Information revelation and public information in IPOs

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Abstract

We analyze the effect of public information on (i) the incentives of rational investors to reveal private information to the underwriter during the book-building process, and (ii) their demand for allocations in the IPO. Our model generates several new predictions. First, investors require more underpricing to reveal positive private information in downmarkets than in upmarkets (the incentive effect). Second, the demand for shares and the proportion underpriced IPOs are increasing in market returns (the demand effect). Combined, these two counteracting effects can explain why IPO underpricing is positively related to pre-issue market returns, consistent with extant evidence. Using a sample of 5,000 U.S. IPOs from 1981-2008, we show that the empirical inferences of the model are borne out in the data. Our results are relevant for IPOs in Europe, where book building is the dominant sales process.

Keywords: Public information, partial adjustment, underpricing, IPOs, book building

JEL Classification: G10, G32.

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1 Introduction

Extant evidence shows that underpricing in initial public offerings (IPOs) is positively related to market-wide equity returns preceding the offering, suggesting that underwriters fail to fully adjust offer prices for publicly available information. As pointed out by Loughran and Ritter (2002) and Lowry and Schwert (2004) among others, partial adjustment to information in prior market returns is puzzling since it implies that underwriters reward investors for easily available public information.[1]

In this paper, we offer a rational explanation for partial adjustment to public information. Our model is based on the framework of Benveniste and Spindt (1989), where underwriters underprice IPOs to compensate investors for revealing private information during the subscription period. While their main prediction is that offer prices will adjust partially to investors' *private* information, this paper shows that it can also be rational with partial adjustment to *public* information. This is because publicly available information affects the incentives of investors to reveal their private information as well as their demand for allocations.

More specifically, the model shows that investors require higher compensation, i.e. more underpricing, to truthfully reveal favorable information when public information is negative. The intuition for this result starts with the optimal rule for the allocation of shares in the IPO, which favors investors revealing positive private signals. In our model, as long as at least one investor reports optimistic information, investors with negative information will be left without any IPO allocation. Since private and public signals are conditionally correlated, the probability of being awarded underpriced shares after hiding good information is higher when public information is negative. The expected gains from concealing favorable private information are therefore higher in bad times. As a result, negative market-wide information increases the need for the underwriter to underprice the issue in order to induce investors to reveal their positive information. We label this mechanism the incentive effect.

At the same time, public information also affects the distribution in investors' demand for allocations. We refer to this mechanism as the demand effect. To start with, there is little need for underpricing to induce truthful revelation of pessimistic private information. When public information is positive, private information is likely to also

[1] See also Logue (1973), Hanley (1993), Bradley and Jordan (2002), and Kutsuna, Smith and Smith (2009).

be favorable, and hence the probability for underpricing the offering is higher. Thus, through the demand effect, positive public information increases the expected IPO underpricing.

The relative strength of the two effects determines how public information ultimately is related to underpricing. While the incentive effect produces a negative relation between public information and underpricing, the demand effect pulls in the opposite direction. Whenever the demand effect dominates the incentive effect, underpricing is positively related to public information and the offer price is only partially adjusted for market-wide returns. This is the case if the number of investors in the issue is sufficiently large.

We test the empirical implications of the model for a sample of 5,000 U.S. IPOs in the period 1981-2008. As a proxy for private information, we use the residual from a regression of the S&P500 returns on the offer price revision at the end of the registration period, effectively purging any effect of market-wide returns from the price update. The predictions of the model are all borne out in the data. First, for a given increase in private information, investors require more underpricing in downmarkets than in upmarkets (the incentive effect). Second, the probability of positive private information and of IPO underpricing is higher when public information is favorable (the demand effect).

We then replicate earlier studies of partial adjustment to public information. Interestingly, the relationship between market returns and IPO initial returns is positive only for the subsample of IPOs taking place prior to September 1998. In subsequent time periods, the offer price tends to be fully adjusted for the information content in pre-issue market-wide returns. This suggests that the relative strength of the incentive and demand effects may be varying over time.

Several papers have analyzed partial adjustment to public information in IPOs. Loughran and Ritter (2002) use prospect theory to develop a behavior-based explanation of the observed positive relation between market returns and underpricing. Edelen and Kadlec (2005) model it as the outcome of a bargaining game between the issuer and the underwriter, where underpricing is traded off against the probability of withdrawal. Sherman (2005) shows that partial adjustment will arise in the Benveniste and Spindt (1989) model if investors' opportunity costs are positively related to public information observed prior to the offering. Finally, in a Rock (1986) setting, Leite (2007) shows that positive public information reduces the winner's curse problem, which in turn induces the issuer to underprice the issue more.

The rest of the paper is organized as follows. Section 2 describes the model. The relation between public information and underpricing is discussed in Section 3. In Section 4, we report the result from our empirical tests of the model. Section 5 summarizes.

2 Setup of the model

We start with a firm that is about to offer its shares to outside investors through an IPO. The firm's true value is good $G = 1$ with probability α and bad $B = 0$ with probability $1 - \alpha$. For simplicity, the number of shares to be floated is normalized to one, and investors are allocated fractions of this one share. All agents are risk neutral, and the risk-free interest rate is zero.

There are $N \geq 2$ investors participating in the offering, each observing an independently identically distributed (i.i.d.) private signal $s_I = \{g_I, b_I\}$, where g_I represents positive information and b_I negative information about the firm. Let $n \in [0, N]$ denote the number of investors who observe positive private signals.

Investors observe their private signals at zero cost.[2] The precision in the private signal s_I is similar across all investors and equals $\gamma = q(g_I|G) = q(b_I|B) > 1/2$, where $q(\cdot|\cdot)$ and $q(\cdot)$ denote conditional and unconditional probabilities throughout. The assumption that $\gamma > 1/2$ ensures that the signal is informative about the true value of the firm.

In addition, all investor observe a common public signal $s = \{g, b\}$, where $s = g$ represents positive information and $s = b$ negative information. We can think of the public signal as market-wide information that affects the value of the firm, for example, about aggregate demand or the business cycle. The precision in the public signal is given by $f = q(g|G) = q(b|B)$, where $f > 1/2$. Since $f > 1/2$ and $\gamma > 1/2$, the private and the public signals are both informative and therefore also positively conditionally correlated. That is, if $s = g$, then the probability that the private signal is also positive is $\mathrm{p}(s_I = g_I|s = g) > 1/2$, and vice versa $\mathrm{p}(s_I = b_I|s = b) > 1/2$.

Let $v(n, s)$ denote the aftermarket value of the firm, i.e. the value of the firm after it is publicly listed. The aftermarket value of the firm is assumed to fully reflect all available information at the time of the offering. That is, the function $v(n, s)$ is the expected

[2]See Sherman and Titman (2002) for a study of the effect of costly private information in the Benveniste and Spindt (1989) setup.

value of the firm conditional on the n positive private signals observed by investors and the public signal s. The specification of $v(n, s)$ as a conditional expectation implies that the marginal impact of each investor's private signal on the firm's aftermarket value is decreasing in the number of investors in the offering (N).

This is where our model critically differentiates from the one in Benveniste and Spindt (1989). They assume that aftermarket value is additive in investors' private signals. That is, the informational value of a marginal private signal is constant with respect to the number of private signals reported by other investors.[3] In our model, in contrast, the significance of each investor's private signal in the valuation of the firm declines with the number of investors.

Because the aftermarket value of the firm increases in the number n of positive private signals, n is also a measure of the demand for shares in the issue, and where a higher value of n corresponds to higher demand. Indeed, the case for which $n = N$, and hence all investors observe positive private signals, is referred to as the high-demand state. In contrast, the case for which $n = 0$ and all investors observe negative private signals, is called the low-demand state.

The bookbuilding process is conducted as follows. Investors observe their private signals along with the public signal. Bids are submitted to the underwriter effectively by reporting the private signal. Each investor submits a "high" or a "low" bid, which is to say that she reports either a positive or negative signal. In equilibrium, an investor who observes a positive private signal reports this truthfully by bidding high. Similarly, an investor who observes a negative signal reports this truthfully by submitting a low bid.

The firm pays no fees for the services of the underwriter. Before investors submit their bids, the underwriter states his pricing and allocation policy. He then responds to investors' bids according to this pre-committed policy. In equilibrium, the underwriter receives all the relevant information from investors about the firm. Thus, when determining the offer price, he correctly anticipates the firm's true aftermarket value $v(n, s)$.[4]

Let $p(n, s)$ denote the IPO price if n investors report positive private signals ($s_I = g_I$) and given the public signal s. Let $z(g, n)$ denote the fraction of the issue allocated to an

[3] Benveniste and Spindt (1989) states that each private signal "has an equal (absolute) marginal impact on the stock's value" (p. 347).

