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The winner's curse and international methods of allocating initial public offerings

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Abstract

An interesting feature of the allocation of initial public offerings (IPOs) is that issuers in many countries tend to favor small over large investors. This occurs in the U.K., Hong Kong, Singapore, Malaysia, Indonesia, India, Thailand and Bangladesh, among other places. For example in Hong Kong between 1986 and 1992, around 85% of IPOs were allocated in a way that strictly favored smaller orders. The reason for favoring small investors over large investors is often thought to be some notion of 'fairness'. We develop a model to show that such a policy may, in fact, be consistent with revenue maximization by the issuing firm because it reduces the adverse selection or the 'winner's curse' problem pointed out by Rock (1986). The intuition is that informed investors tend to place larger orders than do uninformed investors even when they have the same wealth level; this tendency is obviously stronger if informed investors tend to be wealthier than the uninformed. We derive other empirical implications of the model and relate them to the stylized facts about IPOs in various countries.

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1. Introduction

It is now well established that initial public offerings (IPOs) are underpriced in most countries for which there is data (for the most complete documentation, see Loughran et al. (1994)). Beyond this basic fact, however, there are substantial international differences in IPOs, many of them due to differing regulations. Although there are many variations, there are three main methods for IPOs – the United States Firm Commitment method, the United Kingdom Open Offer For Sale and the tender (auction) method. Chowdhry and Sherman (1996) compare some key features of the first two methods and find that those features tend to lead towards greater underpricing for UK-style offerings. We expand this analysis by examining the strategic allocation of shares.

The US method¹ gives underwriters considerable discretion in allocating shares. Countries using the UK method, on the other hand, usually place restrictions on the allocation of shares. One common form of restriction is a 'Fairness Rule' requiring all orders of the same size to be treated the same *ex ante*.² Although discriminating between orders of the same size may be strictly forbidden in these systems, discriminating between investors on the basis of order size is often encouraged or even mandated. Small investors are typically favored over large investors, whether or not the government encourages such a distribution. Countries which tend to favor small investors include Hong Kong, India, Indonesia, Malaysia, Singapore, Thailand, Bangladesh and of course the United Kingdom, among others.

We will show that favoring small investors may increase the underwriter's expected revenues and reduce underpricing. The reason for this is that favoring small investors reduces the adverse selection or winner's curse problem (pointed out by Rock (1986)³) that the uninformed face, and it therefore reduces the need

¹ When we refer to the US method, we mean a US Firm Commitment offering. The other method available in the US is Best Efforts, which is less common and tends to be used by smaller, younger firms. When we refer to the UK method, we mean a UK Open Offer or Offer for Sale at a Fixed Price. Other methods available in the UK are Offer for Subscription, Offer for Sale by Tender, Placing and Introduction.

² Investors must have the same *ex ante* probability of receiving shares, although *ex post* their allocations may differ if shares are allocated through balloting. Balloting is similar to a lottery – investors receive, say, a 1 in 5 chance of being allocated a certain number of shares. This is particularly used for small orders in highly oversubscribed issues, since giving all small investors the same number of shares may lead to allocations of, say, just one or two shares worth only a few cents.

³ Rock (1986) demonstrated that, if some investors have more information than others about the value of IPO shares, the uninformed investors will face an adverse selection problem or 'winner's curse'. The term 'winner's curse' is from the auction literature: In a sealed bid auction with bidders who have some independent private information on the value of the item being auctioned, the highest bidder at the auction finds out *ex post* that her valuation was probably too high. Thus, the person who wins the auction may be cursed by learning that she overpaid. With IPOs, when the uninformed investors 'win' by receiving large allocations, it is because many informed investors chose not to order, and so there is a higher probability that the issue is overpriced. The uninformed realise this problem and reduce their orders accordingly.

to underprice issues in order to compensate investors for this. This is true even if the distribution of wealth is the same for informed and uninformed investors, since the informed optimally place larger orders (unless large orders are discriminated against too heavily).

Previous work by Chowdhry and Sherman (1996) compared US and UK-style IPOs. Under the UK method, underwriters have two reasons for underpricing IPOs. The first, which has already been discussed, is the adverse selection problem. The second reason for underpricing is to reduce the probability that the issue will fail due to the leakage of adverse information. Under the UK method the price of the issue is usually set well in advance, and there is a subscription period of several days or more during which investors may place their orders. During this period, there is a possibility of information leakage. Of course, the information revealed may be good, but the issuer and underwriter face the risk that the news will be bad, lowering demand for the issue and causing it to fail. Therefore, if failure is costly, they will underprice to make failure less likely.

