Are IPOs “overpriced”?: Strategic interactions between the entrepreneur and the underwriter

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ABSTRACT

Two problems are well-known in IPO research as “IPO puzzles.” First, an initial listing price is much higher than the offering price, or “underpricing.” Second, the share price becomes much lower than the offering price in the long-term, or “long-term underperformance.” Extensive research explains why these IPO puzzles coexist.

Assuming that investors’ opinions diverge, we conclude that even the offering price is distorted through strategic interaction between the entrepreneur and the underwriter. Specifically, the offering price is already “overpriced.” Hence, the share price will substantially decrease as information asymmetry is mitigated, which delivers long-term underperformance. Our experiment supports these conclusions.

Ⅰ Introduction

Two major problems known as “IPO puzzles” remain unsolved in IPO research. First, it is observed that an IPO firm’s initial listing price is much higher than the offering price in the short-term (Ibbotson, 1975; Ritter, 1984; Loughran and Ritter, 1995; Loughran and Ritter, 2002; Ritter and Welch, 2002; Loughran and Ritter, 2004). The difference between them is

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called “money left on the table.” Second, it is also observed that the share price becomes much lower than the offering price in the long-term (Aggarwal and Rivoli, 1990; Ritter, 1991; Loughran and Ritter, 1995; Ritter and Welch, 2002), or “long-term underperformance.”

This leads to the question: “Which is the fundamental value, the initial listing price or the offering price？” Two primary research streams attempt to answer this question. First, traditional theories assume that investors are rational and have homogeneous expectations (Markowitz, 1952; Sharpe, 1964; Lintner, 1965; Black and Scholes, 1973), and argued that the initial listing price is the fundamental value. Hence, the difference between them is “underpricing,” in that the underwriter underprices the IPO firm. Several theories have been developed to explain why underpricing exists, based on adverse selection (Rock, 1986; Beatty and Ritter, 1986), signaling (Allen and Faulhaber, 1989; Welch, 1996), agency theory (Baron and Holmstrom, 1980; Baron, 1982), and information revelation (Benveniste and Spindt, 1989). Second, behavioral theories assume that investors’ opinions diverge (Miller, 1977; Shleifer, 1986; Chen, Hong, and Stein, 2002; Chatterjee, John, and Yan, 2012), and argue that the offering price is the fundamental value. Hence, the difference between them can be observed as investors’ sentiment bubble (Cornelli, Goldreich, and Ljungqvisit, 2006; Da, Engelberg, and Gao, 2011; Dorn, 2009).

Our research differs from both traditional and behavioral theories, as we posit that neither the first listing price nor the offering price is the fundamental value. This enables us to explain why these IPO puzzles coexist.

Our model’s settings are distinguishable from most research based on traditional theories in two points. First, traditional theories assume that investors have homogeneous expectations, and hence, the demand curve is flat[1]. However, this is an unrealistic premise, as it is implausible that investors have the same opinion regarding security prices in the real world. According to Miller (1977), we assume investors’ opinions diverge, and hence, the share’s demand curve slopes downward to the right, which sharply contrasts to traditional theories. Second, we assume that the capital market perceives the entrepreneur’s higher ownership retention at the IPO as good news. Namely, the demand curve shifts upward as ownership retention increases[2]. These settings enable us to explore the strategic interaction between the entrepreneur and the underwriter.

The underwriter in our model establishes an offering price based on forecasts of the firm’s

1 Traditional theories, such as those from Sharpe (1964) and Lintner (1965), assume no divergence in investors’ opinions, and hence, the demand curve is flat.

2 This assumption is consistent with Fan’s (2007) empirical findings, which state that ownership retention positively relates to IPO firms’ valuation.

future performance; hence, an incentive exists for the entrepreneur to overstate earnings[3]. Alternatively, the underwriter may benefit from a higher offering price because the underwriting fee generally increases with an increase in proceeds[4]. Hence, the underwriter overlooks overstated earnings and establishes a higher offering price, and especially when the demand for the firm's shares is sufficiently high[5]. However, if the underwriter establishes the offering price too high, the underwriter might incur a loss from shares left unsold.

Hence, the entrepreneur and underwriter can *both* benefit from overstated earnings and an "overpriced" offering price in situations with sufficiently high ownership retention. Therefore, we can even conclude that the offering price is already "overpriced" to its fundamental value through the strategic interaction between the entrepreneur and underwriter. This conclusion sharply contrasts those from a majority of prior research, which is based on traditional and behavioral theories.

As the offering price is overpriced to its fundamental value, the difference between the initial listing price and the offering price represents investors' sentiment bubble. Hence, the share price should naturally and substantially decrease as information asymmetry is mitigated between *both* the entrepreneur *and* the underwriter and investors after the IPO. This delivers long-term underperformance.

Our paper offers several contributions to IPO research. First, and most importantly, we conclude that the offering price is already "overpriced." This sharply contrasts conclusions from a majority of prior research, which argue that IPO firms are underpriced. Therefore, this paper could offer new insights for IPO researchers.

Some papers have argued that the offering price exceeds the fundamental value. Ljungqvist, Nanda, and Singh (2006) argue as such by assuming a divergence in investors' opinions; however, their research setting is restrictive, in that the entrepreneur only sells and does not issue shares at IPO, and the IPO firms do not engage in subsequent business activities. Our model's settings are more realistic, in that an entrepreneur both sells and issues shares at the IPO, and the firm engages in subsequent business activities. We use this more realistic situation to conclude that the offering price is already "overpriced." Hence, our paper

3 Prior empirical research on earnings management around IPOs had mixed results. While Teoh et al. (1998) observed aggressive earnings management, Ball and Shivakumar (2008) argued that IPO firms reported rather conservative earnings before IPOs.

4 Chen and Ritter (2000) observed that from 1995 to 1998, more than 90 percent of IPOs in the United States raising $20 to $80 million had underwriting fees that were exactly seven percent of the proceeds. Abrahamson et al. (2011) observed that this "seven percent solution" expanded in 1998-2007.

5 For example, see Baron (1982), Chen and Mohan (2002), and Deloof, Maeseneire, and Inghelbrecht (2009). Deloof et al. (2009) specifically argue that the final offering price is decided by observing current market conditions.

theoretically extends the work of Ljungqvist et al. (2006).

Purnanandam and Swaminathan (2004) use 2,288 IPOs in the United States from 1980 to 1997 to compare offering prices to fundamental values. They use share prices of non-IPO industry peers as the IPO firms' fundamental value to argue that IPOs are systematically overvalued in their offering prices. However, their archival research is limited, as it cannot avoid using proxies for unobservable variables, such as the fundamental value. We instead conduct experiments to test our theoretical predictions, as experiments can create controllable environments that correspond to the model and directly test its theoretical predictions, unlike other empirical methods. Hence, our paper refines the work of Purnanandam and Swaminathan (2004).

Our paper contributes to experimental IPO studies. Several studies exist regarding how ownership retention functions as a signaling device in IPOs, but do not address earnings management[6]. Alternatively, several studies examine earnings management[7], but do not address earnings management in an IPO context. To the best of our knowledge, this paper is the first experimental study that investigates the relationship between ownership retention and earnings management in IPOs. Therefore, this paper could provide a clue to the issues inherent in IPOs.

The remainder of this paper is organized as follows: Section 2 develops a theoretical model. Section 3 describes the experimental design, and Section 4 reports the experiment's results. Section 5 summarizes and concludes the paper.

Ⅱ Model

Ⅱ.1 Model's Settings

We consider a two-period model; in the first period (hereafter "period 0"), a risk-neutral entrepreneur who owns all of the firm's shares (N) decides that the firm will go public at the beginning of the second period (hereafter "period 1"). The entrepreneur issues another N shares at the IPO, and sells $S = (1 - w)N$ owned shares ($0 \leq w \leq 1$).

As the entrepreneur's payoff from selling the shares increases in the public offering price

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6 Mayhew, Schatzberg, and Sevcik's (2004) work, based on Datar, Feltham, and Hughes' (1991) model, finds that the entrepreneur uses ownership retention to signal the IPO firm's value when computerized investors are programmed to behave as Datar et al.'s (1991) model assumes. Trueman (1986) develops a model in which the entrepreneur uses capital investment and ownership retention as signals in an IPO setting.

7 For example, see Hirst (1994), Hirst and Hopkins (1998), Maines and McDaniel (2000), Tan and Jamal (2006), and Chen et al. (2012).