[4] Since in our model the number of shares is one, the offer price is equal to the proceeds in the IPO.

investor who submits a high bid, and $z(b, n)$ denote the fraction awarded to an investor submitting a low bid. Since all private signals have the same precision, investors with identical bids receive equal allocations. In other words, the issue is allocated pro-rata among investors who submit identical bids. We assume that the issuer is committed to price the firm at or below its aftermarket value, so that $p(n, s) \leq v(n, s)$. Unlike Benveniste and Spindt (1989), however, we place no restrictions on the number of shares that can be allocated to one investor. This implies that an entire issue may be allocated to one investors. As discussed below, as long as at least one investor observes a positive private signal $s_I = g_I$, it is optimal to allocate the issue exclusively to investors with favorable information.

Let us now consider investors' incentives to truthfully reveal their private signals. Trivially, an investor with negative information has little incentive to misrepresent her signal. If she lies and submits a high bid, she is awarded a fraction of the issue at a price exceeding the true firm value implied by her private signal. Thus, she is better off truthfully submitting a low bid, and possibly be allocated a share of the IPO at a price correctly reflecting her negative signal.

Instead, we need to worry about the incentives of investors with positive private signals. These investors may benefit from misrepresenting their private information, pretending to posses a negative signal in order to lower the issue price. The potential drawback is, however, that other investors may submit high bids, leaving the untruthful investor without any allocation in the offering.

For an investor i with a positive private signal, the expected payoff from submitting a high bid that truthfully reveals her signal is

$$U = \sum_{n=1}^{N} q(n|g_I, s) z(g, n)[v(n, s) - p(n, s)], \tag{1}$$

where $q(n|g_I, s)$ is the probability that a total of n investors receive positive private signals conditional on investor i observing the private signal $s_I = g_I$ and the public signal s. Recall that $z(g, n)$ is the fraction of the issue allocated to investor i for a given n if she submits a high bid. The expected payoff to investor i is thus her fraction of the IPO initial returns, probability-weighted across different n.

The expected payoff to the same investor from misrepresenting her information by submitting a low bid equals

$$\hat{U} = \sum_{n=1}^{N} q(n|g_I, s) z(b, n)[v(n, s) - p(n-1, s)]. \tag{2}$$

For a given n and s, the offer price is now lower, $p(n-1, s) < p(n, s)$, and the probability of receiving an allocation in the IPO is now $z(b, n) < z(g, n)$. That is, by submitting a low bid, the investor may get a higher return for a given allocation, but at the same time risks getting a smaller (or no) fraction of the shares in the issue.

The payoff $\hat{U}$ is the minimum rent for an investor with a positive private signal and $\hat{U}$ hence represents the reservation value to such an investor.[5] To induce this investor to truthfully reveal her signal, the expected payoff U from bidding high must be equal to or exceed the expected profits $\hat{U}$ from submitting a low bid. The issue must thus be priced and allocated to satisfy the truth-telling (incentive) constraint

$$U \geq \hat{U}. \tag{3}$$

The expected proceeds from the IPO are given by

$$E\pi = \sum_{n=0}^{N} q(n, s) p(n, s). \tag{4}$$

Formally, the objective of the firm is to maximize $E\pi$ with respect to allocations $z(s, n)$ and prices $p(s, n)$ subject to the incentive constraint (3). Since issuance costs are exclusively determined by investors' informational rents $\hat{U}$, maximizing $E\pi$ is equivalent to minimizing $\hat{U}$. The underwriter will further price and allocate the issue such that the investor's truth-telling constraint $U \geq \hat{U}$ is satisfied as an equality.

The absence of allocation restrictions allows the underwriter to allocate shares only to investors who submits high bids (i.e. report positive private information), regardless of the number of investors submitting high bids. In equilibrium, such an allocation rule sets $z(b, n) = 0$ for all $n > 0$. This in turn minimizes $\hat{U}$ and thus maximizes $E\pi$. In the event that all investors obtain negative signals ($n = 0$), and in equilibrium submit low bids, the issue is allocated pro-rata among the N investors. In other words, the issue is

[5] As discussed above, investors with negative private information earn zero informational rents in equilibrium.

never withdrawn in the low-demand state.[6]

The given allocation rule implies that an investor who submits a low bid receives no shares unless the remaining $N-1$ investors also submit low bids, in which case each investor is allocated a fraction $1/N$ of the issue. The underwriter further reduces $\hat{U}$ (and hence increases $E\pi$) by not underpricing the issue in the low-demand state; i.e., by setting $p(0,s)=v(0,s)$. The expected payoff to an investor with a positive private signal of submitting a low bid now equals

$$\hat{U}=q(1|g_I,s)\frac{1}{N}[v(1,s)-v(0,s)], \tag{5}$$

which is strictly positive since $v(1,s)>v(0,s)$.

The expected payoff to an investor with a positive private signal of submitting a high bid, truthfully revealing his signal, equals

$$U=\sum_{n=1}^{N}q(n|g_I,s)\frac{1}{n}[v(n,s)-p(n,s)]. \tag{6}$$

The set of prices $p(n,s);\ n=1,\ldots,N$ that satisfies the investor's incentive constraint $U=\hat{U}$ is indeterminate, since there are n prices to be determined from only one constraint. For tractability, let the issue be fairly priced (no underpricing), so that $p(n,s)=v(n,s)$, for each $n=1,\ldots,N-1$. Now the offer price in the high-state, $p(N,s)$, is uniquely determined from $U=\hat{U}$. With $\hat{U}>0$, it follows that $U>0$, which requires that $p(N,s)<v(N,s)$. That is, the issue is underpriced in the high-demand state where all investors observe positive private signals.[7]

Since the issue price is set to the firm's aftermarket value $v(n,s)$ in all states where $n<N$, the payoff in these states are zero ($U=0|n<N$). The expected payoff to an investor with a positive signal of submitting a high bid therefore collapses to the

[6]Busaba (2006) shows that it may be optimal to commit to withdraw the issue with a positive probability if demand is low. Busaba, Benveniste, and Guo (2001) find empirically that such a threat reduces underpricing. In our setting, however, it is never optimal to commit to withdraw the issue.

[7]The indeterminacy of prices for states $n\geq 1$ results from our assumption that the underwriter face no allocation restrictions and may therefore allocate the entire issue to one investor. If we relax this assumption, then there will be a cut-off state $n^*\in[1,N]$ such that there is strictly no underpricing for $n<n^*$ while the set of (possible) underpriced states is determined from $n\geq n^*$. (See also bullet points two and three in Theorem 1 of Benveniste and Spindt). For example, restricting the underwriter to allocate no more than a fraction $1/(N-m); m\in[0,N-1]$ of the issue to one investor, there will be no underpricing in states $n<N-m$ while the set of (possible) underpriced states will be determined from $n\geq N-m$. Indeed, as m is decreased, the set of underpriced states reduces to $n=N$ for $m=0$.

expected payoff in the high-state where $n = N$:

$$U = q(N|g_I, s)\frac{1}{N}[v(N, s) - p(N, s)]. \tag{7}$$

The offer price $p(N, s)$ associated with the high-demand state is determined from the investor's incentive constraint $U = \hat{U}$, which gives

$$p(N, s) = v(N, s) - \frac{q(1|g_I, s)}{q(N|g_I, s)}[v(1, s) - v(0, s)]. \tag{8}$$

Since $v(1, s) > v(0, s)$, the issue is at all times underpriced in the high-demand state, i.e., $p(N, s) < v(N, s)$. With fair pricing in the remaining demand states, the issue is underpriced in expectation.

Finally, it is easy to show that initial stock returns are increasing in the magnitude of underpricing. The initial return associated with the high-demand state is given by

$$r(N, s) = \frac{v(N, s)}{p(N, s)} - 1. \tag{9}$$

Thus, the expected initial return equals

$$Er(s) = q(N|s)r(N, s). \tag{10}$$

The analysis so far has established that IPOs are expected to be underpriced in order to induce truthful revelation of positive private information, similar to Benveniste and Spindt (1989). In the next section, we go beyond this standard argument and examine the relation between public information and underpricing.

3 Public information and underpricing

As shown in Equation 10 above, the expected IPO initial return, $Er(s)$, is the product of the initial return in the high-demand state, $r(N, s)$, and the probability that this state occurs $q(N|s)$. An key contribution of this paper is the insight that the public signal affects the expected initial return through both $r(N, s)$ and $q(N|s)$. This insight is summarized in our first proposition.

Proposition 1 *(i) The initial return in the high-demand state is negatively related to* *the public signal s, so that $r(N, g) < r(N, b)$. (ii) The probability of the high-demand state, and hence the probability that the IPO is underpriced, is positively related to the public signal, i.e., $q(N|g) > q(N|b)$.*

The public signal affects initial returns in the high-demand state, $r(N, s)$, through investors' incentives to truthfully reveal their private signals. In particular, the probability to be allocated shares for an investor understating her information is higher when public information is bad, i.e. $q(1|g_I, b) > q(1|g_I, g)$. [8] That is, the chance of getting a positive allocation from low-balling is negatively correlated to the public signal. Accordingly, positive public information lowers investors' incentives to hide favorable information, and vice versa. As a result, positive public information reduces the amount of underpricing required for investors to reveal their positive signals. We call this mechanism the incentive effect. Contrary to extant evidence of partial adjustment to public information, the incentive effect suggests a negative relationship between public information and underpricing.