The problem of information leakage with UK-style issues is aggravated by the fact that investors must pay in advance for the shares that they are ordering. This adds to the cost of ordering, particularly when demand and subscription levels are high, since investors may have to pay for, say, 30,000 shares to receive only 2,000. The payment for any unallocated shares is of course returned, but only after a delay and without any interest payment. The pay-in-advance requirement also increases the likelihood that information about market demand will leak out, as investors often borrow from banks to pay for their order. A third way that 'pay-in-advance' leads to underpricing is by lowering the cost of underpricing to the issuer, since the issuer earns the float or interest on the funds. This can be substantial, if issues tend to be oversubscribed. For instance, in Hong Kong issuers earn an average of HK\$150–200 million (roughly US\$19–26 million) in float alone!⁴ Obviously this reduces the cost of underpricing for the issuer.

Chowdhry and Sherman showed that, because of information leakage and the pay in advance system, UK style IPOs will tend to be more underpriced than US-style issues. Issuers under a UK system will underprice both because of the adverse selection problem and because of information leakage, whereas information leakage in the US is limited because the IPO price in US offerings is set only shortly before the shares are sold. However, the comparison of US and UK offerings becomes more complicated if underwriters can reduce or eliminate the winner's curse through their allocation method. We show that the allocation method can in fact affect the adverse selection problem.

In this paper, we allow issuers to strategically allocate shares based on order size. As in Rock, issuers need uninformed investors to ensure the success of their offering, and they must compensate those uninformed investors for the adverse

⁴ This estimate was given by the Hong Kong Securities and Futures Commission in early 1993.

selection problem that they face. Ideally, the issuers would like to directly favor uninformed over informed investors, but they cannot distinguish between the two. However, an informed investor with a good signal will place a higher value on the shares and will therefore be willing to order a larger amount than an uninformed investor with the same wealth level. Therefore, as long as informed investors on average are at least as wealthy as uninformed investors, we show that issuers can maximise their expected proceeds by favoring small over large investors.

We restrict issuers to discriminating based only on order size, rather than price, because this is the law in most Asian countries. Both Japan and Singapore have started to allow multi-price auctions for IPO shares in the last few years, however. Since April 1, 1989, prices for all IPO shares in Japan have been set through a multi-price auction of about 50% of the issued shares. The price for the remaining shares is based on the average auction price, discounted to reflect the popularity of the issue and general market conditions.⁵ In Singapore, issuers may still use the traditional method or can combine that method with an auction.⁶ The auction method at least potentially allows issuers to discriminate against informed investors through price rather than allocation. Nevertheless, both Japan and Singapore issues still tend to limit order sizes. In Japan, by law, no investor may be allocated more than 5,000 shares. In Singapore, it is common to limit each investor to no more than 1,000 to 2,000 shares or to discriminate heavily in favor of small orders, even when using an auction.

Other work on Asian IPOs has been primarily empirical. Besides the comprehensive Loughran, Ritter and Rydqvist paper, which reports underpricing for a wide range of countries, there are many studies documenting underpricing for individual countries. These include McGuiness (1992), Dawson (1987) and Cheung et al. (1993) for Hong Kong; Wethyavivorn and Koo-Smith (1991) for Thailand; Hwang and Jayaraman (1993), Pettway and Kaneko (1995a) and Pettway and Kaneko (1995b) for Japan; Finn and Higham (1988) and Lee et al. (1994) for Australia; Kim and Lee (1990), Kim et al. (1993) and Lim (1992) for Korea; Yong (1995) for Malaysia; and Koh and Walter (1989) for Singapore. The Koh and Walter paper was an influential test of Rock's winner's curse model of underpricing. It led the way to other similar studies on Asian markets, where the require-

⁵ Before December 27, 1992, issuers were not allowed to offer a discount from the average auction price for the remaining, non-auctioned shares. The underwriter has great discretion in allocating these non-auctioned shares, subject to a few restrictions. See Pettway and Kaneko (1995a) for a detailed description of the issue method for Japanese IPOs.