P_0 decided by an underwriter, the entrepreneur has an incentive to increase this by managing earnings in financial statements issued at the end of period 0. Let θ and μ be true earnings and the amount of earnings management in period 0, respectively, and then the reported earnings e can be written as

$$e = \theta + \mu,$$

where we assume that $\theta > 0$[8] and $0 \leq \mu \leq \theta$.

The firm conducts business activities in period 1, with its probability of success assumed to be $p(0 < p < 1)$, and the share price with this success will increase to $P_1 = P_0 + \alpha(\alpha > 0)$ at the end of period 1. However, risk exists, in that the earnings management will be revealed. We assume that the probability is $q(0 < q < 1)$. If the earnings management is revealed, then the share price will decrease by $k\mu(0 \leq k \leq 2)$ in period 1[9]. And if the business activity fails with the probability as $1 - p$, the share price will decrease to $P_1 = 0$ at the end of period 1, irrelevant of whether the earnings management is revealed.

Hence, the entrepreneur maximizes the expected payoff, which is

$$\begin{aligned}&(1-q)[P_0S + p(P_0+\alpha)(N-S)] + q[P_0S + p(P_0+\alpha-k\mu)(N-S)]\\&= N\{[1-(1-p)w)]P_0 + wp(\alpha - q\mu k)\}.\end{aligned}$$

As N is positive and constant, for simplicity we define the entrepreneur's payoff as

$$U_e = [1-(1-p)w)]P_0 + wp(\alpha - q\mu k).$$

According to Miller (1977), we assume that investors' opinions diverge; hence, the share's demand curve slopes downward to the right, as illustrated in Fig. 1. Let the share's demand curve be

$$P + D(P) = a + f(w),$$

where P and $D(P)$ are a share price and the share's inverse demand function, respectively. A

8 It is plausible to assume $\theta > 0$ as the profitability of firms' going public is generally considered to be relatively high.

9 We assume $\alpha > k\mu$ to avoid cases of $P_1 < 0$.

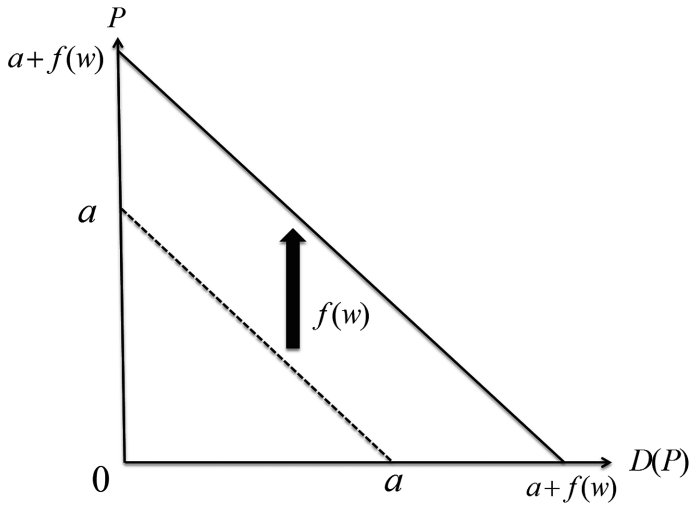
degree of the firm's popularity is represented by a, and we assume $a > 2N$.[10]

Investors perceive higher ownership retention after the IPO as good news, as this signals that the entrepreneur may have private information regarding the firm's favorable prospects; this shifts the demand curve upward, as displayed in Fig. 1. Specifically,

$$f(0) = 0, \quad f(w)_{w \neq 0} > 0, \quad f'(w) > 0.$$

We assume that the marginal effect of retention w is decreasing, or $f''(w) < 0$.

Fig. 1. Demand Curve



The dotted line and the solid line indicate demand curves of $w = 0$ and $w > 0$, respectively, where w is ownership retention at the IPO. $D(P) = -P + a + f(w)$ is the inverse demand function, where P, a, and $f(w)$ are the share price, the firm's degree of popularity, and incremental demand of the shares explained by ownership retention, respectively.

Generally, an underwriter's payoff increases in the product of an offering price and how many shares (Q) are sold in the market[11]. Hence, for simplicity we define the underwriter's payoff as $P_0 Q$. A higher offering price clearly increases the underwriter's payoff as long as the shares' demand exceeds the supply. However, an excessively high offering price results in excess supply, and decreases the underwriter's payoff.

We assume that the underwriter decides the offering price by considering two factors. The first is the earnings in period 0. As an underwriter cannot observe true earnings, but rather, the reported earnings that might be managed by the entrepreneur, the underwriter can only provide an estimate, in other words, they can only estimate earnings management. The larger estimated

10 This is a typical assumption regarding demand curves.

11 For example, see the works of Chen et al. (2000) and Abrahamson et al. (2011).

earnings management leads the underwriter to quote a lower offering price. The second factor involves ownership retention at the IPO. As the underwriter knows that investors perceive higher retention as good news in the stock market, this leads the underwriter to quote a higher offering price.

Hence, we assume that the underwriter decides an offering price P_0 according to

$$P_0 = x + g(w) + e - \hat{\mu} = [x + \theta] + [g(w) + \mu - \hat{\mu}] = FV + OP, \tag{1}$$

where $x(>0)$, $\theta(>0)$, and $\hat{\mu}(\geq 0)$ are the firm's value at the beginning of period 0, the true earnings in period 0, and an amount of earnings management estimated by the underwriter, respectively; and where $g(w)$ is an incremental amount of the offering price by observing the ownership retention ($g(0) = 0$, $g(w)_{w\neq 0} > 0$, and $g'(w) > 0$). We further assume that $g'(w)$ is less than N[12], and the retention's marginal effect on $g(w)$ is decreasing, or $g''(w) < 0$. It can be demonstrated that the offering price can be divided into the fundamental value $FV = x + \theta$ and the overpricing $OP = g(w) + \mu - \hat{\mu}$.

Hence, the underwriter's problem involves maximizing the expected payoff U_u.

$$\begin{aligned} U_u = P_0 Q &= \begin{cases} P_0(N+S) & \text{if } N+S \leq D(P_0) \\ P_0 D(P_0) & \text{otherwise} \end{cases} \\ &= \begin{cases} P_0(N+S) & \text{if } P_0 \leq a + f(w) - (N+S) \\ P_0(a + f(w) - P_0) & \text{otherwise} \end{cases} \\ &= \begin{cases} -(N+S)[\hat{\mu} - (x + g(w) + e)] \\ \quad \text{if } \hat{\mu} \geq x + g(w) - f(w) + e - a + N + S \\ -[\hat{\mu} - (x + g(w) + e)][\hat{\mu} - (x + g(w) - f(w) + e - a)] \\ \quad \text{otherwise.} \end{cases} \end{aligned}$$

The intersections of $U_u = P_0(N+S)$ and $U_u = P_0 D(P_0)$ are $\hat{\mu}_1 = x + g(w) - f(w) + e - a + (2-w)N$ and $\hat{\mu}_2 = x + g(w) + e$, noted in Panels A and B of Fig. 2[13]. It is noteworthy that the larger the earnings management, the higher the $\hat{\mu}_1$, and that the higher the retention, the lower the $\hat{\mu}_1$.[14]

We solve the problem in a case without earnings management costs ($k = 0$) for simplicity, as the implications are qualitatively the same as in a case with earnings management costs ($k > 0$).[15] We then examine the theoretical predictions through experiment.

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12 As a substantial number of shares are issued at IPO, it is plausible to assume $g'(w)$ is less than N.

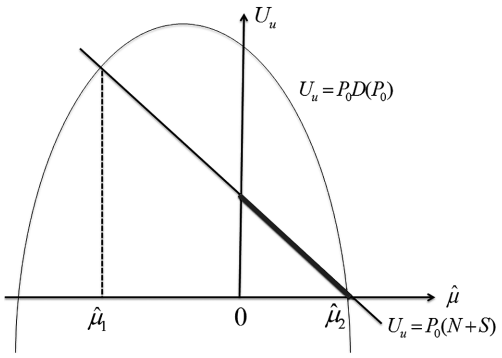
13 We assume that the axis of symmetry for U_u is greater than $\hat{\mu}_1$ in Panels A and B of Fig. 2. We demonstrate why this assumption is appropriate in Appendix A.

14 $\partial\hat{\mu}_1/\partial\mu = 1$, $\partial\hat{\mu}_1/\partial w = g'(w) - f'(w) - N < 0$ ($f'(w) > 0, 0 < g'(w) < N$).

