A simple model of IPO underpricing

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March 25, 2016

Abstract

We propose a new theory of IPO underpricing where the asymmetry of the underwriter’s incentives and presence of valuation uncertainty makes underpricing unavoidable. We show how the size of underpricing is defined by valuation uncertainty of the stock (“volatility”) and by the fee level. We quantify the relationship between level of underpricing and level of price volatility. We also show that the “winner’s curse” is a by-product of the ex-ante valuation uncertainty.

We explain the conditional underpricing as a natural by-product of interplay between valuation uncertainty and the underwriter’s reward asymmetry; We explain why underwriters’ allocation authority in book-building is an efficient device that can be used to translate the power to allocate undervalued asset into higher IPO prices(via grooming of “loyal clients” with assured favorable allocation);

We motivate use of warrants as a partial remedy of the reward asymmetry: the underwriter absorbs all downside risk, but benefits only partially from the upside; warrants give the underwriter participation in upside risk; warrants give the underwriter the upside benefits- thus increasing the IPO price.

We derive some of these results for any general distribution and all of these results for the uniform distribution.

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Introduction

Initial Public Offering (IPO) statistics show that new IPOs are systematically priced below the mean, causing the well-documented average underpricing. In this paper we ask what portion of underpricing can be explained by desire to avoid the damage to the underwriter imparted when the market value happens to be below the IPO price (overpricing).

In the U.S., underwriter usually makes a firm commitment to buy the IPO shares from the issuer at an agreed-upon price, and place them with the public at the ‘offer price’ (which is higher than the price to the issuer by the ‘gross spread’) or to sell them at the market price if the latter is lower than the “offer price”. The underwriter thus makes the gross spread on each share if demand is strong, but stands to lose if it is weak.

As the market value of a share presently issued is a random variable, any chosen IPO price has a probability to be above the market realization of the firm’s value, thus causing losses to the underwriter. The damage could be substantial. To minimize losses, underwriters systematically price new IPOs below the mean, causing underpricing.

We know that underwriters have other ways to manage risk of overpricing; e.g., via ‘book building,’ i.e. lining up and recording non-binding indications of interest on and around a marketing ‘road show.’ To the extent this goes according to plan, i.e. the investors follow through on their indications with purchases at the offer price, the risk imparted directly by the firm commitment is inconsequential: after placing the shares, the underwriter can walk away and leave the buyers to deal with any subsequent softness in demand.

However, the underwriters do not simply walk away, for two reasons. First, underwriters are expected to support the aftermarket price, and prepare for this contingency with the “Green Shoe.” That is, the underwriters initially over-sell the offering by fifteen percent, and then buy back these shares if demand is weak, and expand the offering (i.e. exercise the Green Shoe option) if demand is strong. So the underwriter does play a formal role in defending against price drops, but even here the contractual exposure is limited: the underwriter could just buy back the Green Shoe and walk away at that point, and let whatever happens next to the stock be somebody else’s problem.

This leads to the second reason why underwriters do not walk, which is that their exposure to weak IPOs is not limited to their contractual duties. A weak IPO costs the buyers and embarrasses the issuer, and is unpleasant for the other syndicate members as well. These consequences will all tend to reduce the underwriter’s access to future business by harming its reputation. The underwriter can combat this harm by repurchasing more than the Green Shoe, thereby supporting the price more and exhibiting more commitment to its clients, but the damage may not be so easily reversible.

The relation between these consequences and underpricing is simple. To the extent an underwriter expects bad consequences from overpricing an offering, it will discount the offering price from the expected market price. The relation between offer and market price is asymmetric: every dollar the offer price is below the market price loses the underwriters their gross spread on that dollar, whereas every dollar the offer price is above brings trading and reputational losses that could exceed the gross spread. If the latter sufficiently outweighs the former, it could deliver the sizable underpricing we observe.

It is well understood that the firm commitment is effectively a (complicated) put option written by the underwriter to the issuer. However, it is not so well-understood what this means for the gross spreads and offer
prices chosen by the issuer and the underwriter. This paper presents a simple model of the IPO process which embeds the firm commitment and derives its implications for spreads, prices and other variables of interest. We find that this simple model can explain much of what we see.