⁶ For instance, with the Singapore Telecom privatisation there were three tranches: a traditional fixed price tranche at a very favorable price, with a strict limit on the number of shares that could be purchased; another fixed price, limited order size tranche at a slightly higher price, for those who wanted more shares in addition to those they ordered through the first tranche; and an auction which was open to everyone. The first two tranches were open only to citizens of Singapore. Foreigners and those wanting a large number of shares had to bid for them through the multi-price auction.

ment (in some markets) that allocations be revealed ex post provides a unique opportunity to perform such tests.

There are also many papers which examine the post issue performance of IPOs.

While Ritter (1991) for the US and Lee, Taylor and Walter for Australia find that IPOs underperform in the long run, Kim et al. (1995a) and Kim and Lee (1990) for Korea, Kunimura and Severn (1990) for Japan and Dawson (1987) for Hong Kong and Singapore find no significant under- or over-performance after the initial return. Dawson also examines Malaysian IPOs and finds that they actually overperform relative to the available index, although he warns that this might be due to the lack of a comprehensive market index.

There is a need for more papers that describe the specific regulations and methods for IPOs in the countries studied. Many empirical IPO papers do not discuss or adjust for institutional features such as whether or not shares are paid for in advance, how shares are allocated, how the offering price is set (i.e. whether the government interferes), how long the process takes or whether the issuer earns interest on the total subscription funds. The best papers we have found for describing the features of their respective markets are Pettway and Kaneko (1995a) and Pettway and Kaneko (1995b) for Japan; McGuinness (1993) and Cheung et al. (1993) for Hong Kong; Finn and Higham (1988) for Australia; and Kim et al. (1995b) for Korea. In addition, Chowdhry and Sherman (1996) have a general discussion of common features in Asian markets.

The rest of the paper is organised as follows. Section 2 presents the model and gives the main results. Section 3 lists several testable empirical implications. Section 4 is the conclusion.

2. The model

Let V denote the true per share value of the firm. We assume that V can take two possible values with equal probabilities:

$$V = \begin{cases} \bar{V} + \delta & \text{with probability } \frac{1}{2}, \\ \bar{V} - \delta & \text{with probability } \frac{1}{2}, \end{cases}$$

with $\delta > 0$ and $\bar{V} \equiv E[V]$. We will denote the state with $V = \bar{V} + \delta$ as the good (G) state and the other as the bad (B) state. Let N denote the number of shares the firm issues. Let N_I denote the number of informed investors and N_U denote the number of uninformed investors. For simplicity we assume that all investors are risk-neutral. We assume that informed investors get to observe the true value V but the uninformed only know the distribution of V . We assume that a fraction ϕ of the informed and fraction ϕ of the uninformed investors have $\$W$ available for investing in the IPO: we will call these 'small' investors. The remaining investors

have $\$KW$, where $K > 1$, available for investing in the IPO. We will call these 'large' investors. We assume that

$$N(\bar{V} - \delta) > N_U W. \quad (1)$$

This assumption ensures that if all uninformed investors were to bid only $\$W$ for the issue (recall that a fraction $(1 - \phi)$ can bid more than $\$W$), the issue will not be fully subscribed when informed investors do not bid. Thus we are trying to capture the idea that the firm may need 'large' uninformed investors in order to ensure that the issue gets fully subscribed.

In addition to their own funds available for investing in the IPO, all investors can borrow from competitive banks using their own funds plus the shares of IPO that they receive as collateral. Without any loss of generality we assume that the risk-free rate of interest equals zero. We assume that banks are also uninformed about true per share value but know the distribution of V .

We assume that the firm can discriminate in its allocation of shares based only on the size of the bid. For a given bid size the allocation must be pro-rata. Let

α_G^L : fractional allocation in the good state for large orders,

α_G^S : fractional allocation in the good state for small orders,

α_B^L : fractional allocation in the bad state for large orders,

α_B^S : fractional allocation in the bad state for small orders.

Uninformed investors placing small orders will expect to make zero profits if

$$\alpha_G^S(\bar{V} + \delta - P_0) + \alpha_B^S(\bar{V} - \delta - P_0) = 0. \quad (2)$$

Similarly, uninformed investors placing large orders will expect to make zero profits if

$$\alpha_G^L(\bar{V} + \delta - P_0) + \alpha_B^L(\bar{V} - \delta - P_0) = 0. \quad (3)$$

From (2) and (3), it follows that

$$\frac{\alpha_G^L}{\alpha_G^S} = \frac{\alpha_B^L}{\alpha_B^S} \equiv \beta. \quad (4)$$

If $\beta < 1$, it implies that the firm discriminates against large orders in favor of small orders in its allocation. $\beta = 1$ implies that allocation is strictly pro-rata.