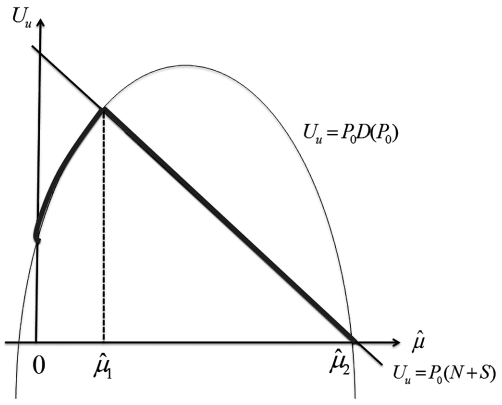
15 Due to paper volume constraints, the proof is omitted.

Fig. 2. An underwriter's payoff.

Panel A: Benchmark case of a "very popular" firm ($a \geq x + 2\theta + 2N$)



Panel B: Benchmark case of an "unpopular" firm ($a < x + g(1) - f(1) + \theta + N$)



The thick curve indicates an underwriter's payoff. U_u is an underwriter's payoff. P_0 is the public offering price, and $D(P_0)$ is the demand of shares at P_0. N and S are the numbers of shares that the entrepreneur holds before the IPO and sells at the IPO, respectively. Further, $\hat{\mu}_1$ and $\hat{\mu}_2$ are the intersections of $U_u = P_0 D(P_0)$ and $U_u = P_0(N + S)$.

II.2 Solutions without earnings management costs

We solve the problem by considering two benchmark cases (involving "very popular" and "unpopular" firms) and a primary case (with a "popular" firm).

II.2.1 Benchmark case (I): a "very popular" firm

We call a firm with $a \geq x + 2\theta + 2N$ a "very popular" firm, in that even if the entrepreneur sells all owned shares ($w = 0$) at the IPO, and manages earnings to the maximum degree ($\mu = \theta$),

$$\hat{\mu}_1|_{w=0,\mu=\theta} = x + 2\theta - a + 2N \leq 0.$$

Hence, the underwriter chooses $\hat{\mu}^* = 0$, as indicated by Panel A of Fig. 2.

As the offering price in this case is $P_0 = x + g(w) + \theta + \mu$, the entrepreneur's payoff can be written as

$$U_e = \{1 - (1-p)w\}(x + g(w) + \theta + \mu) + wp\alpha.$$

As $\partial U_e / \partial \mu = 1 - (1-p)w > 0$, the entrepreneur chooses $\mu^* = \theta$, and hence, U_e can be rewritten as

$$U_e = \{1 - (1-p)w\}(x + g(w) + 2\theta) + wp\alpha.$$

We define the derivative function of a very popular firm's U_e as $\phi_0^H(w)$, or

$$\phi_0^H(w) \equiv \frac{dU_e}{dw} = p\alpha - (1-p)\{g(w) + wg'(w) + x + 2\theta\} + g'(w).$$

As $g'(w) > 0,\ g''(w) < 0$,

$$\frac{d^2U_e}{dw^2} = \frac{d\phi_0^H(w)}{dw} = -2(1-p)g'(w) + \{1 - (1-p)w\}g''(w) < 0.$$

Hence, $\phi_0^H(w)$ is a strictly decreasing function of w. Further, the partial derivative functions of $\phi_0^H(w)$ with respect to p and α are, respectively,

$$\frac{\partial \phi_0^H(w)}{\partial p} = \alpha + g(w) + wg'(w) + x + 2\theta > 0.$$

$$\frac{\partial \phi_0^H(w)}{\partial \alpha} = p > 0.$$

These two inequalities demonstrate that the larger the values of p and α, the more upward the curve $\phi_0^H(w)$ shifts. As $\phi_0^H(w)$ is a strictly decreasing function of w, as illustrated by Panel A of Fig. 3. Hence, the optimal retentions are as follows:

[A_0] When p and / or α are large enough to hold $\phi_0^H(1) \geq 0,\ w^* = 1$.

[B_0] When p and / or α are such that these hold $\phi_0^H(1) < 0 < \phi_0^H(0),\ 0 < w^* < 1$.

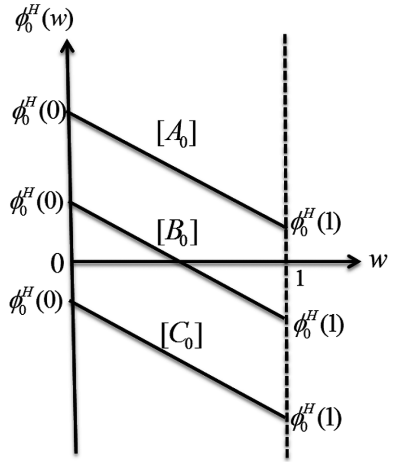
[C_0] When p and / or α are small enough to hold $\phi_0^H(0) \leq 0,\ w^* = 0$.

From [A_0], [B_0], and [C_0], we obtain $\hat{\mu}^* = 0,\ \mu^* = \theta,\ 0 \leq w^*(p, \alpha) \leq 1$, and

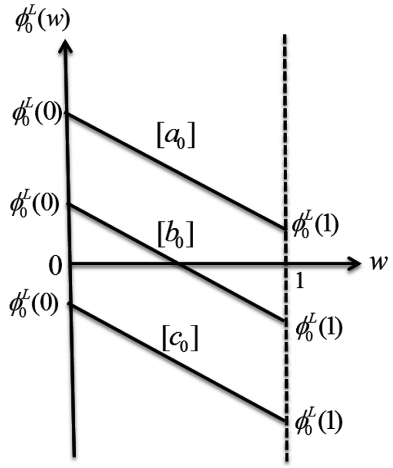
$$OP^* = g(w^*) + \theta > 0.$$

Fig. 3. Determination of the optimal ownership retention.

Panel A: Derivative function of entrepreneur's payoff of a very popular firm's entrepreneur



Panel B: Derivative function of entrepreneur's payoff of an unpopular firm's entrepreneur



w is the ownership retention at the IPO. $\phi_0^H(w)$ and $\phi_0^L(w)$ are derivative functions of the entrepreneur's payoff of a very popular firm and an unpopular firm, respectively.

These solutions imply that a "very popular" firm is always overpriced at the IPO because the entrepreneur knows the underwriter chooses to estimate no earnings management, and hence, manages earnings to a maximum degree.

II.2.2 Benchmark case (II): an "unpopular" firm

We call a firm with $a < x + g(1) - f(1) + \theta + N$ an "unpopular" firm, in that even if the entrepreneur holds all owned shares ($w = 1$) at the IPO, and does not manage earnings at all ($\mu = 0$),

$$\hat{\mu}_1|_{w=1,\mu=0} = x + g(1) - f(1) + \theta - a + N > 0.$$

Hence, the underwriter chooses $\hat{\mu}^* = \hat{\mu}_1$, illustrated by Panel B of Fig. 2.

As the offering price in this case is $P_0 = x + g(w) + e - \hat{\mu}^* = f(w) + (w-2)N + a$, the entrepreneur's payoff can be written as

$$U_e = \{1 - (1-p)w\}\{f(w) + (w-2)N + a\} + wp\alpha. \tag{2}$$

This implies that the entrepreneur's payoff is irrelevant of reported earnings. Hence, the entrepreneur chooses $\mu^* = any(0 \le \mu^* \le \theta)$.

We define the derivative function of an unpopular firm's U_e as $\phi_0^L(w)$, or

$$\phi_0^L(w) \equiv \frac{dU_e}{dw} = -(1-p)\{f(w) + wf'(w) + 2(w-1)N + a\} + f'(w) + N + p\alpha.$$

As $f'(w) > 0$ and $f''(w) < 0$,

$$\frac{d^2U_e}{dw^2} = \frac{d\phi_0^L(w)}{dw} = -2(1-p)\{f'(w) + N\} + \{1 - (1-p)w\}f''(w) < 0.$$

Hence, $\phi_0^L(w)$ is a strictly decreasing function of w. Further, the partial derivative functions of $\phi_0^L(w)$ with respect to p and α are, respectively,

$$\frac{\partial\phi_0^L(w)}{\partial p} = f(w) + wf'(w) + 2(w-1)N + a + \alpha > 0 \ (a > 2N).$$

$$\frac{\partial\phi_0^L(w)}{\partial\alpha} = p > 0.$$

These two inequalities demonstrate that the larger the values of p and α, the more upward the curve $\phi_0^L(w)$ shifts. As $\phi_0^L(w)$ is a strictly decreasing function of w, as illustrated by Panel B of Fig. 3, the optimal retentions are as follows:

[a_0] When p and / or α are large enough to hold $\phi_0^L(1) \ge 0$, $w^* = 1$.