In the model, an issuer chooses the gross spread at which an underwriter will place its shares via firm commitment. The underwriter then chooses the offer price, subject to its uncertainty about the market price. The model allows for a strict interpretation of the contract, whereby the underwriter alone bears the risk of any shortfall of the market price from the offer price, and the underwriter gets no benefit from any excess of the market price above the offer price. It also allows for a softer interpretation, whereby the investors share a portion of the loss from overpricing, and also share a portion of the gain from underpricing. We derive some results that apply to all differentiable distributions, and others for which we make specific distributional assumptions.

The spirit of the model is that underwriters in practice bear at least a substantial portion of the risk that, in theory, they bear all of. So if for example the offer price is $20 and the market price is $19, then the per-share reduction of the underwriter’s revenue does not have to be the full dollar but is at least a lot of it. This loss could stem from never finding a buyer at $20 and eventually unloading for $19, but it could also come from finding a buyer at $20, who then sells it right back to the underwriter as it tries to support the market price, so that the underwriter later unloads it for $19, or instead from finding a buyer who buys and holds at $20, knowing that it is going to $19, and charging the $1 to the underwriter’s reputation. And on top of these sources of loss on the investor side, there is also the embarrassment visited on the issuer by a bad debut, and the reputation cost to the underwriter of its role in that. So while it might appear to some that underwriters lay off overpricing risk through book building, it could appear so and yet the risk could be substantial, and thus in the spirit of the analysis here.

The theoretical model trades off three influences on the manager’s choice of offer price: the loss share, the profit share and the gross spread (i.e. the fee). Both the loss share and the profit share encourage lower price, as this reduces losses and increases profits. The fee is the lone influence in the other direction, as it is proportional to the offer price. Given the fee, the underwriter chooses the price delivering to itself the maximum expected revenue from these three sources, and the issuer, anticipating the underwriter’s subsequent optimization, chooses the fee that delivers itself the maximum revenue. Our analysis is not concerned with optimal contracting, i.e. whether firm commitment is an optimal way to float shares, but rather just takes as given that flotation occurs this way and optimizes within that context.

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2 See Ritter(2011) for an example of modeling that situation
3 See Ritter(2011) for literature related to the issue
This model yields several predictions. Underwriters will underprice IPOs, and this underpricing will grow as the gross spread shrinks, and as uncertainty about the market price grows. Also, underwriters will revise their prices more in response to negative information than in response to positive information.

We then concentrate on the uniform distribution case, find closed-form solutions and conclude that our model can explain a long list of phenomena: why underpricing is an unavoidable by-product of the firm-commitment contract; why IPOs with larger fee will on average be less underpriced; how fluctuations in average level of underpricing are explained by changes in market volatility; why “book-building” became the dominant form of IPO allocation; how side-payments from issuers to underwriters could increase the issuer’s net proceeds; and why price adjustment (following road show) will fully reflect “bad news” but will incorporate only a small portion of the “good news.”

We start with the general model.

The Model

The model is as follows. A risk-neutral issuer chooses the fee \( k > 0 \) that it will pay a risk-neutral underwriter to float a fixed number of shares (the precise number of shares is not important; it’s important only that the number of shares is fixed). The flotation is through a firm commitment contract, which means that

- The underwriter chooses the price at which shares will be offered to the public
- The underwriter buys the shares from the issuer for \((1 - k)\) times the offer price
- The underwriter then allocates the shares to bidders for the offer price, unless the market price of the shares is less than the offer price, in which case the underwriter sells the share for the market price.