In order to change the required return of the uninformed investors, the issuer must somehow commit in advance, before the total demand is known, to some sort of allocation scheme. Announcing beta is one method that the issuer could specify in advance, at the same time that the price is set and before investors place their orders. In practice, issuers do not announce such a scheme, and any announcement that they intended to favor small investors might not even be binding. In many places that use the UK method for IPOs, however, the actual allocation becomes public knowledge ex post. Thus, an underwriter could develop a reputation by consistently favoring small investors. For such a reputation to be effective, though,

it must be at least somewhat predictable. The method used in this paper is one way of formalising the intention to favor small investors in all issues.

This method can never eliminate the adverse selection problem of the uninformed, however. The winner’s curse stems from the fact that the informed investors bid for shares only when the value of the firm is high. This is aggravated by the fact that the informed place higher bids than the uninformed. The two combined mean that the uninformed get a much smaller share of good issues than of bad issues. This method of favoring the uninformed reduces the second problem by decreasing the optimal bid size of the informed. It does not change the first problem, though – there are still more informed investors bidding for (ex post) underpriced than for overpriced shares.

The firm (or its underwriter) chooses the initial offer price P_0 as well as the rule for allocating the shares, β , so as to maximize the total proceeds NP_0 and ensure that the issue will be fully subscribed.

Lemma 1. If the offer price and the allocation rule is such that the expected profits that an uninformed investor makes by investing his own funds equal zero, then the uninformed investor has no incentive to borrow any funds from banks to bid for firm’s shares.

Proof. An uninformed investor makes zero expected profits if

$$\alpha_G \left(\frac{\bar{V} + \delta}{P_0} - 1 \right) + \alpha_L \left(\frac{\bar{V} - \delta}{P_0} - 1 \right) = 0,$$

where, for notational convenience, we have omitted the superscripts on α s which denote whether uninformed investor’s order is large or small. Let $\theta \equiv \alpha_G[(\bar{V} + \delta)/P_0 - 1]$.

Let E (equity) denote the uninformed investor’s own funds and let D (debt) denote the amount he borrows from banks. Let r denote the competitive interest that is charged by banks which satisfies the following zero-profit condition for banks:

$$\frac{1}{2} \left[\text{Min} \left\{ (1+r)D, \alpha_G \frac{E+D}{P_0} (\bar{V} + \delta) + (1 - \alpha_G)(E+D) \right\} + \text{Min} \left\{ (1+r)D, \alpha_B \frac{E+D}{P_0} (\bar{V} - \delta) + (1 - \alpha_B)(E+D) \right\} \right] = D.$$

The above condition can be rewritten as follows:

$$\text{Min}\{(1+r)D, (E+D)(1+\theta)\} + \text{Min}\{(1+r)D, (E+D)(1-\theta)\} = 2D.$$

In order to focus on a non-trivial case let us consider a scenario in which

$0 < r < \infty$. This is the case in which the borrowing is risky which must mean that the investor is able to meet his contractual loan repayment $(1+r)D$ in the good state but not in the bad state. It follows then that

$$(1+r)D = 2D - (E+D)(1-\theta).$$

The investor's expected wealth after repaying his debt equals

$$\frac{1}{2}[(E+D)(1+\theta) - (1+r)D].$$

Substituting from (5), the above expression equals E which is exactly the amount the uninformed investor invests from his own funds. Thus, he does not make any additional profits from borrowing and therefore has no incentive to borrow. \square

The result in the above lemma is trivial and the intuition is straightforward. Banks possess the same information as does any uninformed investor and therefore if an uninformed investor were to make positive expected profits by borrowing, it can only come at the expense of banks which is not feasible in a competitive equilibrium.

Since no uninformed investors will bid an amount larger than KW , it is straightforward to see that the firm can set a maximum order size equal to KW that will prevent an informed investor from bidding any amount larger than that.

Lemma 2. To ensure that the issue is fully subscribed in the bad state, β cannot be smaller than $1/K$.