However, the public signal also impacts the probability $q(N|s)$ that there is sufficient demand—that the number of positive signals n is sufficiently high—for the issue to be underpriced. Specifically, positive public information (s=g) increases the probability that investors obtain favorable private signals ($s_I = g_I$). This in turn raises the probability that investors submit high bids. We label this mechanism the demand effect. Obviously, a higher probability that investors have favorable private information increases the likelihood that the issue is underpriced in the first place. Thus, through the demand effect, the probability $q(N|s)$ that an issue is underpriced is positively related to the public signal.

In sum, the incentive and demand effects give rise to opposite relationships between public information and underpricing. Proposition 1 therefore implies that the expected initial return can be positively or negatively related to the public signal depending on which of the two effects that dominates. The next proposition shows that the demand effect dominates if the number of investors in the issue, N, is sufficiently large.

Proposition 2 *Whenever the number of investors in the issue, N, is sufficiently large, the demand effect strictly dominates the incentive effect. In this case, initial returns are positively related to public information.*

[8] Formally, it is required that $q(1|g_I, b)/q(N|g_I, b) > q(1|g_I, g)/q(N|g_I, g)$.

As the number of investors in the issue, N, increases, the marginal impact of each investor's signal on the aftermarket value of the firm declines. This reduces the potential payoff, $v(1,s) - v(0,s)$, to the investor of hiding her positive private signal. This in turn lowers the amount of underpricing required to induce truthful revelation of favorable private information. In other words, an increase in the number of investors decreases the relative importance of the incentive effect. Once the demand effect strictly dominates, the public signal will be positively related to underpricing. Indeed, Proposition 2 predicts a positive relation between public information and initial returns—consistent with partial adjustment to public information—whenever the number of investors in the issue is sufficiently large.

The result that the incentive effect weakens with the number of investors N is critical to our model. It stems from our assumption that the marginal impact on firm value of each investor's signal declines in N. Interestingly, this result exists in any standard micro structure model where investors' private information is reflected in the stock's price through the trading process.[9] It does not, however, arise in the Benveniste and Spindt (1989) setup where each investor's signal has constant marginal value.

Overall, our model provides a rational explanation for the empirical fact that offer prices adjust only partially to pre-issue market returns. We propose that this partial adjustment is a result of favorable private information and high demand for shares in the issue. We further identify a counteracting incentive effect, which produces a negative relationship between public information and underpricing. Although prior evidence establishes a positive correlation between initial returns and market returns, our model allows for either effect to dominate.

The incentive and demand effects have several empirical implications that are relatively straightforward to test. For example, the demand effect implies that the fraction of underpriced IPOs will be higher when issued in upmarkets than when issued in downmarkets.[10] Moreover, the incentive effect implies less underpricing in good markets than in bad markets for revelation of favorable private information. Thus, initial returns should be more sensitive to private information in IPOs preceded by negative rather than positive market returns. We next turn to an empirical examination of the implications

[9]See, e.g., Kyle (1985). In Chen and Wilhelm (2008) a similar effect in the IPO aftermarket leads early stage investors to bid aggressively as they expect their information to become less important as new informed investors enters the market.

[10]A substantial fraction of IPOs are overpriced. See, e.g., Ruud (1993) and more recently Lowry, Officer, and Schwert (2008).

of the model.

4 Empirical tests of the model

4.1 Sample description

To get our sample, we identify 8498 U.S. IPOs in the period 1970-2008 from the Global New Issues databases in Thompson Financial's SDC. Since the model describes the book building process, we want to purge fixed price offerings. We therefore restrict the sample to 6301 cases with a positive pricing range, i.e. with a positive spread between the high and low filing price. SDC does, however, not report the filing range prior to 1981. As a result, this restriction effectively eliminates all IPOs in the 1970s.

We require firms to have a filing midpoint of at least \$5 per share, to be listed in CRSP, and to be traded by the 40th trading day after the public listing on NYSE, AMEX or Nasdaq. All unit offerings, real estate investment trusts (REITs), American depository receipts (ADRs), and closed-end funds are eliminated. We further require the IPO firm to have a founding year in the Field-Ritter founding dataset and a lead underwriter rank in the Ritter underwriter ranking dataset. Both these databases are from Jay Ritter's webpage at University of Florida. Our final dataset consists of 5093 IPOs in 1981-2008, all of which have a complete set of control variables.

Table 1 reports the number of cases and average initial returns by year. Two-thirds of the sample firms go public in the 1990s, one quarter in the 2000s and one tenth in the 1980s. Column 2 shows the first-day return $IR1 = p_1/p_0 - 1$, where p_1 is the firm's closing price on the first day of trading and p_0 is the IPO offer price. All stock price data is from CRSP. If there is no trade in a given day, we use the midpoint of the bid-ask spread. The average one-day return is 20% and varies substantially over time. The largest underpricing takes place in the years 1999 and 2000, with a mean $IR1$ of 74% and 58%, respectively. In contrast, the annual average one-day initial return never exceeds 6% in the period 1984-1989.

Column 3 reports the initial stock return over the first 21 trading days, adjusted with the value-weighted Fama-French 49 industry portfolios (from Ken French's webpage at Dartmouth College). This one-month initial return is defined as $IR21 = p_{21}/p_0 - i_{21}/i_0$, where p_{21} is the closing price of the IPO firm's stock on the 21st trading day after the offering, and i_t is the value of the firm's value-weighted industry portfolio on day

$t \in \{0, 21\}$. The one-month initial return averages 25% for the full sample and is slightly higher than the average one-day return. Similar to $IR1$, $IR21$ takes the highest values in 1999 and 2000 with a mean of 100% and 68%, respectively, and its annual average stays below 5% in the period 1986-1989.

In the empirical analysis below, we follow Lowry, Officer and Schwert (2008) and use the one-month initial return as our primary measure for the underpricing in the offering. Underwriters tend to trade actively in the newly-issued stock in order to provide price stabilization, sometimes covering a short position resulting from an overallotment of shares (a greenshoe option). Most such market intervention takes place in the days immediately following the offering.[11] While the one-day initial return may be substantially affected by underwriter trades, the one-month return is more likely to accurately capture the underlying demand for the firm's shares. For robustness, however, we also report the results for the one-day return $IR1$.

The last three columns of Table 1 show the return of the S&P500 index over the 45 trading days preceding the IPO ($SP500$), and the proportion of IPOs that take place in positive ($SP500 > 0$) and negative ($SP500 \leq 0$) market conditions, respectively. The average pre-issue market return is 2.7% and three-quarters of the sample IPOs take place in upmarkets. In the following, we use the S&P500 45-day return as a proxy for new public information during the book building period. We choose a 45-day window to largely match the average and median number of trading days in the registration period.

4.2 Univariate analysis

In the model, the expected underpricing depends on relative size of the two counteracting effects from public information on investors incentives. On the one hand, when public information is negative, underwriters must underprice the issue more in order to induce investors to reveal their positive private information (the incentive effect). On the other hand, since public and private signals are conditionally positively correlated, the demand for shares in the IPO is higher when publicly available information is positive (the demand effect). These two effects predict several empirical patterns. First, for a given increase in private information, we should observe more underpricing in downmarkets than in upmarkets. Second, when public information is good, investors are more likely to have favorable private information. Third, the proportion underpriced offerings

[11] See, e.g., Ruud (1993) and Hanley, Kumar and Seguin (1993).

should be higher when market-wide prospects are bright. In the following, we will test these predictions in several different ways. To start with, we focus on the univariate results across different information sets.

Testing the model requires a measure for private information. Since private information in itself is unobservable, we follow the literature and turn to the outcome of the book building process. As discussed above, the objective of this process is to uncover investors' private information. Any revision in the final offer price from the indicated price in the initial filing range will—at least partly—reflect new information revealed by investors to the underwriter during the road show. We define the price update as $PU = p_0/p_{mid} - 1$ and where p_{mid} is the filing range midpoint.

The price update will, however, also incorporate new broadly available information that reaches the market during the registration period. We therefore compute a measure for private information which purges the effect of public information from the offer price revision. Specifically, this measure, the price update residual ($PUres$), is the residual from the regression $PU = \alpha + \beta * SP500 + \epsilon$. In other words, $PUres$ is any information in the price revision above and beyond what can be inferred from the aggregate information incorporated in the public markets. For 616 cases with no revision in the final offer price, i.e. with $PU = 0$, we set $PUres$ to zero. This is because when $PU = 0$, by construction, $PUres > 0$ if $SP500 < 0$ and vice versa, although the book building process may not have uncovered any new information. Instead, we characterize these cases as book building processes that fail to generate any new private information, and thus set $PUres = 0$.

It may appear somewhat extreme to eliminate any overlap in public and private information from our private information measure ($PUres$). On the other extreme, one could consider all information in the price update to be generated by private investors. As a robustness check, we therefore control that the results hold also when using the price update PU as a proxy for private information.