To allow for the possibility that the underwriter is affected only partially by any shortfall of the market price from the offer price, due to the willingness of investors to bear some of this loss themselves by purchasing some shares at the offer price, we let \( \beta \) represent the portion of the shortfall affecting the underwriter, i.e. the loss share. So if

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4 It will be present even when the field of underwriting is fully competitive. The contract’s asymmetry risk cannot be diversified away.
5 We do not observe side-payments, but we do observe allocation of warrants to underwriters (which give the underwriters a stake in the share’s upside) that increase the IPO proceeds.
6 The model is able to show that issuers’ IPO proceeds may be increased by a modest increase in the underwriter’s fee \( k \), i.e., higher underwriter fees may serve the interest of both parties.
7 Some of the downside from overpricing has been measured. Regarding the trading losses from aftermarket price support, Ellis et al (2000) find that the lead underwriter accumulates far more shares of cold offerings on the first day – 15.6% vs. 0.4% of hot offerings – and even sixty days later holds 16.5%. Since they also find that the cold offerings tend to keep dropping after the offering, it follows that these holdings tend to impart losses. Regarding the loss of reputation, Nanda and Yun (1997) conclude that the overpricing hurts the underwriter’s stock price.
for example the offer price is 10 and the market price is 8, then the underwriter experiences a loss per share of 2 if \( \beta = 1 \), and a loss per share of only 1.2 if \( \beta = 0.6 \). Similarly, to allow for the possibility that the underwriter gains some benefit from profits earned by the investors to whom it allocates shares, such as from those investors routing future business to the underwriter, we let \( \gamma \) represent the portion of any excess of the market price over the offer price affecting the underwriter, i.e. the profit share. So if the offer price is 10 and the market price is 12, then if \( \gamma = 0.02 \) then the underwriter enjoys a gain per share of 0.04. With this notation, the incentives imparted simply by the firm commitment contract are captured by setting \( \beta = 1 \) and \( \gamma = 0 \).(this is the case covered in the part that deals with uniform distribution).The market price \( p \) is unknown when the underwriter prices the shares. The cumulative density function of the distribution of the market price at this point is \( F(p) \), which is continuous and differentiable, and which is known to both the issuer and the underwriter. For some purposes we specify that this distribution is uniform between \( p_L \) and \( p_H = p_L + \Delta \), and for other purposes we specify that it is normal with mean \( \mu \) and standard deviation \( \sigma \). The underwriter takes the fee as given and chooses the price \( p^* \) that maximizes its expected revenues. The issuer chooses the fee \( k^* \) that maximizes its revenue, given the effect of this choice on the underwriter’s subsequent choice.

We assume throughout that \( k > \gamma \) and \( \beta > \gamma \) so that the underwriter isn’t pushed right to the corner solution of pricing as low as possible.

We first analyze the investment bank’s pricing problem with a theoretical model of firm commitment, and then we take the predictions to the data. In the model, the underwriter has negotiated a gross spread, and is now choosing the offer price that maximizes its own expected profit, subject to uncertainty about the market price. For simplicity we abstract from the Green Shoe, so the underwriter simply offers a quantity of shares at a price, and if the market price is higher then investors buy all shares at the offer price, and if the market price is lower then investors buy all shares at the market price. This analysis also abstracts from book building, in that the underwriter directly suffers the loss when the offer price exceeds the market price. This direct loss captures what in practice would be the underwriter’s trading losses from price support and reputation losses from embarrassing the issuer and visiting losses on the buyers, in addition to direct losses from the firm commitment. So while the model is explicitly a one-period expected profit maximization, it is intended as a reduced form of the multi-period consequences of the pricing decision.
This model yields several predictions. Underwriters will underprice IPOs, and this underpricing will grow as the gross spread shrinks, and as uncertainty about the market price grows. Also, underwriters will revise their prices more in response to negative information than in response to positive information.

Solving the Model

For a given fee \( k \), the underwriter maximizes

\[
kp^* + \beta \left( \int_{-\infty}^{p^*} pf(p) dp - F(p^*)p^* \right) + \gamma \left( \int_{p^*}^{\infty} pf(p) dp - (1 - F(p^*))p^* \right)
\]

Over \( p^* \). So the underwriter gets the revenue per share, plus a share \( \beta \) of losses arising from overpricing and a share \( \gamma \) of investors’ gains arising from underpricing. Differentiating with respect to \( p^* \) we get

\[
k + \beta (p^* f(p^*) - F(p^*) - p^* f(p^*)) + \gamma (-p^* f(p^*) - (1 - F(p^*)) + p^* f(p^*)).
\]

Setting this equal to zero and rearranging yields

\[
F(p^*) = \frac{k - \gamma}{\beta - \gamma}.
\]