Proof. To ensure that the issue will be fully subscribed in the bad state the following constraint must hold:

$$\phi N_U \alpha_B^S W + (1-\phi) N_U \alpha_B^L KW = NP_0,$$

where $\alpha_B^S \leq 1$ and $\alpha_B^L \leq 1$. Substituting from (4) into the above equation and rearranging, we get

$$\alpha_B^S = \frac{NP_0}{[\{\phi + (1-\phi)K\beta\}N_U]W} \leq 1. \quad (6)$$

Since $P_0 \geq \bar{V} - \delta$, it follows from our restriction (1) that the above constraint can only be satisfied if

$$K\beta > 1. \quad \square \quad (7)$$

It follows from the restriction (7) that an informed investor will have an incentive to bid a large amount despite the fact that large allocation may be discriminated against. The above restriction guarantees that despite this discrimination, i.e., $\beta < 1$, it is not large enough that he will prefer to bid W instead of bidding KW . This is because bidding KW generates a profit that is $K\beta$ times the profit generated by bidding W .

Lemma 3. Each small informed investor will borrow $(K - 1)W$ and invest KW to bid for firm's shares in the good state.

Proof. Let E denote the informed investor's own funds and let D denote the amount he borrows from banks. First, consider the scenarios in which the loan is risk-less. This happens if, in even the low state, there are enough funds to pay off the loan, i.e., if

$$(E + D)(1 - \theta) \geq D.$$

The informed investor will bid only in the good state when he knows that $V = \bar{V} + \delta$. If the loan is risk-less, the informed investor's profits after repaying the loan equal

$$(E + D)(1 + \theta) - D = (1 + \theta)E + \theta D.$$

It is easy to see that the above expression is increasing in D for $\theta > 0$. Therefore, the informed investor has an incentive to choose as large a loan as possible as long as it is risk-less. The largest feasible risk-less loan is given by

$$D = (E + D)(1 - \theta).$$

Rearranging, we get

$$D = \frac{1 - \theta}{\theta} E.$$

Substituting in (8), the profits with the maximal risk-free loan equal $2E$.

Now consider the case when he borrows more so that the loan becomes risky. Notice that Eq. (5) determines the competitive interest rate when the loan is risky. His profits then equal

$$(E + D)(1 + \theta) - (1 + r)D$$

which upon substitution from (5) can be seen to equal $2E$. Therefore, it follows that the informed investor is indifferent between borrowing the maximal amount of risk-free loan and any amount larger than that.

Thus, a small informed investor starting with initial funds of W will borrow $(K - 1)W$ in order to be able to bid KW . This is because, if he bids any amount larger than W that is not equal to KW he will be identified as an informed investor since uninformed investors bid either W or KW .⁷ □

The allocations in the good state must be such that

$$\left[N_I \alpha_G^L KW + \left\{ \phi N_U \alpha_G^S W + (1 - \phi) N_U \alpha_G^L KW \right\} \right] = NP_0.$$

⁷ A continuous distribution of wealth for uninformed investors will obviate the need for borrowing more than an amount that is consistent with risk-free borrowing.

Substituting from (9) into the above equation and rearranging, we get

$$\alpha_G^S = \frac{NP_0}{[K\beta N_1 + \{\phi + (1 - \phi)K\beta\}N_U]W}. \quad (9)$$

Proposition 1. The firm's revenues are maximized if it discriminates against large orders as much as is feasible, i.e., it chooses the smallest feasible β , which is obtained when $\alpha_B^S = 1$.

Proof. Solving for P_0 from (2), (6) and (9), we get

$$P_0 = \bar{V} - \delta \frac{1}{1 + 2[\{\phi + (1 - \phi)K\beta\}N_U/K\beta N_1]}. \quad (10)$$

Differentiating with respect to β , we get

$$\frac{\partial P_0}{\partial \beta} = -\delta \frac{2(\phi/K\beta^2)(N_U/N_1)}{[1 + 2[\{\phi + (1 - \phi)K\beta\}N_U/K\beta N_1]]^2} < 0. \quad (11)$$

This implies that firm's revenues are larger, the smaller is β . From (6), we have

$$\alpha_B^S = \frac{NP_0}{[\{\phi + (1 - \phi)K\beta\}N_U]W}.$$

Since P_0 is decreasing in β , it follows that α_B^S is also decreasing in β . The smallest feasible β then is one that makes α_B^S equal the largest feasible value, 1. It is straightforward to see from (6) and (9), that $\alpha_G^S < \alpha_B^S = 1$. Then, from (4), it follows that $\alpha_G^L < 1$ and $\alpha_B^L < 1$. \square

In other words, the issuer increases his expected revenues if he favors small investors. This is the key result of the paper, since it explains why IPOs in so many countries are allocated in a way that favors small over large orders.