Table 2 reports average IPO returns split by positive and negative public and private information, respectively. Variable definitions and data sources are shown in Table 3. In Panel A, the price update residual ($PUres$) is used as a proxy for private information, while Panel B uses the price update (PU). Interestingly, the univariate results presented in the table are consistent with the empirical patterns predicted by the model. Focusing on $PUres$ (Panel A) and the one-month initial return $IR21$, when private information is dismal ($PUres < 0$), the average level of underpricing is relatively small ($IR21$ is 7% in upmarkets and 9% in downmarkets). Consistent with Benveniste and Spindt (1989), the degree of underpricing is much higher when private information is good ($PUres > 0$). Unique to our model predictions, however, the underpricing is particularly high when the issue takes place in a downmarket (mean $IR21 = 58\%$ vs. 44% in an upmarket). Finally, when public markets are up ($SP500 > 0$), a higher fraction of the IPOs have positive rather than negative private information (46% vs. 42%), while the opposite holds when public markets are down ($PUres$ is positive for 34% and negative for 54% of the IPOs).

As shown in the table, the same patterns appear also for the one-day initial return $IR1$ as well as when the price update PU is used as a proxy for private information (Panel B). We next test if the incentive and demand effects hold in the cross-section.

4.3 Tests of the incentive effect

When private information is negative, investors have little incentive to hide their proprietary information. In contrast, in order to persuade investors to reveal positive private information, underwriters have to underprice the offering. A novel and central prediction of the model is that investors require more underpricing to reveal their private information when the public outlook is gloomy. We test this prediction by regressing $PUres$ on the IPO initial return (IR):

$$IR = \alpha + \beta_1 \ PUres * SP500Pos + \beta_2 PUres * SP500Neg + \beta_3 SP500Pos + \epsilon. \quad (11)$$

$SP500Pos$ and $SP500Neg$ are two mutually exclusive dummy variables. The first variable $SP500Pos = 1$ if the 45-day pre-issue market return is positive ($SP500 > 0$) and the second variable $SP500Neg = 1$ if $SP500 \leq 0$. The interaction variables $PUres * SP500Pos$ and $PUres * SP500Neg$ hence capture the effect of private information on underpricing when public information is good and bad, respectively. We further include the dummy $SP500Pos$ separately to allow the two interaction variables to have different intercepts.

The regression results are shown in Table 4, using an ordinary least square (OLS) estimation. The dependent variable is the one-month initial return ($IR21$) in the first four columns and the first-day return ($IR1$) in the last four columns. Adjusted R^2 is generally relatively high, ranging from 0.20 (columns 1-2) to 0.44 (columns 7-8). When underpricing is measured by $IR21$ (column 1), the coefficients for $PU * SP500Pos$ and $PU * SP500Neg$ are $\beta_1 = 1.11$ and $\beta_2 = 1.34$, respectively, both highly significant from zero. In other words, the more positive information the investors have, the more underpricing is required to induce truthful revelation of this information.

The second regression specification is:

$$IR = \gamma + \delta_1 PUres + \delta_2 PUres * SP500Neg + \delta_3 SP500Pos + \omega. \qquad (12)$$

This equation provides a direct test of whether the two coefficients β_1 and β_2 are different from each other. Specifically, the coefficient δ_2 for $PUres * PublicNeg$ is such that $\delta_2 = \beta_2 - \beta_1$.[12] As shown in column 2 of Table 4, the coefficient $\delta_2 = 0.23$, i.e. $\beta_2 > \beta_1$, and is significant at the 1%-level. In other words, for a given change in private information, investors require more underpricing in downmarkets than in upmarkets, as predicted by the model.

The third and fourth columns add other characteristics of the offering that have previously been shown to affect IPO returns. These control variables include the logarithm of the number of years since the firm was founded (Age), the logarithm of the total \$ proceeds raised in the IPO ($Proceeds$), the logarithm of the total number of shares sold in the issue ($Shares$), and the average rank of the lead underwriter ($Rank$). We further add dummy variables indicating that the firm is in a high-tech industry ($HighTech$), is listed on the New York Stock Exchange ($NYSE$) or Nasdaq ($Nasdaq$), and that the IPO takes place in the period 9/1998-8/2000 ($Bubble$), respectively.

Importantly, the empirical implications of the model hold when we include control variables in the regression. As shown in columns 3 and 4 of Table 4, the coefficients $\beta_1 = 0.94$ and $\beta_2 = 1.09$ are both positive and highly significant. Also, $\beta_2 > \beta_1$, with the difference being significantly different from zero at the 5%-level.

Most of the control variables produce significant coefficients. The initial one-month returns are decreasing in firm age and the \$ proceeds raised in the IPO, and increasing in the number of shares offered and the average rank of the lead underwriter. Moreover,

[12] To see why, note that equation (12) can be rewritten as

$$IR = \gamma + \delta_1 PUres * (SP500Pos + SP500Neg) + \delta_2 PUres * Sp500Neg + \delta_3 SP500Pos + \omega, \text{ or}$$

$$IR = \gamma + \delta_1 PUres * SP500Pos + (\delta_1 + \delta_2) PUres * SP500Neg + \delta_3 SP500Pos + \omega.$$

Compare this with equation (11) and it is obvious that $\delta_1 = \beta_1$ and $\delta_1 + \delta_2 = \beta_2$.

IPO returns tend to be higher for high-tech firms and offerings that take place in the bubble period.

The last four columns of the table report the regression results when using the one-day initial return ($IR1$) as dependent variable. As with $IR21$, the coefficients β_1 and β_2 are both positive and significant, with $\beta_1 = 1.09$ and $\beta_2 = 1.21$ in columns 5-6. The difference is significant ($p - value < 0.05$) when entered alone (column 7), but not when adding the control variables (column 8).

As a robustness check, Table 5 shows the corresponding coefficient estimates when instead using the price update as a proxy for private information. All the results derived for $PUres$ also hold when using PU. Again, when $IR21$ is used as a measure of underpricing, $\beta_2 > \beta_1 > 0$ with the difference being significant at the 1%-level.

Overall, the regression results support the existence of the incentive effect as predicted by the model. Investors' incentives to reveal their private information—and therefore the required level of underpricing—depends on nature of the public information. Specifically, investors require a higher compensation to reveal favorable proprietary information when market-wide information is bad than when it is good. Having empirically established the existence of the incentive effect, we now turn to tests of the effects of private and public information on investors' demand for shares.

4.4 Tests of the demand effect

In general, investor demand for IPO allocations depends on their private information: the better the information, the more demand for shares in the IPO. The demand effect arises from the positive conditional correlation between private and public information derived in the model. Given positive public information, it is likely that the private signal is also favorable. This is the first implication of the demand effect that we test. Moreover, the proportion underpriced IPOs should be higher when public information is positive than when it is negative. This is the second implication of the demand effect that we test.

Table 6 shows the coefficient estimates from a probit regression of the determinants of positive (versus negative) private information. The dependent variable in the first four columns is a dummy indicating that the the price update residual is positive ($PUresPos$) and in the last four columns a dummy indicating that the the price update is positive ($PUPos$). As discussed above, the model predicts that public and private information are positively correlated. This prediction is borne out in the data. As shown in the table, the coefficient is positive and highly significant for both public information ($SP500$) and a dummy indicating positive public information ($SP500Pos$), and holds for both $PUResPos$ and $PUPos$. Thus, although the price update residual by construction is orthogonal to public information with respect to the price update, this residual is still positively correlated to public information, as predicted by the model.

Moreover, the addition of control variables do no affect the sign or significance of the coefficient for public information. Interestingly, the price update residual is more likely to be negative the older the firm, the more shares that are offered, and the higher the average rank of the lead underwriter. In contrast, the likelihood of a positive price update residual increases with the size of the proceeds raised in the offering, and is higher for high-tech firms and during the bubble years. The effect of these variables on the likelihood for a positive price update is largely the same (columns 5-8).

We next move on to test the effect of public information on the likelihood that the issue is underpriced. Table 7 reports the coefficient estimates from probit regressions of the determinants of a positive (versus negative) initial return. The first four columns use a dummy for positive one-month initial return ($IR21Pos$) as dependent variable, while the last four columns use a dummy indicating a positive one-day initial return ($IR1Pos$). Again, the coefficients for $SP500$ and $SP500Pos$ are positive and significant at the 1%-level. The higher the pre-issue market return, the more likely is the issue to be underpriced. The coefficient estimates are largely the same when adding the price update residual ($PUres$) and other control variables to the regression model, and are even more significant when predicting $IR1Pos$.

While the market return helps predict underpricing, the price update residual also produce a positive and significant coefficient. That is, the better the private information, the more likely is the offer to be underpriced (the incentive effect). Most of the control variables are insignificant, with exception of the lead underwriter rank ($Rank$), which enters with a positive coefficient when $IR21Pos$ is the dependent variable and the indicators for Nasdaq and NYSE, which both increases the likelihood of underpricing.

Table 8 provides a robustness check of the results, using the price update as a proxy for private information. While the results hold for the one-day positive return, the coefficients for $SP500$ and $SP500Pos$ both become insignificant when adding the price update to the probit regression predicting $IR21Pos$ (columns 3-4). This is likely an artifact of the high covariance between $SP500$ and PU. Overall, the data shows that public information has a positive impact on the likelihood of underpricing, as suggested by the model.