What fee would the issuer choose to pay to underwriter? The issuer maximizes

\[
(1 - k)p^* = (1 - k) F^{-1} \left( \frac{k - \gamma}{\beta - \gamma} \right)
\]

So the issuer’s FOC is

\[
(1 - k) \frac{dF^{-1}}{dk} \left( \frac{1}{\beta - \gamma} \right) - F^{-1} \left( \frac{k - \gamma}{\beta - \gamma} \right) = 0.
\]

Applying the formula for the derivative of an inverse function, we get

\[
F^{-1} \left( \frac{k - \gamma}{\beta - \gamma} \right) F' \left( F^{-1} \left( \frac{k - \gamma}{\beta - \gamma} \right) \right) = \frac{1-k}{\beta - \gamma},
\]

which means that \( k^* \) is the \( k \) that solves this equation, and then \( p^* \) is the offer price that it implies.

These equations yield a number of predictions about IPO fees and offer prices:
Result 1: The offer price is $F^{-1} \left( \frac{k^* - \gamma}{\beta - \gamma} \right)$, where $k^*$ is the fee, $\beta$ is the loss share, $\gamma$ is the profit share and $F$ is the cdf of the market price.

Result 2: The probability of overpricing is $\frac{k^* - \gamma}{\beta - \gamma}$, where $k^*$ is the fee, $\beta$ is the loss share, $\gamma$ is the profit share and $F$ is the cdf of the market price.

To extract the other dynamics this result implies, we must grapple with the endogeneity of the fee to the other parameters. Fortunately, there is one simple but powerful result we can extract with little effort. Suppose $\beta = 1$, i.e. the underwriter absorbs all losses from underpricing. Then in equilibrium, an increase in the profit share increases the fee but does not affect the equilibrium offer price. To see this, suppose the loss share increases from $\gamma_0$ to $\gamma_0 + \Delta$, and that the equilibrium fee implied by $\gamma_0$ is $k_{0}^*$. If the fee is increased to $k_0^* + \Delta \frac{1-k_0^*}{1-\gamma_0}$ then

\[
\frac{1-k_0^*-\Delta\frac{1-k_0^*}{1-\gamma_0}}{1-\gamma_0-\Delta} = 1-\frac{k_0^*}{1-\gamma_0} \quad \text{and} \quad \frac{k_0^*+\Delta\frac{1-k_0^*}{1-\gamma_0}-\gamma_0-\Delta}{1-\gamma_0-\Delta} = \frac{(k_0^*+\gamma_0)(1-\gamma_0-\Delta)}{(1-\gamma_0)(1-\gamma_0-\Delta)} = \frac{k_0^*-\gamma_0}{1-\gamma_0}
\]

which mean that both the left-hand and right-hand side of the equation are unchanged, so the equality still holds. And since this is true for any value of $\gamma_0$ including $\gamma_0 = 0$, we have a result that holds for any differentiable distribution which we can state as follows:

Result 3: If the underwriter bears all losses from overpricing, and if the fee is $k_0^*$ when the profit share is 0, then an increase of the profit share to $\gamma > 0$ increases the fee by $\gamma(1-k_0^*)$ but leaves the offer price unchanged.

It is worth pausing to consider what this means. It means that if we start with the standard firm-commitment contract, whereby the underwriter bears all the losses if the offer price is too high, and then we let the underwriter share the investors’ profits from underpricing, there is ultimately no effect on the offer price, and thus no effect on underpricing. The effect is actually on the fee, as the issuer finds it optimal to offset the effect of the profit share by sharing more of the offer price. This also means that the underwriter benefits twice from the profit share: besides the profit share itself, it also gets more fee from the issuer to combat the increased incentive to price lower.