The optimal offer price, P_0^* and the optimal discrimination policy, β^* , then satisfy Eq. (10) and the following:

$$P_0 = \left[\{\phi + (1 - \phi)K\beta\} \frac{N_U W}{N} \right]. \quad (12)$$

Lemma 4. P_0^* is increasing in $N_U W/N$ and decreasing in δ and N_1 . β^* is decreasing in $N_U W/N$, δ , N_1 and K .

Proof. See the appendix.

In other words, underpricing will decrease (the issue price will increase) when there are relatively more uninformed investors or they have more wealth (relative

to the number of shares available), or when there are fewer informed investors or greater variations in firm value. Similarly, the optimal discrimination against large orders increases with the number of informed investors, the size of the informed investors' orders, the wealth of the uninformed relative to the shares available or the variation in firm value. All of these results are due to the need to compensate uninformed investors for adverse selection.

3. Empirical implications

This model generates many testable empirical implications.

Implication 1. Large investors will always be discriminated against, in good as well as bad states. The level of discrimination will be identical in good and bad states.

Follows from (4). Kang and Hui (1994) found that roughly 85% of the Hong Kong IPOs in their sample were allocated in a way that strictly favored small investors, while the rest of the issues were allocated on a straight pro rata basis. The current model cannot explain why some issues were pro rata, but the great majority strictly favored small investors and none favored large investors, which is consistent with our model.

Implication 2. Larger orders will receive larger allocations.

Follows because $K\beta > 1$ in equilibrium. This is not surprising, since larger orders are more costly (due to the pay in advance feature of UK style offerings). If it were known that placing an order over the minimum would result in a strictly lower allocation, everyone would order only the minimum.

Implication 3. In bad states, small orders receive full allocation.

Follows because $\alpha_B^S = 1$ in equilibrium.

Implication 4. The larger the number of informed investors, the larger the underpricing with larger orders discriminated against more heavily, all else being equal.

Implication 5. For firms with larger uncertainty in firm value, IPOs are underpriced more, with larger orders discriminated against more heavily, all else being equal.

Implication 6. Larger IPOs are underpriced more, with larger orders discriminated against less heavily, all else being equal.

Implication 7. The larger the size of 'large' orders relative to the small orders, the stronger the discrimination against large orders, all else being equal.

These last three implications should help to guide future empirical work, since they could be tested for many countries. The prediction on informed investors and underpricing might also be testable, if a proxy can be found for measuring the number of informed investors.

4. Conclusion

We have shown that the strategic allocation of shares in IPOs can reduce the winner's curse problem faced by investors. This allows issuers to choose a higher offering price, since the need to compensate investors for the adverse selection problem is reduced. We also offer an explanation for the observation that small investors are favored in many countries, by showing that favoring small investors increases the issuer's expected revenue. This builds on the work of Chowdhry and Sherman (1996) comparing US Firm Commitment and UK Open Offer for Sale IPO methods. Chowdhry and Sherman found that key characteristics of the UK method would tend to lead to greater underpricing. We show that this may be partly offset by the policy of favoring small investors, which is common in UK-style systems. Once again, however, the US method has at least the potential for less underpricing, since underwriters in the US are given more freedom in terms of allocation than are underwriters in most UK-style systems.

There is a great need for further empirical work on how shares are allocated in IPOs. Two papers which examine this are McGuinness (1993) and Kang and Hui (1994), both of which examine Hong Kong offerings. A key question to be examined is whether the favoritism towards small investors is fairly constant for all issues, or whether it is stronger for high-subscription issues, which would lead to a greater reduction in the adverse selection problem for small investors. It is even possible that the favoritism decreases for 'hot' issues, which would increase the adverse selection problem of the small investor, leading one to question whether they are really being 'favored'. Another question is whether the treatment of small investors is fairly uniform for each country or system, or whether it varies by underwriter, with some underwriters perhaps developing a reputation for strongly favoring small investors.