4.5 Partial adjustment to public information

Having established that the incentive effect and the demand effect exist in the data, we now turn to an examination of which of the two effects dominates. Our model predicts that public information is positively correlated to the underpricing in the IPO if the demand effect dominates the incentive effect. That is, the offer price adjusts only partially for the content of public information and hence IPO initial returns will be increasing in pre-issue stock market returns. See, e.g. Loughran and Ritter (2002) and Lowry and Schwert (2004) for empirical evidence on this empirical regularity. The model further predicts that if the incentive effect dominates the demand effect, the offer price *overadjusts* for publicly available information, and IPO initial returns should be decreasing in the pre-issue return of the S&P500. Which of the two effects dominate is an empirical question that we now turn to.

Table 9 reports the coefficient estimates from OLS regressions of IPO initial returns. The dependent variable is the one-month initial return ($IR21$) in the first four columns and the one-day initial return ($IR1$) in the last four columns. Importantly, the market return has very little explanatory power in this regression. When $SP500$ is entered as the only independent variable, the adjusted R^2 of the regression is close to zero. In particular, when $IR21$ is the dependent variable (columns 1-4), the coefficient for $SP500$ is negative and significant only when PU and the other control variables are included in the regression. That is, the price revision at the end of the registration period appears to be fully (or over-) adjusted for any content in publicly available information with respect to the one-month initial return. The one-day initial return, in contrast, increases with market returns, except when the price update is added to the regression model (columns 5-8).

Interestingly, the coefficients for the price update residual and the price update are positive and highly significant in all specifications. In other word, irrespective of which measure of underpricing we use, the offer price is never fully updated for the private information revealed in the book building process. This supports the argument of Benveniste and Spindt (1989) that underwriters compensate private investors for revealing private information by not fully adjusting the offer price for their information.

The remaining control variables produce coefficient estimates in line with earlier studies. The initial IPO returns tend to decrease with Age and $Proceeds$ and increase with $Shares$ and $Rank$. Moreover, the initial returns is on average higher for high-technology companies and during the bubble period.

Overall, the results with respect to partial adjustment to public information are largely inconclusive. To further examine the relationship between public information and initial returns, Table 10 shows the regression results for different time periods. The dependent variable is the one-month initial return $IR21$. The first five columns is limited to IPOs in the period 1/1981-8/1998 and essentially overlaps with the sample periods in Loughran and Ritter (2002) and Lowry and Schwert (2004). Consistent with their findings, the coefficient for $SP500$ is now positive and highly significant.

In contrast, $SP500$ enters the regression model with a negative or insignificant coefficient when limiting the sample to IPOs during the internet bubble (9/1998-8/2000, columns 6-8) and the "post-bubble" period (9/2000-12/2008, columns 9-10), respectively. That is, in the last decade, the offer price seems to fully (or even over-) adjust for publicly available information. In other words, there is no evidence of partial adjustment in more recent time periods. While not shown here, the results are similar when using $IR1$ as the independent variable.

Importantly, the coefficient for $PUres$ is positive and significant at the 0.1%-level across all different time periods. Again, this suggests that the offer price is only partially adjusted for private information revealed by the investors during the book building process, allowing them to profit from a subsequent price increase. The control variables produce the standard coefficients for the pre-bubble period, but are largely insignificant for the two later subperiods.

In sum, the phenomena of partial adjustment of the offer price to public information appears to be concentrated to the 1981-1998 period. Over the 1999-2008 period, there is little predictive power of pre-issue market returns on subsequent IPO returns, and offer prices seem to be fully adjusted for market-wide information. To our knowledge, our model is the first to predict a relationship between public information and initial returns that can vary from positive to negative, consistent with the data.

5 Summary

This paper presents a model that explains the relationship between *public* information and IPO initial returns. Building on the framework of Benveniste and Spindt (1989), where investors are compensated with underpriced shares for disclosing private information, we show that publicly available information is related to IPO underpricing through two different mechanisms.

First, market-wide information affects the underpricing required for investors to reveal their positive private signal. When the public outlook is negative, the expected profits from hiding favorable private information is higher. Accordingly, investors require a higher compensation—in the form of more underpricing—to disclose good news when public information is bad. This is the incentive effect.

Second, because public and private signals are informative, they are also conditionally correlated. That is, the probability of receiving a good private signal given a positive market outlook exceeds 0.5. Consequently, investors are more likely to have positive signals—which is necessary for the issue to be underpriced in the first place—in upmarkets than in downmarkets. As a result, the probability that an issue is underpriced is higher when public information is positive. This is the demand effect.

Whether public information ultimately is positively or negatively related to underpricing depends on which of the two effects dominates. If the number of investors in the offering is sufficiently large, the demand effect will dominate and initial IPO returns will be increasing in pre-issue market returns. If the price investors require to disclose their private information increases, the incentive effect will dominate and IPO returns will decrease in market returns. Our model is the first to predict the possibility of either under- or over adjustment in the offering price.

We test the predictions of the model for a sample of 5,000 U.S. IPOs in 1981-2008. As a proxy for private information, we use the residual from an OLS regression of the pre-issue market return on the IPO price revision. This purges any effect of market-wide information from the price update, attributing the remaining change to investors' private signals.

In cross-sectional tests, we show that investors require more underpricing in downmarkets than in upmarkets for a given change in private information. This is consistent with the incentive effect. We also find a positive correlation between private and public information—despite the orthogonalization procedure described above—and a positive correlation between market returns and the probability of underpricing. This is consistent with the demand affect.

Having established the presence of the two effects in the data, we turn to the partial adjustment phenomenon. Interestingly, the positive correlation between initial IPO returns and market returns found by e.g. Loughran and Ritter (2002) and Lowry and Schwert (2004) is concentrated to IPOs prior to 1998 (similar to their samples). In the time period 1999-2000, market-wide returns have little power to predict IPO returns. In other words, in the last decade, offer prices in IPOs on average have been fully adjusted to market returns. In terms of our model, the relative strength of the incentive effect and the demand effect may vary over time. Specifically, it is possible that there has been an increase in the compensation that investors require in return for their information (strengthening the incentive effect), or a decrease in the relative demand for shares in the offering (reducing the demand effect).

Our model is interesting because it provides a rational explanation for partial adjustment as well as full adjustment to public information, as observed more recently. One potential extension is to explore the mechanisms that determine the relative strengths of the demand and the incentive effect. Another extension is to develop the model's predictions with respect to the volatility of initial returns, and understand how return volatility is affected by market conditions. Both extensions will help us better understand the larger mechanisms behind IPO pricing and allocations.

A Appendix

Proof of Proposition 1. (i) The initial return associated with the high-demand state equals

$$r(N,s) = \frac{v(N,s)}{p(N,s)} - 1; s = \{b, g\}, \tag{13}$$

where

$$p(N,s) = v(N,s) - \frac{q(1,g_I,s)}{q(N,g_I,s)} \left[v(1,s) - v(0,s)\right]. \tag{14}$$

We want to show that $r(N,g) < r(N,b)$, or that

$$\frac{v(N,g)}{p(N,g)} \leq \frac{v(N,b)}{p(N,b)}, \tag{15}$$

which is equivalent to

$$\frac{q(N,g_I,g)v(N,g)}{q(N,g_I,b)v(N,b)} \geq \frac{q(1,g_I,g)}{q(1,g_I,b)} \frac{[v(1,g) - v(0,g)]}{[v(1,b) - v(0,b)]} \tag{16}$$

Using Bayes rule and rearranging, this inequality may be written

$$1 \geq \frac{\gamma - (1-\gamma)\Xi}{\gamma - (1-\gamma)\Theta}, \tag{17}$$

where

$$\Xi = \frac{(1-\gamma)^{N-1}\gamma f\alpha + \gamma^{N-1}(1-\gamma)(1-f)(1-\alpha)}{(1-\gamma)^N f\alpha + \gamma^N(1-f)(1-\alpha)} \tag{18}$$

and

$$\Theta = \frac{(1-\gamma)^{N-1}\gamma(1-f)\alpha + \gamma^{N-1}f(1-\alpha)}{(1-\gamma)^N(1-f)\alpha + \gamma^N f(1-\alpha)} \tag{19}$$

To prove the proposition, we need to show that $\Xi - \Theta \geq 0$. To see that this inequality is satisfied, note that $\Xi - \Theta$ can be rearranged so that

$$\Xi - \Theta = \frac{\alpha(1-\alpha)(2f-1)[(1-\gamma)^{N-1}\gamma^{N+1} - \gamma^{N-1}(1-\gamma)^N + \gamma^N(1-\gamma)^N]}{[(1-\gamma)^N f\alpha + \gamma^N(1-f)(1-\alpha)]\,[(1-\gamma)^N(1-f)\alpha + \gamma^N f(1-\alpha)]} \tag{20}$$

$$= \frac{\alpha(1-\alpha)(2f-1)(1-\gamma)^{N-1}\gamma^{N-1}(2\gamma-1)}{[(1-\gamma)^N f\alpha + \gamma^N(1-f)(1-\alpha)]\,[(1-\gamma)^N(1-f)\alpha + \gamma^N f(1-\alpha)]}, \tag{21}$$

which is strictly positive since $f, \gamma > 1/2$.