[b_0] When p and / or α are such that these hold $\phi_0^L(1) < 0 < \phi_0^L(0)$, $0 < w^* < 1$.

[c_0] When p and / or α are small enough to hold $\phi_0^L(0) \le 0$, $w^* = 0$.

From [a_0], [b_0], and [c_0], $\hat{\mu}^* = \hat{\mu}_1 > 0$, $\mu^* = any(0 \le \mu^* \le \theta)$, $0 \le w^*(p, \alpha) \le 1$, and

$$OP^* = g(w^*) + \mu^* - \hat{\mu}_1 = (a - 2N) + f(w^*) + w^*N - x - \theta \gtreqless 0.$$

These solutions imply that it is unclear whether an unpopular firm's share are overpriced or underpriced.

II.2.3 Primary case: a "popular" firm

It is implausible that a "very popular" firm exists, such that even if the entrepreneur sells all owned shares and manages earnings to a maximum degree, the underwriter chooses to estimate no earnings management. Alternatively, it is unlikely that an "unpopular" firm will go public, such that even if the entrepreneur holds all owned shares and does not manage earnings at all, the underwriter suspects that the entrepreneur managed earnings to some degree. Hence, firms that actually go public are considered as on a spectrum between these two scenarios.

Thus, we call a firm that is neither very popular nor unpopular a "popular" firm. Specifically, the sign of $\hat{\mu}_1 = x + g(w) - f(w) + e - a + (2-w)N$ can be either positive or negative, depending on μ and w.

When $\hat{\mu}_1$ is negative, the firm is overpriced at the IPO, as a very popular firm is (hereafter "very popular equilibrium"). Alternatively, when $\hat{\mu}_1$ is positive, it is unclear whether the firm is overpriced or underpriced, as an unpopular firm is (hereafter "unpopular equilibrium").

We examine whether the entrepreneur of an underpriced popular firm can increase the payoff through changing an unpopular equilibrium into a very popular equilibrium by increasing the ownership retention at the IPO. If the entrepreneur can do so, we posit that very popular equilibriums are always realized, and that popular firms are always overpriced at the IPOs.

Suppose that for $w = w_1$, the underwriter chooses $\hat{\mu}^* = \hat{\mu}_1 > 0$ (the unpopular equilibrium), and that for $w = w_2 \equiv w_1 + \Delta w (\Delta w > 0)$, the underwriter chooses $\hat{\mu}^* = 0$ (the very popular equilibrium). In the unpopular equilibrium,

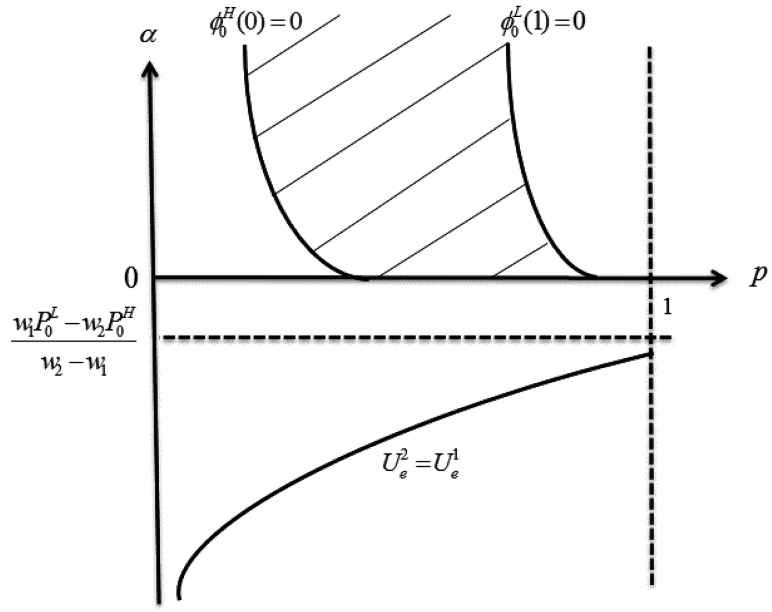
$$U_e^1 = \{1 - (1-p)w_1\}\{f(w_1) + (w_1 - 2)N + a\} + w_1 p \alpha,$$

and in the very popular equilibrium,

$$U_e^2 = \{1 - (1-p)w_2\}\{x + g(w_2) + 2\theta\} + w_2 p \alpha.$$

The necessary and sufficient conditions in which the entrepreneur can increase the payoff by increasing ownership retention include: the entrepreneur in the very popular equilibrium

Fig. 4. Change in equilibrium.



The shadowed area indicates where the entrepreneur can change the equilibrium by raising the ownership retention at the IPO. Further, p is the probability of success in business activities in period 1 $(0 < p < 1)$, and $\alpha(\alpha > 0)$ is the increase in the share price during period 1 if the business activities succeed. $\phi_0^H(w)$ and $\phi_0^L(w)$ are the derivative functions of the entrepreneur's payoff of very popular and unpopular firms, respectively. w_1, P_0^L, and U_e^1 are ownership retention, the offering price, and the entrepreneur's payoff in an unpopular equilibrium, respectively. w_2, P_0^H, and U_e^2 are the same variables in a very popular equilibrium. For any points (p, α) in the shadowed area, w_1 and $\Delta w(\Delta w > 0)$ exist, which satisfies $0 \le w_1 < w_2 = w_1 + \Delta w \le 1$.

does not sell all shares[16], the entrepreneur in the unpopular equilibrium does not hold all shares[17], and the entrepreneur's payoff increases from the change in equilibrium. Specifically,

$$\phi_0^H(0) \equiv p\alpha - (1-p)(x+2\theta) + g'(0) > 0.$$
$$\phi_0^L(1) \equiv p\alpha + f'(1) + N - (1-p)\{f(1) + f'(1) + a\} < 0.$$
$$U_e^2 \equiv \{1-(1-p)w_2\}\{x + g(w_2) + 2\theta\} + w_2 p\alpha$$
$$> \{1-(1-p)w_1\}\{f(w_1) + (w_1 - 2)N + a\} + w_1 p\alpha \equiv U_e^1.$$

The shadowed area in Fig. 4 satisfies all the above conditions. Further, w_1 and $\Delta w(\Delta w > 0)$ exist for any points (p, α) in the shadowed area, which satisfy $0 \le w_1 < w_2 = w_1 + \Delta w \le 1$. The proof is provided in Appendix B.

Collectively, the entrepreneur can increase the payoff by increasing the owner's retention and changing the underwriter's estimation, unless p and / or α are too small or too large.

16 This is equivalent to $[A_0]$ or $[B_0]$ in Benchmark Case (I).
17 This is equivalent to $[b_0]$ or $[c_0]$ in Benchmark Case (II).

Ultimately, the very popular equilibrium is realized; at that point, the IPO firm is overpriced. Hence, we have a proposition:

Proposition

Neither in a situation in which p and / or α are small enough for the entrepreneur in the very popular equilibrium to sell all shares, nor in a situation in which p and / or α are large enough for the entrepreneur in the unpopular equilibrium to hold all shares:
(i) the entrepreneur manages earnings to a maximum degree before the IPO, and keeps ownership retention high at the IPO,
(ii) the underwriter chooses to estimate no earnings management, and
(iii) the offering is overpriced.

On the one hand, the entrepreneur will choose a higher retention and maximum earnings management, as he or she knows that it is optimal for the underwriter in a higher retention case to decide the offering price, assuming the entrepreneur does not manage earnings at all. On the other hand, as the underwriter knows that investors perceive higher retention as good news, the underwriter chooses to estimate no earnings management, irrelevant of whether the underwriter believes that the entrepreneur did not manage earnings, as far as the share demand exceeds the supply.

Firms that go public in the real world can be considered neither very popular nor unpopular firms. Hence, this proposition can explain the strategic interaction between the entrepreneur and underwriter. We examine this proposition through experiment in the following section.

Ⅲ Experimental design

III.1 Experimental parameters and variables

Experimental parameters are deliberately specified so we can examine the interaction between the “popular” firm’s entrepreneur and the underwriter. The experiment’s participants assume the role of either the entrepreneur or the underwriter. The entrepreneur is assumed to own 100 shares of the firm before the IPO, or $N = 100$ shares, and issues an additional 100 shares and sells S owned shares at the IPO.