The implications of the loss share, as opposed to the profit share, are not immediately apparent from the equation. However, we can explore the dynamics by assuming a particular distribution for $p$. Assuming this distribution is Normal with mean $\mu$ and standard deviation $\sigma$, the equation that $k^*$ solves can be written as
\[(\beta - \gamma) \left( \sigma \Phi^{-1} \left( \frac{k^* - \gamma}{\beta - \gamma} \right) + \mu \right) \left( \frac{1}{\sigma} \right) \phi \left( \Phi^{-1} \left( \frac{k^* - \gamma}{\beta - \gamma} \right) \right) - 1 - k^* = 0, \]

where \(\Phi\) and \(\phi\) are the cdf and pdf, respectively, of the standard normal distribution. For illustration, we can set \(\mu\) and \(\sigma\) to 20, and 2, and for clarity set the profit share to zero, and trace out the effect of the loss share on the equilibrium. Figure 1A plots the effect on the offer price and the revenue to the issuer, and shows that both decline as the loss share grows. The intuition is straightforward: a loss share farther from one means investors bears more of the losses from overpricing, and this value given up by the investors is shared between the underwriter and issuer.

The underwriting fee is also free to change with the loss share, but the steady gap between the lines in Figure 1A suggests that it doesn’t change much. Figure 1B addresses this change directly by plotting the underwriting fee against the same change in the loss share. The result confirms the impression that the fee changes little: as the loss share drops from 100 to 50 percent, the equilibrium fee increases from 5.6 to 6.5 percent.

For a better sense of how the loss share affects the equilibrium fee, we can step back from the equilibrium, and ask instead how the offer price and revenue to the issuer vary across the whole range of fees the issuer could pay, and repeat this exercise for different loss shares. This results are presented in Figure 1C, which plots the offer price and revenue to the issuer across the feasible set of fees, as implied by four values of the loss share: 1, 0.75, 0.50 and 0.25. In each case, the fee cannot exceed the loss share, since \(k > \beta \rightarrow k - \gamma/\beta - \gamma > 1 \rightarrow \Phi^{-1} (k - \gamma/\beta - \gamma)\) is undefined. Or to put it another way, a fee greater than the loss share induces the underwriter to price the offering as high as possible, which would be infinite in the Normal case.

One might conclude from this observation that the prediction of the model is that the issuer should go ahead and pay a fee above the loss share, if it is less than one, so as to receive a fraction of an infinite, or in any case extremely high, price. However, this is pushing the idea of a loss share less than one to an outcome space where it makes no sense. The loss share is less than one if investors can be counted on "to eat" a share of the losses from overpricing. This may be plausible for a price that represents a good-faith effort not to overprice, but not for a price that represents an obvious attempt to exploit the investors’ goodwill. So while the model raises the possibility of extreme fees and deliberate overpricing when the loss share is less than one, we will disregard that possibility in our analysis.
Figure 1C sheds some light on why the loss share has such a small effect on the fee. For each loss share there is an upper line for the offer price and a lower line for the revenue to the seller where the lower line rises to the maximum corresponding to the first-order condition, and then declines. As the loss share declines, both lines rotate upward, reflecting the growing strength of the incentive from the fee to price higher, compared to the disincentive from the shrinking loss share. The shrinkage has little effect on the fee optimal to the issuer because this rotation has little effect on the location of this maximum. However, it is worth noting that, for loss shares less than one, the revenue to the issuer reaches a minimum and then heads back up. The figure shows that this is not an issue for higher values of the loss share, but it also shows that when the loss share is just 25 percent, the revenue to the seller is actually higher for fees just below 25 percent than it is at the fee indicated by the first-order condition. One could again read this as a prediction of an extreme fee, but as before, the associated offer price is well above the mean, so this is again an outcome region where the loss-share assumption is implausible.

Figure 1A: Relation of Offer Price and Revenue to Issuer to the Share of Losses Borne by the Underwriter.
Numerical example assumes the market price follows the Normal distribution with mean 20 and standard deviation of 2, and also assumes a profit share of 0.
Figure 1B: Relation of Underwriting Fee to the Share of Losses Borne by the Underwriter. Numerical example assumes the market price follows the Normal distribution with mean 20 and standard deviation of 2, and also assumes a profit share of 0.

Figure 1C: Relation of the Offer Price and Revenue to the Issuer to the Underwriting Fee given Different Loss Shares. Numerical example assumes the market price follows the Normal distribution with mean 20 and standard deviation of 2, and also assumes a profit share of 0.
The uniform distribution case

This is the case that allows closed-form solutions for the IPO price, underwriter’s profit/loss function, issuer’s proceeds function etc. We solve the model and discuss the ramification of the current IPO contract setting for case that $\gamma = 0$ and $\beta = 1$.