(ii) By Bayes' rule it follows that

$$q(N|g) = \frac{\gamma^N f\alpha + (1-\gamma^N)(1-f)(1-\alpha)}{f\alpha + (1-f)(1-\alpha)} \tag{22}$$

and

$$q(N|b) = \frac{\gamma^N (1-f)\alpha + (1-\gamma^N) f(1-\alpha)}{(1-f)\alpha + f(1-\alpha)} \tag{23}$$

The difference between the two may be written

$$q(N|g) - q(N|b) = \frac{\alpha(1-\alpha)(2f-1)[\gamma^N - (1-\gamma)^N]}{[1-\alpha(1-f)-(1-\alpha)f][\alpha(1-f)+f(1-\alpha)]}, \tag{24}$$

which is strictly greater than zero. ■

Proof of Proposition 2.

The proposition is proved by showing that

$$\lim_{N\to\infty} \frac{Er(g)}{Er(b)} > 1 \tag{25}$$

By Bayes' rule and straightforward algebra it follows that

$$\frac{Er(g)}{Er(b)} = \frac{(1-f)\alpha + f(1-\alpha)}{f\alpha + (1-f)(1-\alpha)} \times \frac{f\alpha + (\frac{1-\gamma}{\gamma})^N (1-f)(1-\alpha)}{(1-f)\alpha + (\frac{1-\gamma}{\gamma})^N f(1-\alpha)} \times A, \tag{26}$$

where

$$A = \frac{(1-f)\alpha\Big[\Big(\frac{1-\gamma}{\gamma}\Big)^N (1-f)\alpha + f(1-\alpha)\Big] - f(1-f)\alpha(1-\alpha)\frac{1}{\gamma}\Big(\frac{1-\gamma}{\gamma}\Big)^{N-1}(2\gamma-1)}{f\alpha\Big[\Big(\frac{1-\gamma}{\gamma}\Big)^N f\alpha + (1-f)(1-\alpha)\Big] - f(1-f)\alpha(1-\alpha)\frac{1}{\gamma}\Big(\frac{1-\gamma}{\gamma}\Big)^{N-1}(2\gamma-1)} \tag{27}$$

Recalling that $\gamma > 1/2$ and hence that $\frac{1-\gamma}{\gamma} < 1$ it follows that

$$\lim_{N\to\infty} \frac{Er(g)}{Er(b)} = \frac{(1-f)\alpha + f(1-\alpha)}{f\alpha + (1-f)(1-\alpha)} \times \frac{f}{1-f}. \tag{28}$$

It is now straightforward to show that the right hand side of (29) is strictly greater than one, which completes the proof. ■

Proof of Proposition 3. Using the same approach as in the proof of Proposition

2, it can be shown that

$$\lim_{N\to\infty}\frac{\sigma(g)}{\sigma(b)}=\sqrt{\frac{(1-f)\alpha+f(1-\alpha)}{f\alpha+(1-f)(1-\alpha)}\times\frac{f}{1-f}} \tag{29}$$

which is strictly greater than one. ■

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Table 1: **Sample characteristics**

The table shows the annual distribution of the sample of 5093 U.S. IPOs in 1981-2008, and their average initial returns by year. The first-day return is $IR1 = p_1/p_0 - 1$, where p_1 is the closing price on tradig day 1 and p_0 is the offering price. The one-month return $IR21 = p_{21}/p_0$ is adjusted for the Fama-French 49 value-weighted industry portfolios. The S&P500 return is measured over the 45 days prior to the issue ($SP500$). Market conditions report the proportion of IPOs that take place in a positive market ($SP500 > 0$) and negative market ($SP500 \leq 0$), respectively.

Listing year	Sample size (N)	One-day return (IR1)	One-month return (IR21)	S&P500 return (SP500)	Market conditions: proportion positive	proportion negative
1981	4	3.9%	0.1%	-1.5%	50%	50%
1982	1	4.7%	18.0%	1.6%	100%	0%
1983	14	11.1%	8.4%	2.5%	71%	29%
1984	10	2.0%	8.8%	1.9%	40%	60%
1985	46	5.4%	8.0%	4.0%	78%	22%
1986	207	4.1%	2.6%	2.6%	70%	30%
1987	194	5.6%	3.9%	6.3%	89%	11%
1988	72	4.8%	4.1%	2.0%	64%	36%
1989	58	5.7%	4.9%	4.4%	72%	28%
1990	69	9.2%	10.6%	0.3%	61%	39%
1991	226	10.9%	16.0%	1.4%	58%	40%
1992	305	9.0%	11.9%	2.1%	67%	33%
1993	417	11.6%	13.5%	1.4%	82%	18%
1994	324	8.7%	10.9%	-0.6%	45%	55%
1995	359	20.5%	27.2%	5.1%	100%	0%
1996	571	15.9%	19.8%	4.1%	82%	18%
1997	381	14.2%	14.9%	5.3%	84%	16%
1998	256	22.8%	25.2%	5.4%	79%	21%
1999	421	74.1%	100.2%	2.5%	73%	27%
2000	323	58.3%	68.1%	0.2%	58%	42%
2001	68	14.6%	11.2%	0.2%	49%	51%
2002	49	8.0%	11.4%	-3.8%	27%	73%
2003	53	12.7%	13.8%	4.1%	92%	8%
2004	162	12.2%	14.4%	1.7%	64%	36%
2005	162	12.7%	12.8%	1.2%	65%	35%
2006	168	11.4%	12.1%	2.5%	81%	19%
2007	157	13.3%	12.9%	2.0%	66%	34%
2008	16	2.4%	4.3%	-3.3%	50%	50%
Total	5093	20.5%	25.0%	2.7%	73%	27%

Table 2: **Initial returns split by public and private information**

The table shows the average one-month ($IR21$) and one-day ($IR1$) IPO returns, split by positive and negative private and public information, respectively. In Panel A, the proxy for private information is the price update residual ($PUres$), while Panel B uses the price update (PU) as a measure for private information. All variables are defined in Table 3. The sample is 5093 U.S. IPOs in 1981-2008.

Public Information:	Positive ($SP500 > 0$)			Negative ($SP500 \leq 0$)		
Private Information:	Positive	Zero	Negative	Positive	Zero	Negative
Panel A: Price update residual ($PUres$)						
$IR21$, mean	44.1%	11.7%	6.9%	57.7%	16.8%	9.0%
$IR1$, mean	38.2%	11.0%	5.3%	43.9%	12.1%	3.4%
Number of cases, N	1700	448	1573	469	168	735
Percent of cases	46%	12%	42%	34%	12%	54%
Panel B: Price update (PU)						
$IR21$, mean	42.6%	11.7%	6.5%	59.4%	16.8%	8.9%
$IR1$, mean	37.3%	11.0%	4.9%	45.6%	12.1%	3.5%
Number of cases, N	1788	448	1485	455	168	749
Percent of cases	48%	12%	40%	33%	12%	55%

Table 3: **Variable definitions**

The table shows names, definitions of and sources for the variables used in the analysis. Ken French and Jay Ritter refer to their respective data webpage.

Name	Definition	Sources
$IR21$	One-month initial return adjusted with the value-weighted Fama-French 49 industry portfolios: $IR21 = p_{21}/p_0 - ind_{21}/ind_0$, where p_{21} is the firm's closing price on trading day 21, p_0 is the offering price in the IPO, and ind_t is the value of the Fama-French 49 value-weighted industry portfolio on trading day $t \in \{0, 21\}$.	SDC, CRSP, Ken French
$IR21Pos$	Dummy variable indicating positive one-month initial return, $IR21 > 0$.	SDC, CRSP
$IR1$	One-day initial return, defined as $IR1 = p_1/p_0 - 1$, where p_1 is the firm's closing price on day 1 and p_0 is the offering price.	SDC, CRSP
$IR1Pos$	Dummy variable indicating positive one-day initial return, $IR1 > 0$.	SDC, CRSP
$SP500$	Return on the S&P500 index over the 45 trading days preceding the offer (the book building period). This is our proxy for public information.	CRSP
$SP500Pos$	Dummy variable indicating that $SP500 > 0$ ("upmarket").	CRSP
$SP500Neg$	Dummy variable indicating that $SP500 \leq 0$ ("downmarket").	CRSP
PU	Price update of the offer price from the initial filing range midpoint, defined as $PU = p_0/p_{mid} - 1$, where p_0 is the final offer price and p_{mid} is the midpoint of the initial filing range.	SDC
$PUPos$	Dummy variable indicating a positive price update, $PU > 0$.	SDC, CRSP
$PUres$	Price update residual is the residual (ϵ) from the regression of the S&P500 return on the price update: $PU = \alpha + \beta * SP500 + \epsilon$. If $PU = 0$ we set $PUres = 0$. $PUres$ is our main proxy for private information.	SDC, CRSP
$PUresPos$	Dummy variable indicating that $PUres > 0$ (positive private information).	SDC, CRSP
Age	Log of firm age since its founding year.	Jay Ritter
$Proceeds$	Log of total $ proceeds raised in the IPO.	SDC
$Shares$	Log of total number of shares sold in the IPO.	SDC
$Rank$	Average rank of the lead underwriter.	Jay Ritter
$HighTech$	Dummy indicating that the IPO firm is a high-technology firm.	SDC
$Bubble$	Dummy indicating that the IPO took place in the period 9/1998-8/2000.	SDC
$Nasdaq$	Dummy indicating that the IPO firm is listed on Nasdaq.	CRSP
$NYSE$	Dummy indicating that the IPO firm is listed on the New York Stock Exchange (NYSE).	CRSP

Table 4: **Tests of incentive effect using price update residual**

OLS regressions testing for the incentive effect and using the price update residual ($PUres$) as proxy for private information. The dependent variable is the one-month return ($IR21$), and the one-day return ($IR1$), respectively. The sample is 5093 U.S. IPOs in 1981-2008. All variables are defined in Table 3. t-statistics are in parenthesis. Significance is denoted with +, *, **, and *** for significance at the 10%, 5%, 1%, and 0.01% level, respectively.