The experiment’s sequence of events is as follows: First, nature selects the true earnings θ from the set $\{80, 100, 120\}$, which the entrepreneur observes. Second, the entrepreneur chooses the number of shares S, which are sold at the IPO, from the set $\{0, 50, 100\}$ as well

as how much of the reported earnings he or she manages μ. This is equivalent to choosing the reported earnings e: (i) no earnings management (i.e., $\mu = 0$ or $e = \theta$); (ii) 50% earnings management (i.e., $\mu = 0.5\theta$ or $e = 1.5\theta$); and (iii) 100% earnings management (i.e., $\mu = \theta$ or $e = 2\theta$).

The underwriter then observes the reported earnings and the number of shares the entrepreneur has sold, and chooses to estimate how much of the reported earnings the entrepreneur manages from the set $\{0, 1/4, 1/2, 3/4, 1\}$. For example, when the reported earnings $e = 200$ and the underwriter chooses $3/4$, the underwriter's estimation regarding earnings management $\hat{\mu}$ is calculated as $200 \times 3/4 = 150$.

Depending on the entrepreneur's decisions μ and S, and the underwriter's decision $\hat{\mu}$, the offering price, shares' market demand and supply, and the stock's trading volume at the IPO are determined, as follows:

$$\text{Offering price } (P_0) = 100 + 10 \times (1 - S/100) + \theta + \mu - \hat{\mu},$$
$$\text{Demand} = -P_0 + 10 \times (1 - S/100) + 450,$$
$$\text{Supply} = 100 + S,$$
$$\text{Stock trading volume at the IPO} = \min \{ \text{Demand, Supply} \}.$$

Finally, the firm's business activities after the IPO succeed with a probability of 75 percent, and the share price will increase to $P_1 = P_0 + 100$. Business activities with a probability of 25 percent will fail, and the share price will decrease to $P_1 = 0$. The entrepreneur and underwriter both know the probability for success. The entrepreneur's payoff is calculated as follows:

$$U_e = P_0 \times S + 0.75 \times (P_0 + 100) \times (100 - S).$$

The underwriter's payoff does not depend on whether the firm's business activities after the IPO are successful, and is calculated as follows:

$$U_u = P_0 \times \text{ Stock Trading Volume.}$$

Appendix C provides the instructions to the experiment's participants. Analyses are conducted on participants' roles, as either the entrepreneur or the underwriter. We compare several predictions, derived from the proposition in the previous section, with the participants'

actual behavior.

We also measure three variables in the experiment regarding the entrepreneurs' behavior. First, the earnings management ratio (μ/θ) represents the entrepreneur's earnings management intensity, which is calculated as the amount of earnings management (μ) divided by the true earnings (θ). The ownership retention (w) represents the entrepreneur's commitment level to the post-IPO firm, which is calculated as the number of shares held at the IPO ($100 - S$) divided by the number of shares the entrepreneur held before the IPO. The unreliability ratio ($\mathrm{E}_e(\hat{\mu})/\theta$) represents the entrepreneur's expectations regarding the quantity of earnings the underwriter assumes that the entrepreneur manages, which is calculated as the entrepreneur's expected value of an earnings management amount estimated by the underwriter ($\mathrm{E}_e(\hat{\mu})$), divided by the true earnings (θ).

Additionally, we measure three variables in the experiment regarding the underwriters' behavior. First, the earnings management estimation ($\hat{\mu}/e$) represents the quantity of earnings that the underwriter assumes the entrepreneur manages, which is defined as an earnings management amount estimated by the underwriter ($\hat{\mu}$), divided by reported earnings (e). The expected true earnings ($\mathrm{E}_u(\theta)$) is the underwriter's expected value of true earnings (θ). The earnings management permission ($(e - \hat{\mu})/\mathrm{E}_u(\theta)$) is defined as earnings after the assessment ($e - \hat{\mu}$) divided by the expected true earnings ($\mathrm{E}_u(\theta)$). The higher this permission, the higher the earnings that the underwriter permits as reasonable.

III.2 Predictions

III.2.1 Entrepreneur's behavior

From (i) of Proposition in the previous section, we expect that the entrepreneur uses ownership retention to signal commitment, and manages earnings to a maximum degree. This leads to Prediction 1a:

Prediction 1a: Commitment and earnings management

The entrepreneur manages earnings to a maximum degree before the IPO, and maintains a higher retention at the IPO.

When the entrepreneur maintains a high ownership retention and manages earnings to a maximum degree, the entrepreneur anticipates the underwriter's optimistic earnings assessment. We can predict in this case that the entrepreneur manages more earnings than the amount of earnings management that the entrepreneur expects the underwriter to estimate

($\mathrm{E}_e(\hat{\mu})$). This leads to Prediction 1b:

Prediction 1b: Optimistic assessment bias

The earnings management ratio (μ/θ) is higher than the unreliability ratio ($\mathrm{E}_e(\hat{\mu})/\theta$).

III.2.2 Underwriter's behavior

Higher reported earnings are likely to lead a higher offering price, as in Eq. (1); the higher the offering price, the more risk the underwriter should assume from the shares left unsold. The underwriter in this case risks incurring loss from unsold shares. However, as stated in (ii) of Proposition, we anticipate that as long as ownership retention is high, the underwriter estimates much less earnings management because this diminishes the underwriter's risk, and a higher offering price increases the underwriter's payoff. This leads to Prediction 2a:

Prediction 2a: Commitment and assessment

The higher the ownership retention (w), the lower the earnings management estimation ($\hat{\mu}/e$).

The above arguments suggest that even if the underwriter detects earnings management, this might be overlooked with high retention. If so, the higher the ownership retention, the more earnings management the underwriter overlooks, and hence, the more reported earnings the underwriter permits as reasonable. This leads to Prediction 2b:

Prediction 2b: Commitment and permission

The higher the ownership retention (w), the higher the earnings management permission ($(e-\hat{\mu})/\mathrm{E}_u(\theta)$).

Our predictions 1a, 1b, 2a, and 2b are based on (i) and (ii) of Proposition in the previous section. Note that if our experimental results support these predictions, then (iii) of Proposition is automatically supported, and we can argue that the IPO firm is overpriced.

III.3 Participants and procedures

We conducted two sessions in July 2015 with the same parameters to follow the experimental design. Participants were recruited from a business studies program at a large private university, and 25 students participated in the experiment. Participants were randomly assigned the role of either the entrepreneur or the underwriter upon their arrival at the lab.

Thirteen assumed the entrepreneur's role, and twelve were the underwriter; the roles remained constant throughout the session. There were 39 total observations of the entrepreneurs' behaviors[18], and there were 288 for the underwriters' behavior[19]. This is because we used the strategy method in all sessions, in which participants compose contingent decisions for all possible scenarios (Brandts and Charness, 2011; Casari and Cason, 2009).

Participants were 19.5 years old on average, and 60 percent were male. Business and accounting research widely debates one issue concerning participant selection, or whether experiments should use professionals (e.g., Dickhaut, Livingstone, and Watson, 1972; Libby, Bloomfield, and Nelson, 2002). Several studies argue that mature business students are appropriate proxies for professionals because their experimental results revealed no differences between students and professionals, and especially when their basic traits or perceptions were examined (Campbell, 1986; Greenberg, 1987; Remus, 1986; Ward, 1993). Moreover, several experimental accounting studies use student participants to proxy for professionals (e.g., Geiger and Smith, 2010). Additionally, Libby et al. (2002) argue that using more sophisticated participants than necessary might create negative externalities. Our student participants had taken accounting courses before entering the experiment, and had sufficient knowledge to understand our experimental scenario. Therefore, our student participants are appropriate in achieving our experiment's goals.

Each participant in the experiment was assigned a computer and provided written instructions. The experimenter then read the instructions aloud, and the participants answered questions to confirm their understanding of the game. The instructions used an economic framework, as our experimental setting is somewhat complicated, and we believe that the participants can imagine a more concrete situation through this appropriate framework. Additionally, they can use both a payoff calculator and payoff table to calculate their payoff.

Each participant in the experiment used a computer to access the website designated to their assigned role, and responded to all possible cases under our experimental parameters. Experimental earnings were converted to cash as a reward for the participants. The entrepreneurial role earned an average of 18.10 USD, and the underwriter role earned an average of 16.70 USD. The experiment sessions lasted for nearly 80 minutes, including instructions.

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18 Each 13 participants answered under the three conditions: when true earnings were 80, 100, and 120.

19 Each 12 participants answered under the 8×3 conditions: the 8 conditions of reported earnings (80, 100, 120, 150, 160, 180, 200, and 240) and the 3 conditions of ownership retention (0, 50, and 100).