We start assuming that $p$ is uniform between $p_L$ and $p_L + \Delta$, then

$$F(p^*) = \frac{k - \gamma}{\beta - \gamma} \rightarrow p^* = p_L + \left(\frac{k - \gamma}{\beta - \gamma}\right)\Delta$$

And for case that $\gamma = 0$ and $\beta = 1$ we get

$$p^* = p_L + k\Delta$$

Results: The underwriter will bring the IPO to the market at price $P^*$; st IPO price $P^*$ the average IPO will be underpriced as the expected post-IPO price is $\frac{1}{2}(p_H + p_L) > (kp_H + (1-k)p_L)$ for $k < 0.5$; i.e., the underwriter’s revenue maximization under a “firm-commitment” contract causes underpricing.

1. The IPO price is an increasing\(^8\) function of $k$ (as $\frac{dp^*}{dk} = \Delta > 0$);

Expected Dollar underpricing and expected relative underpricing

If $p$ is the post-IPO market price the dollar underpricing will be $(p - p^*)$ and the expected dollar underpricing will be

$$\int_{p_L}^{p_H} (p - p^*) \frac{1}{\Delta} dp = \frac{1}{2}(2k)\Delta$$

Following results are attained:

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\(^8\) The IPOs with higher $k$ will be brought to the market at higher prices and, accordingly, should result in lower underpricing (controlling for level of uncertainty $\Delta$). This result is supported by Ljungqvist (2003), who shows that “…contracting on higher commissions in a large sample of U.K. IPOs completed between 1991 and 2002 leads to significantly lower initial (IPO) returns, after controlling for other influences on underpricing and a variety of endogeneity concerns. These results indicate that issuing firms’ contractual choices affect the pricing behavior of their IPO underwriters.” (p.398-Ch 7)

The underwriter’s revenue maximization causes underpricing.
1. For $k < .5$ the IPO is expected to be underpriced\(^9\).

2. The expected dollar underpricing is a decreasing function of $k$: IPOs with larger values of $k$ are expected to be less underpriced in absolute terms;

3. Expected dollar underpricing is an increasing function of valuation uncertainty\(^10\) as $(\Delta/\sqrt{12})$ measures volatility of the distribution.

The IPO literature pays special attention to the first-day return, generally defined as the return from offering price to the closing price on the first day of trading. The model predicts a dollar return from the offering price to the market price of $\frac{(1-2k)\Delta}{2(k\Delta+p_L)}$. This is increasing in $\Delta$ and decreasing in $k$, which implies two more results:

Result: First day returns are increasing in uncertainty about the market price.

Result: First day returns are decreasing in the underwriting fee.

Another statistic of interest is the probability of a ‘cold’ IPO, i.e. one where the offer price exceeds the market price. In the model, this probability is straightforward: as $p^*$ is $k\Delta$ above $p_L$, the probability that the market price falls between $p_L$ and $p^*$ is $\frac{k\Delta}{\Delta} = k$. Thus we have

Result: The probability of a cold IPO increases with the underwriting fee.

We sum up: Relative expected underpricing is positive; it is an increasing function of uncertainty $\Delta$ and a decreasing function of fee $k$.

Expected losses due to a “cold” IPO

Define an IPO as “cold” if $(p - p^*) < 0$. For IPO price $p^*$.

$$\text{Expected losses due to a IPO are } \int_{p_L}^{p^*} (p - p^*) \frac{1}{\Delta} dp = -\frac{k^2\Delta}{2}$$

\(^9\) Assume for the rest of the article that $k < .5$

\(^10\) This will explain why IPO underpricing became so large during the dot.com bubble as it is well-known that the volatility in valuation of dot.com companies was very large.
Expected gain/loss due to a IPO are

\[ \int_{p_L}^{p_H} (p - p^*) \frac{1}{\Delta} dp = \Delta(1 - 2k) \]

Result: Expected losses due to cold IPOs increase with the square of the underwriting fee; and

Result: Expected losses due to cold IPOs increase with uncertainty about the market price.