Dependent variable:	One-month return ($IR21$)				One-day return ($IR1$)			
$PUres$		1.115***		0.939***		1.092***		0.990***
		(29.30)		(22.42)		(42.02)		(34.60)
$PUres * SP500Pos$	1.115***		0.939***		1.092***		0.990***	
	(29.30)		(22.42)		(42.02)		(34.60)	
$PUres * SP500Neg$	1.343***	0.228**	1.091***	0.152*	1.213***	0.120*	1.058***	0.0686
	(20.80)	(3.04)	(16.73)	(2.20)	(27.48)	(2.35)	(23.76)	(1.45)
$SP500Pos$	-0.0460**	-0.0460**	-0.0350*	-0.0350*	0.00496	0.00496	0.0123	0.0123
	(-2.70)	(-2.70)	(-2.23)	(-2.23)	(0.43)	(0.43)	(1.15)	(1.15)
Age			-0.0234***	-0.0234***			-0.0146**	-0.0146**
			(-3.37)	(-3.37)			(-3.07)	(-3.07)
$Proceeds$			-0.0860**	-0.0860**			-0.0739***	-0.0739***
			(-3.19)	(-3.19)			(-4.02)	(-4.02)
$Shares$			0.0787*	0.0787*			0.0701***	0.0701***
			(2.53)	(2.53)			(3.31)	(3.31)
$Rank$			0.0108***	0.0108***			0.00386*	0.00386*
			(3.93)	(3.93)			(2.06)	(2.06)
$HighTech$			0.0653***	0.0653***			0.0425***	0.0425***
			(4.13)	(4.13)			(3.94)	(3.94)
$Bubble$			0.554***	0.554***			0.384***	0.384***
			(25.14)	(25.14)			(25.48)	(25.48)
$Nasdaq$			0.0583	0.0583			0.0111	0.0111
			(1.45)	(1.45)			(0.41)	(0.41)
$NYSE$			0.0179	0.0179			-0.0187	-0.0187
			(0.39)	(0.39)			(-0.60)	(-0.60)
Constant	0.294***	0.294***	0.429**	0.429**	0.210***	0.210***	0.372***	0.372***
	(20.13)	(20.13)	(2.88)	(2.88)	(21.09)	(21.09)	(3.66)	(3.66)
Adjusted R^2	0.202	0.202	0.328	0.328	0.331	0.331	0.437	0.437

Table 5: **Tests of incentive effect using price update**

OLS regressions testing for the incentive effect and using the price update (PU) as proxy for private information. The dependent variable is the one-month return ($IR21$) and the one-day return ($IR1$), respectively. The sample is 5093 U.S. IPOs in 1981-2008. All variables are defined in Table 3. t-statistics are in parenthesis. Significance is denoted with +, *, **, and *** for significance at the 10%, 5%, 1%, and 0.01% level, respectively.

Dependent variable:	One-month return ($IR21$)				One-day return ($IR1$)			
PU		1.120***		0.948***		1.099***		1.002***
		(29.56)		(22.71)		(42.57)		(35.26)
$PU * SP500Pos$		1.120***	0.948***		1.099***		1.002***	
	(29.56)		(22.71)		(42.57)		(35.26)	
$PU * SP500Neg$	1.328***	0.209**	1.088***	0.140*	1.203***	0.103*	1.060***	0.0574
	(20.57)	(2.79)	(16.68)	(2.03)	(27.32)	(2.03)	(23.86)	(1.22)
$SP500Pos$	-0.0938***	-0.0938***	-0.0747***	-0.0747***	-0.0406***	-0.0406***	-0.0284**	-0.0284**
	(-5.47)	(-5.47)	(-4.74)	(-4.74)	(-3.47)	(-3.47)	(-2.64)	(-2.64)
Age			-0.0234***	-0.0234***			-0.0145**	-0.0145**
			(-3.37)	(-3.37)			(-3.07)	(-3.07)
$Proceeds$			-0.0920***	-0.0920***			-0.0817***	-0.0817***
			(-3.41)	(-3.41)			(-4.45)	(-4.45)
$Shares$			0.0870**	0.0870**			0.0804***	0.0804***
			(2.79)	(2.79)			(3.79)	(3.79)
$Rank$			0.0107***	0.0107***			0.00381*	0.00381*
			(3.91)	(3.91)			(2.04)	(2.04)
$HighTech$			0.0637***	0.0637***			0.0406***	0.0406***
			(4.04)	(4.04)			(3.77)	(3.77)
$Bubble$			0.554***	0.554***			0.383***	0.383***
			(25.17)	(25.17)			(25.54)	(25.54)
$Nasdaq$			0.0623	0.0623			0.0153	0.0153
			(1.56)	(1.56)			(0.56)	(0.56)
$NYSE$			0.0213	0.0213			-0.0149	-0.0149
			(0.47)	(0.47)			(-0.48)	(-0.48)
Constant	0.313***	0.313***	0.421**	0.421**	0.228***	0.228***	0.366***	0.366***
	(21.30)	(21.30)	(2.83)	(2.83)	(22.73)	(22.73)	(3.62)	(3.62)
Adjusted R^2	0.203	0.203	0.329	0.329	0.335	0.335	0.441	0.441

Table 6: **Tests I of the demand effect**

Probit regressions testing for the demand effect. The dependent variable is a dummy for positive price update residual ($PUresPos$) and positive price update ($PUPos$), respectively, both used as proxies for positive private information. The sample is 5093 U.S. IPOs in 1981-2008. All variables are defined in Table 3. t-statistics are in parenthesis. Significance is denoted with +, *, **, and *** for significance at the 10%, 5%, 1%, and 0.01% level, respectively.

Dependent variable:	Positive price update residual ($PUresPos$)				Positive price update ($PUPos$)			
$SP500$	1.869***	1.150**			3.818***	3.789***		
	(4.94)	(2.70)			(9.91)	(8.68)		
$SP500Pos$			0.299***	0.266***			0.387***	0.386***
			(7.39)	(5.82)			(9.52)	(8.38)
Age		-0.0827***		-0.0834***		-0.0855***		-0.0863***
		(-4.20)		(-4.23)		(-4.32)		(-4.37)
$Proceeds$		2.455***		2.453***		2.484***		2.490***
		(32.84)		(32.79)		(33.05)		(33.15)
$Shares$		-2.562***		-2.561***		-2.596***		-2.615***
		(-29.63)		(-29.63)		(-29.86)		(-30.10)
$Rank$		-0.0221**		-0.0214**		-0.0214**		-0.0202**
		(-2.88)		(-2.77)		(-2.77)		(-2.62)
$HighTech$		0.390***		0.391***		0.388***		0.390***
		(8.76)		(8.77)		(8.68)		(8.73)
$Bubble$		0.397***		0.401***		0.407***		0.410***
		(6.42)		(6.47)		(6.52)		(6.57)
$Nasdaq$		0.298*		0.295*		0.247*		0.220+
		(2.35)		(2.31)		(1.98)		(1.76)
$NYSE$		-0.0823		-0.0735		-0.101		-0.106
		(-0.58)		(-0.52)		(-0.72)		(-0.76)
Constant	-0.238***	-4.868***	-0.407***	-5.010***	-0.255***	-4.855***	-0.435***	-4.840***
	(-11.58)	(-11.36)	(-11.68)	(-11.65)	(-12.30)	(-11.32)	(-12.43)	(-11.29)

Table 7: **Tests II of the demand effect using price update residual**

Probit regressions testing for the demand effect, using the price update residual ($PUres$) as a proxy for private information. The dependent variable is a dummy for positive one-month ($IR21Pos$) and one-day ($IR1Pos$) initial return, respectively. The sample is 5093 U.S. IPOs in 1981-2008. All variables are defined in Table 3. t-statistics are in parenthesis. Significance is denoted with +, *, **, and *** for significance at the 10%, 5%, 1%, and 0.01% level, respectively.