Ⅳ Results

IV.1 Entrepreneur’s behavior

Panel A of Table 1 provides descriptive statistics of the entrepreneur’s behavior, and indicates that the means of earnings management ratio and ownership retention both exceed 0.5. This implies that the entrepreneur manages earnings upward, with a high commitment level, suggesting Prediction 1a.

Panel B of Table 1 illustrates the distribution of the observations classified by ownership retention and the earnings management ratio. This demonstrates that the number of

Table 1. The entrepreneur’s behavior.

Panel A: Summary statistics about the entrepreneur’s behavior

		True earnings			
		80	100	120	Total
Obs.		13	13	13	39
Earnings management ratio	Mean	0.88	0.76	0.65	0.73
	Std	0.21	0.31	0.41	0.33
Ownership retention	Mean	0.73	0.57	0.61	0.64
	Std	0.31	0.26	0.34	0.31
Unreliability ratio	Mean	0.41	0.51	0.41	0.44
	Std	0.49	0.51	0.38	0.47

Panel B: Results of testing Prediction 1a

		Ownership retention			
		0%	50%	100%	Total
Earning management ratio	0%	1 2.6%	2 5.1%	1 2.6%	4 10.3%
	50%	1 2.6%	7 17.9%	2 5.1%	10 25.6%
	100%	2*** 5.1%	11*** 28.2%	12*** 30.8%	25 64.1%
	Total	4 10.3%	20 51.3%	15 38.5%	39 100%

Panel C: Results of testing Prediction 1b

	Earnings management ratio	Unreliability ratio	Difference
Mean	0.73	0.44	0.29***

Panel A provides descriptive statistics of the entrepreneur’s behavior. Panel B illustrates a distribution of the observations classified by the ownership retention and earnings management ratios. Panel C displays the means of the earnings management and unreliability ratios. The variables are defined in Appendix D; asterisks indicate significance at the 10% (*), 5% (**), and 1% (***) levels.

observations in which the entrepreneur participant manages earnings to a maximum degree and retains all shares is 30.8 percent of all the observations. The result implies that the entrepreneur manages earnings to a maximum degree before the IPO, and maintains a higher retention at the IPO. The observations in the row with a 100% earnings management ratio monotonously increase with ownership retention, and the observations in the column with 100% ownership retention also monotonously increase with the earnings management ratio. The observations' proportions in each case are significantly different at the 1 percent level (the 3-sample test for equality of proportions: $\chi^2(2) = 10.92$, with p value = 0.004 in the 100% earnings management ratio row, while $\chi^2(2) = 22.2$, with p value = 0.000 in the 100% ownership retention column). This result supports Prediction 1a.

Panel C of Table 1 reveals the means of the earnings management and unreliability ratios, and reports that the earnings management ratio is higher than the unreliability ratio at the 1 percent significance level (the Mann-Whitney U test, W = 1,087.5, p value = 0.000). This supports Prediction 1b.

In conclusion, our experiment's results support Predictions 1a and 1b. As our model anticipated, the entrepreneur tends to manage earnings to a maximum degree with a high commitment level, as the entrepreneur anticipated that the underwriter would overlook the entrepreneur's earnings management.

IV.2 Underwriter's behavior

Panel A of Table 2 indicates both the means and standard deviations of the earnings management estimation, expected true earnings, and earnings management permission by the levels of ownership retention (0%, 50%, and 100%). Further, we test Prediction 2a by focusing on the subsample, in which the reported earnings are 240. Panel B of Table 2 displays the proportion of the number of entrepreneur's participants in the subsample who estimate no earnings management when reported earnings are at a maximum level of 240.

Panel A of Table 2 notes that the earnings management estimation was especially low (0.169) when the ownership retention was 100 percent. This result implies that underwriters permit earnings management when the entrepreneur's commitment level is high. Panel B of Table 2 indicates that the higher the ownership retention becomes, the higher the number of participants who estimate no earnings management. The portions among the three groups are significantly different at the 1 percent level (the 3-sample test for equality of proportions: $\chi^2(2) = 11.25$, p value = 0.003). This result supports Prediction 2a.

Panel B of Table 2 also reveals that the higher the ownership retention, the higher the

Table 2. The underwriter's behavior.

Panel A: Summary statistics and results of testing Prediction 2a

		Ownership retention			
		0%	50%	100%	Total
Obs.		96	96	96	288
Earnings management estimation	Mean	0.19	0.188	0.16	0.185
	Std	0.27	0.26	0.31	0.284
Expected true earnings	Mean	101.04	101.88	99.17	100.69
	Std	16.17	14.17	16.81	15.79
Earnings management permission	Mean	1.19	1.20	1.30	1.23
	Std	0.53	0.52	0.63	0.56

Panel B: Results of testing Prediction 2b

	Ownership retention			
	0%	50%	100%	Total
Obs.	2	1	8	11
% of obs.	0.17*	0.08*	0.66*	0.31

Panel A illustrates both the means and standard deviations of the earnings management estimation, expected true earnings, and earnings management permission by the levels of ownership retention (0%, 50%, and 100%). Panel B notes the proportion of the number of entrepreneur-participants in the subsample that estimates no earnings management when reported earnings are at a maximum level of 240. The variables are defined in Appendix D; asterisks indicate significance at the 10% (*), 5% (**), and 1% (***) levels.

earnings management permission; the portions among the three groups are significantly different at the 10 percent level (the Kruskal-Wallis test; $\chi^2(2, N = 288) = 4.744$, p value = 0.093[20]). The result supports Prediction 2b, and implies that the underwriter is permissive to earnings management, and especially with 100 percent ownership retention. Panel A of Table 2 also indicates no statistically significant difference in the expected true earnings by ownership retention (the Kruskal-Wallis test; $\chi^2(2) = 1.38$, p value = 0.50). This suggests that the underwriter precisely estimates true earnings regardless of ownership retention.

In conclusion, our experiment's results support Predictions 2a and 2b. As anticipated in our model, the underwriter tends to provide an optimistic assessment, and especially with high ownership retention, while the underwriter might be aware of the entrepreneur's earnings management. This leads to a higher offering price, and hence, the underwriter's higher payoff.

In summary, our theoretical and experimental findings suggest that the entrepreneur uses ownership retention to signal commitment and manage earnings upward to align the

20 A post-hoc test using Mann-Whitney tests with Holm's correction displayed a significant difference between the 50 and 100 percent ownership retention groups at a 10 percent level ($p = 0.082$), and between the 0 and 100 percent ownership retention groups at a 5 percent level ($p = 0.044$).

entrepreneur's and underwriter's interests. Therefore, the offering price is "overpriced" through strategic interaction between the entrepreneur and the underwriter.

Ⅴ Conclusions

Underpricing and long-term underperformance currently exist as unsolved puzzles in IPO research. We have developed a theoretical model based on the assumption that investors' opinions diverge, and hence, the share's demand curve slopes downward to the right. We predict that the entrepreneur increases ownership retention and manages earnings to a maximum degree, and the firm is overpriced to its fundamental value. This last prediction sharply contrasts a substantial body of prior research, which argues that the IPO firm is underpriced, and can explain long-term underperformance as information asymmetry between *both* the entrepreneur *and* the underwriter and investors is mitigated after the IPO. We obtain results through experimentation that support our predictions.

Our theoretical and experimental findings suggest that the entrepreneur uses ownership retention to signal commitment and manage earnings upward, and that the underwriter overlooks distorted earnings.

This is the first paper to the best of our knowledge that explains IPO puzzles using both theory and experiment. Therefore, our research could act as a cornerstone to answer the question, "Why do these IPO puzzles coexist?"

References

Abrahamson, M., Jenkinson, T., Jones, H. 2011. Why don't U.S. issuers demand European fees for IPOs? *The Journal of Finance* 66(6), 2055-2082.

Aggarwal, R., Rivoli, P. 1990. Fads in the initial public offering market? *Financial Management* 19(4), 45-57.

Allen, F., Faulhaber, G. R. 1989. Signaling by underpricing in the IPO market. *Journal of Financial Economics* 23(2), 303-332.

Ball, R., Shivakumar, L. 2008. Earnings quality at initial public offerings. *Journal of Accounting and Economics* 45, 234-349.

Baron, D. P. 1982. A model of the demand for investment banking advising and distribution services for new issues. *The Journal of Finance* 37(4), 995-976.

Baron, D. P., Holmstrom, B. 1980. The investment banking contract for new issues under asymmetric information: Delegation and the incentive problem. *The Journal of Finance* 35(5), 1115-1138.

Beatty, R. P., Ritter, J. R. 1986. Investment banking, reputation, and the underpricing of initial public offerings. *Journal of Financial Economics* 15(1-2), 213-232.

