_I\gamma_L + a(1-\gamma_L)(1-\gamma_I))(1-\alpha)}.$$

To see that $\alpha_L = \alpha_{va}$ (and hence that $P_0 = \bar{v}_a$) for $\gamma_I = \gamma_L$, let $\gamma \equiv \gamma_L = \gamma_I$ and note that this yields

$$\alpha_L = \alpha_{va} = \frac{[2-(1-a)\gamma]\gamma\alpha}{[2-(1-a)\gamma]\gamma\alpha + [1+\gamma+a(1-\gamma)](1-\gamma)(1-\alpha)}.$$

To see that $\alpha_L < \alpha_{va}$ if $\gamma_L < \gamma_I$, note that it is sufficient for this inequality to be satisfied if

$$\bigl[2-(1-a)\gamma_I\bigr]\gamma_L > \bigl(\gamma_I+\gamma_L-(1-a)\gamma_I\gamma_L\bigr)$$

and

$$\bigl[1+\gamma_I+a(1-\gamma_I)\bigr](1-\gamma_L) < \bigl(1-\gamma_I\gamma_L+a(1-\gamma_L)(1-\gamma_I)\bigr)$$

are both satisfied. Straightforward manipulation shows that they are so long as $\gamma_L < \gamma_I$. □

Proof of Lemma 1. Differentiating U_a with respect to a gives

$$\frac{\partial U_a}{\partial a} = \frac{1}{2}P\bigl(s_G^L \mid s_G^I\bigr)\bigl[V\bigl(s_G^L, s_G^I\bigr)-P_0\bigr] - \left[P\bigl(s_G^L \mid s_G^I\bigr)+\frac{1+a}{2}P\bigl(s_G^L \mid s_G^I\bigr)\right]\frac{\partial P_0}{\partial a},$$

where

$$\frac{\partial P_0}{\partial a} = \frac{\frac{1}{2}P\bigl(s_G^I \mid s_G^L\bigr)P\bigl(s_B^I \mid s_G^L\bigr)\bigl[V\bigl(s_G^L, s_G^I\bigr)-V\bigl(s_G^L, s_B^I\bigr)\bigr]}{\bigl[P\bigl(s_B^I \mid s_G^L\bigr)+\frac{1+a}{2}P\bigl(s_G^I \mid s_G^L\bigr)\bigr]^2}.$$

It can now be shown that $\partial U_a/\partial a > 0$ if

$$\frac{P\bigl(s_G^L \mid s_G^I\bigr)}{P\bigl(s_B^L \mid s_G^I\bigr)+\frac{1+a}{2}P\bigl(s_G^L \mid s_G^I\bigr)} > \frac{P\bigl(s_G^I \mid s_G^L\bigr)}{P\bigl(s_B^I \mid s_G^L\bigr)+\frac{1+a}{2}P\bigl(s_G^I \mid s_G^L\bigr)},$$

which is satisfied if $P(s_G^L \mid s_G^I) > P(s_G^I \mid s_G^L)$.

To see that $P(s_G^L \mid s_G^I) > P(s_G^I \mid s_G^L)$ if $\alpha > 1/2$, note that

$$P\bigl(s_G^L \mid s_G^I\bigr) = \frac{P\bigl(s_G^L, s_G^I\bigr)}{P\bigl(s_G^I\bigr)} \quad \text{and} \quad P\bigl(s_G^I \mid s_G^L\bigr) = \frac{P\bigl(s_G^L, s_G^I\bigr)}{P\bigl(s_G^L\bigr)},$$

so $P(s_G^L \mid s_G^I) > P(s_G^I \mid s_G^L)$ iff $P(s_G^I) < P(s_G^L)$. Finally, noting that $P(s_G^I) = \gamma_I\alpha + (1-\gamma_I)(1-\alpha)$ and $P(s_G^L) = \gamma_L\alpha + (1-\gamma_L)(1-\alpha)$, it follows that $P(s_G^L \mid s_G^I) > P(s_G^I \mid s_G^L)$ if $\alpha > 1/2$. □

Proof of Proposition 3. Let $v_B = 0$, in which case

$$\bar{r} = \frac{\bar{v}}{P_0} - 1 = \frac{\alpha_v}{\alpha_L} - 1.$$

Comparing α_v and α_L, the condition for overpricing (underpricing) can be expressed:

$$\bigl(2-(1-a)\gamma_I\bigr)(1-\gamma_I\gamma_L)\gamma_L > (<)\,(\gamma_I+\gamma_L-\gamma_I\gamma_L)\bigl(1+\gamma_I+a(1-\gamma_I)\bigr)(1-\gamma_L).$$

An increase in α holding Ev constant implies lower ex ante uncertainty. Since v_G appears nowhere in expression for $\bar{r}$ to check for the impact of a change in ex ante uncertainty we take the change in $\bar{r}$ with respect to a change in α. It is now straightforward (although a bit tedious) to show that

$$\frac{\partial \bar{r}}{\partial \alpha} > (<)\,0$$

if

$$\big(2-(1-a)\gamma_I\big)(1-\gamma_I\gamma_L)\gamma_L > (<)\,(\gamma_I+\gamma_L-\gamma_I\gamma_L)\big(1+\gamma_I+a(1-\gamma_I)\big)(1-\gamma_L).$$