Dependent variable:	Positive one-month return ($IR21Pos$)				Positive one-day return ($IR1Pos$)			
$SP500$	1.056** (2.69)	1.135** (2.79)			3.320*** (7.96)	3.658*** (8.24)		
$SP500Pos$			0.114** (2.78)	0.0998* (2.36)			0.316*** (7.58)	0.320*** (7.21)
$PUres$		1.732*** (13.70)		1.721*** (13.64)		2.895*** (19.51)		2.847*** (19.30)
Age		0.0008 (0.04)		0.0005 (0.03)		0.0005 (0.02)		-0.0006 (-0.03)
$Proceeds$		-0.109 (-1.46)		-0.100 (-1.35)		-0.257** (-3.18)		-0.223** (-2.79)
$Shares$		0.157+ (1.82)		0.144+ (1.68)		0.311*** (3.33)		0.263** (2.84)
$Rank$		0.0193** (2.66)		0.0195** (2.69)		0.0112 (1.44)		0.0113 (1.46)
$HighTech$		0.0471 (1.11)		0.0482 (1.13)		0.0826+ (1.82)		0.0871+ (1.92)
$Bubble$		0.0351 (0.56)		0.0367 (0.59)		0.0459 (0.66)		0.0508 (0.73)
$Nasdaq$		0.406*** (3.94)		0.397*** (3.86)		0.403*** (3.80)		0.378*** (3.58)
$NYSE$		0.315** (2.65)		0.311** (2.62)		0.301* (2.44)		0.292* (2.37)
Constant	0.456*** (21.74)	-0.491 (-1.23)	0.402*** (11.52)	-0.486 (-1.22)	0.573*** (26.78)	0.0231 (0.05)	0.429*** (12.27)	0.0486 (0.12)

Table 8: **Tests II of the demand effect using the price update**

Probit regressions testing for the demand effect, using the price update (PU) as a proxy for private information. The dependent variable is a dummy for positive one-month ($IR21Pos$) and one-day ($IR1Pos$) initial return, respectively. The sample is 5093 U.S. IPOs in 1981-2008. All variables are defined in Table 3. t-statistics are in parenthesis. Significance is denoted with +, *, **, and *** for significance at the 10%, 5%, 1%, and 0.01% level, respectively.

Dependent variable:	Positive one-month return ($IR21Pos$)				Positive one-day return ($IR1Pos$)			
$SP500$	1.056^{**}	0.199			3.320^{***}	2.097^{***}		
	(2.69)	(0.49)			(7.96)	(4.72)		
$SP500Pos$			0.114^{**}	0.0309			0.316^{***}	0.207^{***}
			(2.78)	(0.73)			(7.58)	(4.65)
PU		1.766^{***}		1.764^{***}		2.927^{***}		2.940^{***}
		(13.92)		(13.93)		(19.59)		(19.71)
Age		0.0008		0.0008		-0.0002		-0.0005
		(0.04)		(0.04)		(-0.01)		(-0.02)
$Proceeds$		-0.121		-0.121		-0.266^{**}		-0.262^{**}
		(-1.62)		(-1.62)		(-3.29)		(-3.25)
$Shares$		0.170^{*}		0.170^{*}		0.321^{***}		0.312^{***}
		(1.97)		(1.97)		(3.44)		(3.34)
$Rank$		0.0195^{**}		0.0196^{**}		0.0112		0.0116
		(2.68)		(2.69)		(1.45)		(1.49)
$HighTech$		0.0448		0.0451		0.0806^{+}		0.0825^{+}
		(1.05)		(1.06)		(1.77)		(1.81)
$Bubble$		0.0339		0.0339		0.0475		0.0478
		(0.54)		(0.54)		(0.68)		(0.69)
$Nasdaq$		0.406^{***}		0.404^{***}		0.403^{***}		0.388^{***}
		(3.94)		(3.93)		(3.81)		(3.67)
$NYSE$		0.318^{**}		0.318^{**}		0.305^{*}		0.301^{*}
		(2.68)		(2.68)		(2.48)		(2.44)
Constant	0.456^{***}	-0.477	0.402^{***}	-0.487	0.573^{***}	0.0322	0.429^{***}	0.0396
	(21.74)	(-1.20)	(11.52)	(-1.22)	(26.78)	(0.08)	(12.27)	(0.09)

Table 9: **Tests of partial adjustment to public information**

OLS regressions testing for partial adjustment to public information. The dependent variable is the one-month ($IR21$) and one-day ($IR1$) initial return, respectively. The sample is 5093 U.S. IPOs in 1981-2008. All variables are defined in Table 3. t-statistics are in parenthesis. Significance is denoted with +, *, **, and *** for significance at the 10%, 5%, 1%, and 0.01% level, respectively.

Dependent variable:	One-month return ($IR21$)				One-day return ($IR1$)			
$SP500$	-0.129	-0.114	-0.129	-0.643***	0.364**	0.355***	0.364**	-0.192+
	(-0.72)	(-0.77)	(-0.72)	(-4.30)	(2.72)	(3.50)	(2.72)	(-1.88)
$PUres$		0.975***				1.009***		
		(25.27)				(38.37)		
PU				0.982***				1.015***
				(25.51)				(38.71)
Age		-0.0235***		-0.0236***		-0.0145**		-0.0146**
		(-3.38)		(-3.40)		(-3.06)		(-3.08)
$Proceeds$		-0.0851**		-0.0888***		-0.0773***		-0.0806***
		(-3.15)		(-3.30)		(-4.21)		(-4.39)
$Shares$		0.0773*		0.0813**		0.0751***		0.0786***
		(2.48)		(2.61)		(3.53)		(3.71)
$Rank$		0.0108***		0.0108***		0.00386*		0.00387*
		(3.95)		(3.96)		(2.06)		(2.07)
$HighTech$		0.0642***		0.0631***		0.0414***		0.0403***
		(4.07)		(4.00)		(3.85)		(3.75)
$Bubble$		0.558***		0.557***		0.385***		0.385***
		(25.32)		(25.33)		(25.63)		(25.67)
$Nasdaq$		0.0584		0.0586		0.0141		0.0143
		(1.46)		(1.46)		(0.51)		(0.52)
$NYSE$		0.0189		0.0206		-0.0166		-0.0149
		(0.41)		(0.45)		(-0.53)		(-0.48)
Constant	0.254***	0.409**	0.254***	0.415**	0.195***	0.354***	0.195***	0.359***
	(26.11)	(2.75)	(26.11)	(2.79)	(26.91)	(3.49)	(26.91)	(3.54)
Adjusted R^2	-0.000	0.327	-0.000	0.328	0.001	0.438	0.001	0.440

Table 10: **Tests of partial adjustment to public information for various sub-period**

OLS regressions testing for partial adjustment to public information. The dependent variable is the one-month initial return ($IR21$). The sample is 5093 U.S. IPOs in 1981-2008. All variables are defined in Table 3. t-statistics are in parenthesis. Significance is denoted with +, *, **, and *** for significance at the 10%, 5%, 1%, and 0.01% level, respectively.

Sample:	Pre-bubble, 1/81-8/98					Bubble, 9/98-8/00			Post-bubble, 9/00-12/08	
$SP500$	0.436***	0.316**	0.317**	0.436***	-0.0416	-2.207*	-1.536^{+}	-1.084	0.136	0.0669
	(3.98)	(3.15)	(3.18)	(3.98)	(-0.41)	(-2.36)	(-1.82)	(-1.29)	(0.71)	(0.37)
$PUres$		0.624***	0.656***				1.531***	1.396***		0.435***
		(25.67)	(21.94)				(12.98)	(8.79)		(8.57)
PU					0.663***					
					(22.23)					
Age			-0.0168***		-0.0169***			-0.107^{+}		0.0127
			(-3.98)		(-4.01)			(-1.93)		(1.35)
$Proceeds$			-0.0647***		-0.0678***			-0.0346		0.0239
			(-3.56)		(-3.73)			(-0.22)		(0.73)
$Shares$			0.0788***		0.0820***			-0.121		-0.0583
			(3.78)		(3.94)			(-0.67)		(-1.58)
$Rank$			0.00602***		0.00602***			0.0550*		0.00431
			(3.32)		(3.33)			(2.42)		(1.41)
$HighTech$			0.0399***		0.0392***			0.236^{+}		0.0305
			(4.12)		(4.05)			(1.75)		(1.43)
$Nasdaq$			0.0698**		0.0695**			0.681		0.0810
			(3.11)		(3.10)			(1.04)		(1.07)
$NYSE$			0.0234		0.0241			0.545		0.0804
			(0.89)		(0.91)			(0.76)		(0.98)
Constant	0.131***	0.153***	0.0244	0.131***	0.0309	0.968***	0.733***	2.157^{+}	0.135***	0.482*
	(21.86)	(27.62)	(0.23)	(21.86)	(0.29)	(18.44)	(14.50)	(1.79)	(14.05)	(2.15)
N	3485	3485	3485	3485	3485	712	712	712	896	896
Adjusted R^2	0.004	0.162	0.186	0.004	0.189	0.006	0.196	0.230	-0.001	0.115