Benveniste, L. M., Spindt, P. A. 1989. How investment bankers determine the offer price and allocation of new issues. *Journal of Financial Economics* 24(2), 343-361.

Black, S., Scholes, M. 1973. The pricing of options and corporate liabilities. *The Journal of Political Economy*

81(3), 637-654.

Brandts, J., Charness, G. 2011. The strategy versus the direct-response method: A first survey of experimental comparisons. *Experimental Economics* 14(3), 375-398.

Campbell, J. P. 1986. Labs, fields, and straw issues. In: Locke, E. A. (Ed.), *Generalizing from Laboratory to Field Settings*. Lexington Books, Lexington, MA, pp. 269-279.

Casari, M., Cason, T. N. 2009. The strategy method lowers measured trustworthy behavior. *Economics Letters* 103(3), 157-159.

Chatterjee, S., John, K., Yan, A. 2012. Takeovers and divergence of investor opinion. *Review of Financial Studies* 25(1), 227-277.

Chen, C. R., Mohan, N. J. 2002. Underwriter spread, underwriter reputation, and IPO underpricing: A simultaneous equation analysis. *Journal of Business Finance and Accounting* 29(3-4), 521-540.

Chen, H. C., Ritter, J. R. 2000. The seven percent solution. *The Journal of Finance* 55(3), 1105-1131.

Chen, J., Hong, H., Stein, J. C. 2002. Breadth of ownership and stock returns. *Journal of Financial Economics* 66, 171-205.

Chen, Q., Kelly, K., Salterio, S. E. 2012. Do changes in audit actions and attitudes consistent with increased auditor skepticism deter aggressive earnings management? An experimental investigation. *Accounting, Organizations and Society* 37(2), 95-115.

Cornelli, F., Goldreich, D., Ljungqvisit, A. 2006. Investor sentiment and pre-IPO markets. *The Journal of Finance* 61(3), 1187-1216.

Da, Z., Engelberg, J., Gao, P. 2011. In search of attention. *The Journal of Finance* 66(5), 1461-1499.

Datar, S. M., Feltham, G. A., Hughes, J. S. 1991. The role of audits and audit quality in valuing new issues. *Journal of Accounting and Economics* 14(1): 3-49.

Deloof, M., Maeseneire, W. D., and Inghelbrecht, K. 2009. How do investment banks value initial public offerings (IPOs)? *Journal of Business Finance and Accounting* 36(1-2), 130-160.

Dickhaut, J., Livingston, W. J., and Watson, D. 1972. On the use of surrogates in behavioral experimentation. *The Accounting Review* 47, 455-470.

Dorn, D. 2009. Does sentiment drive the retail demand for IPOs? *Journal of Financial and Quantitative Analysis* 44(1), 85-108.

Fan, Q. 2007. Earnings management and ownership retention for initial public offering firms: Theory and evidence. *The Accounting Review* 82(1), 27-64.

Geiger, M., Smith, J. L. 2010. The effect of institutional and cultural factors on the perceptions of earnings management. *Journal of International Accounting Research* 9(2), 21-43.

Greenberg, J. 1987. The college sophomore as guinea pig: Setting the record straight. *Academy of Management Review* 12(1), 157-159.

Hirst, D. E. 1994. Auditor sensitivity to earnings management. *Contemporary Accounting Research* 11(1), 405-422.

Hirst, D. E., Hopkins, P. E. 1998. Comprehensive income reporting and analysts’ valuation judgment. *Journal of Accounting Research* 36, 47-75.

Ibbotson, R. G. 1975. Price performance of common stock new issues. Journal of Financial Economics 2(3), 235-272.

Libby, R., Bloomfield, R., Nelson, M. W. 2002. Experimental research in financial accounting. Accounting, *Organizations and Society* 27(8), 775-810.

Lintner, J. 1965. The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. *The Review of Economics and Statistics* 47(1), 13-37.

Ljungqvist, A., Nanda, V., Singh, R. 2006. Hot markets, investor sentiment, and IPO pricing. *Journal of Business* 79(4), 1667-1702.

Loughran, T., Ritter, J. R. 1995. The new issues puzzle. *The Journal of Finance* 50(1), 23-51.

Loughran, T., Ritter, J. R. 2002. Why don't issuers get upset about leaving money on the table in IPOs? *Review of Financial Studies* 15(2), 413-444.

Loughran, T., Ritter, J. R. 2004. Why has IPO underpricing changed over time? *Financial Management* 33(3), 5-37.

Maines, L. A., McDaniel, L. S. 2000. Effects of comprehensive-income characteristics on nonprofessional investors' judgments: The role of financial-statement presentation format. *The Accounting Review* 75(2), 179-207.

Markowitz, H. 1952. Portfolio selection. *The Journal of Finance* 7(1), 77-91.

Mayhew, B. W., Schatzberg, J. W., Sevcik, G. R. 2004. Examining the role of auditor quality and retained ownership in IPO markets: Experimental evidence. *Contemporary Accounting Research* 21(1), 89-130.

Miller, E. M. 1977. Risk, uncertainty, and divergence of opinion. *The Journal of Finance* 32(4), 1151-1168.

Purnanandam, A. H., Swaminathan, B. 2004. Are IPOs really underpriced? *Review of Financial Studies* 17(3), 811-848.

Remus, W. 1986. Graduate students as surrogates for managers in experiments on business decision making. *Journal of Business Research* 14(1), 19-25.

Ritter, J. R. 1984. The "hot issue" market of 1980. *Journal of Business* 57(2), 215-240.

Ritter, J. R. 1991. The long-run performance of initial public offerings. *The Journal of Finance* 46(1), 3-27.

Ritter, J. R., Welch, I. 2002. A review of IPO activity, pricing, and allocations. *The Journal of Finance* 57(4), 1795-1828.

Rock, K. 1986. Why new issues are underpriced. *Journal of Financial Economics* 15(1-2), 187-212.

Sharpe, W. F. 1964. Capital asset prices: A theory of market equilibrium under conditions of risk. *The Journal of Finance* 19(3), 425-442.

Shleifer, A. 1986. Do demand curves for stocks slope down? *The Journal of Finance* 41(3), 579-590.

Tan, H. C., Jamal, K. 2006. Effect of accounting discretion on ability of managers to smooth earnings. *Journal of Accounting and Public Policy* 25(5), 554-573.

Teoh, S. H., Welch, I., Wong, T. J. 1998. Earnings management and the long-run market performance of initial public offerings. *The Journal of Finance* 53(6), 1935-1974.

Trueman, B. 1986. The relationship between the level of capital expenditure and firm value. *Journal of Financial and Quantitative Analysis* 21(2), 115-129.

Ward, E. 1993. Generalizability of psychological research from undergraduates to employed adults. *The Journal of Social Psychology* 133(4), 513-519.

Welch, I. 1996. Equity offerings following the IPO: Theory and evidence. *Journal of Corporate Finance* 2(3), 227-259.

Appendix A. Location of the symmetry axis of U_u

The axis of symmetry for $U_u = -[\hat{\mu} - (x + g(w) + e)][\hat{\mu} - (x + g(w) - f(w) + e - a)]$ is:

$$\hat{\mu}_a = x + g(w) + e - \frac{1}{2}[f(w) + a].$$

As $\hat{\mu}_1 = x + g(w) - f(w) + e - a + (2 - w)N$,

$$\hat{\mu}_a - \hat{\mu}_1 = \frac{1}{2}[f(w) + a - 2(2 - w)N].$$

Consider a case of $\hat{\mu}_a \leq \hat{\mu}_1$ and $w = 1$, or specifically,

$$a \leq 2N - f(1).$$

As $a > 2N$ from the assumption of the demand function, no cases exist of $\hat{\mu}_a \leq \hat{\mu}_1$ and $w = 1$. However, some IPO firms exist in the real world in which entrepreneurs hold all the shares they own ($w = 1$). Hence, it is appropriate to assume $\hat{\mu}_a > \hat{\mu}_1$.