There is also a need for more work on the allocation of shares in the US. The paper by Hanley and Wilhelm (1995) is the first direct evidence of how issues are allocated. Hanley and Wilhelm found that institutional investors tend to receive a fairly constant proportion of all IPOs. Although this does not match the specific model used by Rock in his 1986 paper, these results are consistent with the idea that investors are concerned about the adverse selection problem and that issuers may have to react to it. It must be remembered that, in general, informed investors

are also subject to the winner's curse, although not to as great an extent as the uninformed. The only cases in which informed investors are totally unaffected by the winner's curse are when 1) they have perfect information (which is true in our model); or 2) their information is perfectly correlated with that of other informed investors (as in the Rock model). If the signals of the informed are noisy and not identical, then they also suffer from adverse selection. In this case, any allocation scheme that reduces the adverse selection that they face will increase the price that they are willing to pay for shares.

Seen in this light, the findings of Hanley and Wilhelm may indicate that underwriters in the US are using the allocation of shares to protect institutional investors from adverse selection, since allocating a fixed proportion of all issues to an investor will eliminate the adverse selection problem for that investor. A formal model of this would have to be part of a more complicated repeated game where, as in Benveniste and Spindt (1989) and Benveniste and Wilhelm (1990), the informed investors reveal their information to the underwriter and the underwriter in turn rewards them through the allocation of shares.

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Appendix A. Proof of Lemma 4

Rewrite Eqs. (10) and (12) as

$$P_0^* = f(\theta, \beta^*), \quad (\text{A.1})$$

$$P_0^* = g(\theta, \beta^*), \quad (\text{A.2})$$

where θ represents the parameter of interest. Differentiating (A.1) and (A.2) with respect to θ , we get:

$$\frac{dP_0^*}{d\theta} = f_\theta + f_{\beta^*} \frac{d\beta^*}{d\theta}, \quad (\text{A.3})$$

$$\frac{dP_0^*}{d\theta} = g_\theta + g_{\beta^*} \frac{d\beta^*}{d\theta}. \quad (\text{A.4})$$

From (A.3) and (A.4), it follows that:

$$\frac{d\beta^*}{d\theta} = \frac{g_\theta - f_\theta}{f_{\beta^*} - g_{\beta^*}}, \quad (\text{A.5})$$

$$\frac{dP_0^*}{d\theta} = f_\theta + f_{\beta^*} \frac{g_\theta - f_\theta}{f_{\beta^*} - g_{\beta^*}} \quad (\text{A.6})$$

$$= g_\theta = g_{\beta^*} \frac{g_\theta - f_\theta}{f_{\beta^*} - g_{\beta^*}}. \quad (\text{A.7})$$

From (11),

$$f_{\beta^*} < 0. \quad (\text{A.8})$$

From (12),

$$g_{\beta^*} > 0. \quad (\text{A.9})$$

From (10) and (12) respectively,

$$f_\delta < 0, \quad g_\delta = 0; \quad (\text{A.10})$$

$$f_{N_1} < 0, \quad g_{N_1} = 0; \quad (\text{A.11})$$

$$f_K < 0, \quad g_K > 0; \quad (\text{A.12})$$

$$f_\phi < 0, \quad g_\phi < 0. \quad (\text{A.13})$$

The following relationship holds keeping N_U/N_I constant:

$$\frac{f_{N_U W}}{N} = 0, \quad \frac{g_{N_U W}}{N} > 0. \quad (\text{A.14})$$

From (A.5)–(A.9) and (A.10), it follows that

$$\frac{dP_0^*}{d\delta} < 0, \quad \frac{d\beta^*}{d\delta} < 0.$$

From (A.5)–(A.9) and (A.11), it follows that

$$\frac{dP_0^*}{dN_1} < 0, \quad \frac{d\beta^*}{dN_1} < 0.$$

From (A.5)–(A.9) and (A.12), it follows that

$$\frac{d\beta^*}{dK} < 0.$$

From (A.5)–(A.9) and (A.13), it follows that

$$\frac{dP_0^*}{d(N_U W/N)} > 0, \quad \frac{d\beta^*}{d(N_U W/N)} < 0.$$

The signs of all other comparative statics results are ambiguous.

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