In other words, the equilibrium initial return $\bar{r}$ will be decreasing (increasing) in ex ante uncertainty if the IPO is overpriced (underpriced) in equilibrium. □

Proof of Proposition 4. Let $v_B = 0$, in which case

$$\bar{r}_a = \frac{\bar{v}_a}{P_0} - 1 = \frac{\alpha_{va}}{\alpha_L} - 1$$
$$= \psi \frac{[2-(1-a)\gamma_I]\gamma_L\alpha + [1+\gamma_I + a(1-\gamma_I)](1-\gamma_L)(1-\alpha)}{[\gamma_I+\gamma_L-(1-a)\gamma_I\gamma_L]\alpha + [1-\gamma_I\gamma_L + a(1-\gamma_L)(1-\gamma_I)](1-\alpha)} - 1,$$

where

$$\psi \equiv \frac{[\gamma_I+\gamma_L-(1-a)\gamma_I\gamma_L]}{[2-(1-a)\gamma_L]\gamma_I} > 0.$$

An increase in α is associated with a decrease in ex ante uncertainty. Thus, to prove the proposition, it must be shown that $\bar{r}_a$ is decreasing in α. Taking the derivative shows after some substitution that $\partial\bar{r}_a/\partial\alpha < 0$ so long as $\gamma_I > \gamma_L$. □

Appendix B. Two related frameworks

B.1. Rock (1986)

In Rock (1986), informed investors observe the true value of the firm without error (i.e., $\gamma_I = 1$), and uninformed investors observe no signals. In the present setting, an uninformed investor L will randomize between requesting and not requesting shares (requesting shares with probability $P(s_G^L) = 1/2$). An uninformed investor in the Rock setting requests shares as long as he expects to at break even.

Assume that there is one informed investor and one uninformed investor in the offering, and let investors be informed and uninformed in the sense of Rock. The IPO is priced from the participation constraint of the uninformed investor:

$$(1-\alpha)[v_B - P_0] + \frac{1+a}{2}\alpha[v_G - P_0] = 0 \tag{B.1}$$

where unlike Rock the size of the issue is allowed to covary with demand. Solving (B.1) with respect to the IPO price gives

$$P_0 = (1-\alpha_R)v_B + \alpha_R v_G \tag{B.2}$$

where

$$\alpha_R \equiv \frac{(1+a)\alpha/2}{(1-\alpha)+(1+a)\alpha/2}. \tag{B.3}$$

Note that the issue fails with probability zero since the uninformed investor submits non-randomized bids. The relevant ‘equally-weighted’ benchmark is therefore Ev.

Noting that $\alpha_R \leqslant \alpha$ if $(1+a)/2 \leqslant 1$, it follows that $P_0 \leqslant Ev$ for any $a \leqslant 1$, with the inequality being strict if $a < 1$. In other words, the IPO can never be overpriced in equilibrium (relative to Ev), even for $a = 1$. Hence, simply allowing the size of the issue to covary with demand does not trivially deliver overpricing in the basic Rock setting.

B.2. Chemmanur (1993)

At $\gamma_I = \gamma_L$, my model resembles a reduced form of Chemmanur (1993), where underpricing represents a compensation to investors for their costs of acquiring information. There are some differences, though. Specifically, he assumes that the investment bank picks up any unsold shares. This ensures that the IPO will fail with probability zero and hence that the relevant equally-weighted benchmark is Ev rather than $\bar{v}$ as in the present setting. Another difference is that investors calculate expectations with respect to final values rather than aftermarket values. This feature makes it necessary to define state-by-state allocation probabilities implicitly rather than explicitly as is done in the present analysis. Finally, he assumes that the size of the issue is unrelated to the state of demand, which in the present setting implies that $a = 0$.

To complete the comparison, let $\gamma \equiv \gamma_I = \gamma_L$ and $a = 0$, and assume that investors compute expectations over aftermarket value (as in the present setting) rather than final value. This gives an IPO price of

$$P_0 = \alpha_I v_G + (1 - \alpha_I) v_B (= \bar{v}),$$

where

$$\alpha_I = \frac{(2-\gamma)\gamma\alpha}{(2-\gamma)\gamma\alpha + (1-\gamma^2)(1-\alpha)}.$$

It can now be shown that $\alpha_I > \alpha$, which implies that $P_0 > Ev$. For the n-investor case, it can be shown that $P_0 \downarrow Ev$ as $n \to \infty$. Thus, the IPO will be overpriced relative to Ev for any $n < \infty$. Chemmanur notes the possibility of overpricing (relative to Ev) in his model, but he does not pursue this angle. In any case, the empirical implication of overpricing relative to Ev is not clear.

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