Appendix B. Proof of the Proposition

From $\phi_0^H(0) \equiv p\alpha - (1 - p)(x + 2\theta) + g'(0) > 0$,

$$\alpha > \frac{1}{p}(x + 2\theta - g'(0)) - (x + 2\theta)$$
$$\text{where } x + 2\theta - g'(0) > 0.$$

From $\phi_0^L(1) \equiv p\alpha + f'(1) + N - (1 - p)(f(1) + f'(1) + a) < 0$,

$$\alpha < \frac{1}{p}(f(1) + a - N) - (f(1) + f'(1) + a)$$
$$\text{where } f(1) + a - N > 0, \quad f(1) + f'(1) + a > 0.$$

$\phi_0^H(0) = 0$ represents a set of marginal points (p, α) that compel a very popular firm's entrepreneur to sell all owned shares. $\phi_0^L(1) = 0$ represents a set of marginal points (p, α) that compel the unpopular firm's entrepreneur to hold all owned shares. As the α that satisfies $\phi_0^L(1) = 0$ is larger than the α that satisfies $\phi_0^H(0) = 0$ for a certain $p(0 < p < 1)$, the curve $\phi_0^L(1) = 0$ is located above the curve $\phi_0^H(0) = 0$. Hence, the set of (p, α) that satisfies

$\phi_0^H(0) > 0$ and $\phi_0^L(1) < 0$ is the shadowed area in Fig 4.

We prove that $(w_1, w_2 = w_1 + \Delta w)$ exists, which satisfies $U_e^2 > U_e^1$ in that area. Let P_0^H and P_0^L be offering prices in the very popular and unpopular equilibrium, respectively. Namely,

$$P_0^H = x + g(w_2) + 2\theta, \quad P_0^L = f(w_1) + (w_1 - 2)N + a \qquad (P_0^H > P_0^L).$$

Consider Δw, such that

$$0 < \Delta w < (1 - w_1)\left(1 - \frac{P_0^L}{P_0^H}\right). \tag{B.1}$$

As

$$(1 - w_1)\left(1 - \frac{P_0^L}{P_0^H}\right) < 1, \quad 0 < \Delta w < (1 - w_1)\left(1 - \frac{P_0^L}{P_0^H}\right) < 1,$$

hence,

$$w_1 < w_2 = w_1 + \Delta w < w_1 + (1 - w_1)\left(1 - \frac{P_0^L}{P_0^H}\right).$$

As

$$1 - \left[w_1 + (1 - w_1)\left(1 - \frac{P_0^L}{P_0^H}\right)\right] = (1 - w_1)\frac{P_0^L}{P_0^H} \geq 0,$$

$$0 \leq w_1 < w_2 = w_1 + \Delta w < w_1 + (1 - w_1)\left(1 - \frac{P_0^L}{P_0^H}\right) \leq 1. \tag{B.2}$$

From $U_e^2 > U_e^1$ and $(1 - w_1)P_0^L - (1 - w_2)P_0^H < 0$,[21]

$$\alpha > \frac{w_1 P_0^L - w_2 P_0^H}{w_2 - w_1} + \frac{1}{p} \cdot \frac{(1 - w_1)P_0^L - (1 - w_2)P_0^H}{w_2 - w_1}$$

$$\text{where } \frac{w_1 P_0^L - w_2 P_0^H}{w_2 - w_1} < 0, \text{ and } \frac{(1 - w_1)P_0^L - (1 - w_2)P_0^H}{w_2 - w_1} < 0. \tag{B.3}$$

Eq. (B.2) and (B.3) reveal that $(w_1, w_2 = w_1 + \Delta w)$ exists, which satisfies $U_e^2 > U_e^1$ in the

21 From Eq. (B.1), $\Delta w < (1 - w_1)(1 - P_0^L / P_0^H)$. Noting that $w_2 = w_1 + \Delta w, (1 - w_1)P_0^L - (1 - w_2)P_0^H < 0$ can be easily obtained.

shadowed area in Fig. 4.

Appendix C. Instructions to the participants of the experiment

1. Roles and background

Two roles exist in this experiment: the entrepreneur and the underwriter. The participants' allocations to these roles are completely random and computerized. The entrepreneur, whose company will go public on a stock exchange, considers both the company's reported earnings in the period just before the IPO and the number of shares the entrepreneur continues to hold at IPO. The underwriters will assess the reported earnings. The company continues to conduct business activities after the IPO, and whether they are successful is contingent on the state of nature.

2. Entrepreneur's decision making

The timeline is as follows: First, nature selects the true earnings θ from the set $\{80, 100, 120\}$ and the entrepreneur observes it. Second, the entrepreneur chooses the number of shares S sold at the IPO from the set $\{0, 50, 100\}$ (the entrepreneur holds 100 shares prior to the IPO), and decides how much of the reported earnings he or she manages μ, which is equivalent to choosing the reported earnings e: (i) no earnings management ($e = \theta$), (ii) 50% earnings management ($e = 1.5\theta$), and (iii) 100% earnings management ($e = 2\theta$).

The higher the number of shares sold at the IPO, the higher the entrepreneur's profit through stock sales, but the lower the profit from future business success. Subsequently, the entrepreneur also decides the expected value of the underwriter's earnings management estimation and the future expectation for business success.

3. Underwriter's decision making

The underwriter then observes the reported earnings and the number of shares sold by the entrepreneur, and estimates how much of the reported earnings the entrepreneur manages $\hat{\mu}$ from the set $\{0, 1/4, 1/2, 3/4, 1\}$. For example, when the reported earnings is $e = 200$ and the underwriter chooses $3/4$, the underwriter's earnings management estimation $\hat{\mu}$ is calculated as $200 \times 3/4 = 150$.

The higher the earnings after the assessment, the higher the share price. The underwriter then decides the expected true earnings $\mathrm{E}_u(\theta)$ from the set $\{80, 100, \text{or} 120\}$.

4. Offering Price

The offering price is then decided as follows:

$$\text{Offering price} = 100 + 10 \times \left(1 - \frac{\#\text{ of shares sold by the entrepreneur at the IPO}}{100}\right) + \text{reported earnings} - \text{earnings management estimation.}$$

5. Payoff

The entrepreneur's payoff depends upon whether business activities after the IPO are successful, and is decided as follows:

(i) If business activities after the IPO are successful:

Entrepreneur's payoff

$$= \text{Stock price} \times \#\text{ of shares sold by the entrepreneur at the IPO} + (\text{Stock price} + 100) \times \left(1 - \frac{\#\text{ of shares sold by the entrepreneur at the IPO}}{100}\right) \times 100;$$

(ii) Otherwise:

Entrepreneur's payoff

$$= \text{Stock price} \times \#\text{ of shares sold by the entrepreneur at the IPO.}$$

The underwriter's payoff is decided as follows:

$$\text{Underwriters' payoff} = \text{Stock price} \times \text{Stock trading volume}$$

Appendix D. Key variable definitions in the paper

The theoretical model's key variables are as follows:

N = the number of shares held by the entrepreneur before the IPO
= the number of shares that the entrepreneur issues at the IPO

w = ownership retention at the IPO $(0 \leq w \leq 1)$

$S = (1 - w)N$ = the number of the entrepreneur's shares sold at the IPO

P_0 = public offering price

P_1 = the share price at the end of period 1

θ = true earnings in period 0 $(\theta > 0)$

μ = an amount of earnings management in period 0 $(0 \leq \mu \leq \theta)$

$e = \theta + \mu$ = reported earnings in period 0

p = probability of success in business activities in period 1 $(0 < p < 1)$

α = an increase in the share price during period 1 if the business activities succeed $(\alpha > 0)$

q = probability of earnings management being revealed $(0 < q < 1)$

$k\mu$ = a decrease in the share price when earnings management being revealed $(k\mu < \alpha)$

U_e = an entrepreneur’s payoff

U_u = an underwriter’s payoff

P = the share price in the demand function

$D(P)$ = an inverse demand function of the share

a = a degree of a firm’s popularity $(a > 2N)$

$f(w)$ = incremental demand of the shares explained by the ownership retention

Q = the number of shares that the underwriter trades in the IPO

x = fundamental value at the beginning of period 0

$g(w)$ = an increase in the offering price explained by the ownership retention

$\hat{\mu}$ = an amount of earnings management estimated by the underwriter

FV = fundamental value at the IPO

OP = overpricing in the offering price

The experiment’s key variables are as follows:

Earnings management ratio = an amount of earnings management (μ)/true earnings (θ)

Ownership retention = # of shares held at the IPO/# of shares held before the IPO

Unreliability ratio = the entrepreneur’s expected value of an earnings management amount estimated by the underwriter ($\mathrm{E}_e(\hat{\mu})$)/true earnings (θ)

Earnings management estimation = the amount of earnings management estimated by the underwriter ($\hat{\mu}$)/reported earnings (e)

Expected true earnings = an underwriter’s expected value of true earnings ($\mathrm{E}_u(\theta)$)

Earnings management permission = earnings after the assessment $(e - \hat{\mu})$/ expected true earnings ($\mathrm{E}_u(\theta)$)