Result: Expected gain/loss due to an IPOs decrease with the underwriting fee; and

Result: Expected gain/loss due to an IPOs increase with uncertainty about the market price.

What is striking about these results is that the underwriter’s expected losses can be quite modest. In the model’s notation, a typical IPO might have \( q_0 = 5000000 \), \( p_L \) and \( p_H = $20 \) and $30, and \( k = 7 \) percent, so that \( p^* = $20.70 \). The expected first-day return would be \( $4.30 / $20.70 = 21 \) percent, near the historical average of 18 percent, and expected losses due to cold IPOs would be just \( (0.07^2 \cdot 10/2) \cdot (5000000) = $122,500 \), compared to expected profits gross of these expected losses of \( (0.07) \cdot ($20.70) \cdot (5000000) = $7,245,000 \).

Interestingly, this calculation is supported by observed data: “For 8,061 operating company IPOs during 1980-2014, the average amount of first-day capital losses is -$691,000, and the average proceeds is $99,975,000. If one calculates the mean loss per dollar raised, the mean is 0.814% (this equally weights each IPO)".

Book-building as an efficient use of underpricing.

Book building is a relatively new US invention that came into existence in early 1990s. It is characterized by

1. “market show” to collect info about the issuer’s value from its clients and to collect “orders” at different prices;

2. Complete autonomy in allocation of IPOed shares – according to the underwriter’s sole decision. Prior to book building the allocation was done on a pro-rata basis.

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11 This empirical result was reported to us via a private communication by a colleague. He explained his calculation in the following: “I found these numbers by multiplying the number of shares issued (not including overallotment shares) by the difference between the closing price and the offer price (if negative), or zero. For example, if the company sold 10 million shares at $20, and the stock price increased to $21 on the first day, the number would be zero since there was no capital loss. If the stock price closed at $18.50, the $15 million in losses divided by the $200 million in proceeds would be a 7.5% loss. If these were the only two IPOs, the average loss per IPO would be 3.75% of gross proceeds. I don’t have the 30-day prices, but I’ll send you a file with the CRSP permanent Id number for each company.”
The literature concentrates on the market show and takes the allocation authority as a trivial (and sometimes even as devious) addition. Well, it is not.

Under the firm-commitment contract underpricing is unavoidable i.e., the IPOed shares are on average 20% cheaper than their market value. The underwriter cannot diversify the contract risk but a group with guaranteed allocation in all IPOs will capture these 20% premium. The power to allocate IPO shares is therefore valuable and can be utilized to attain higher prices for the issue: an underwriter can organize a group of “loyal clients” that are “obliged” to show up to all of its IPOs, (a “frequent flier club”), to promise not to flip these shares for an agreed period and in return to receive a guaranteed allocation of X% of the shares; this insures the buyer against the danger of “winner’s curse”.

To enforce the “promise not to flip”, the underwriters introduced in 1996 a system that records (by share number) all sales in the newly-issues stock for a number of up to 120 trading days. The presence of “loyal clients” club diminishes the allocational uncertainty and need for after-market support; which should cause a decrease in IPO underpricing. Empirical work shows that this is indeed the case.

Conclusion: book-building is a second-best arrangement given the inefficiencies introduced by the “firm-commitment” contract. It should decrease overall underpricing by allowing capture of at least some of underpricing benefits by underwriters and most probably also by issuers.

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12See Aggarwal(2003) “Flipping of shares is formally tracked via the Depository Trust Company’s (DTC) Initial Public Tracking System (for details, see SEC Release No. 34-37208, May 13, 1996). The system was implemented in June 1996 on a pilot basis and was fully implemented on June 2, 1997. It allows the lead underwriter and syndicate members to monitor flipping activities through two types of reports. The first report, which is sent only to the lead underwriter, contains a list of all syndicate members whose allocated shares were flipped. This report is generated daily in either hard copy or machine-readable format and contains the sale price, trade date, number of shares, and the clearing agent’s participant number. This report does not contain detailed information about customers for other syndicate members. The second report, which is sent to each syndicate member (including the lead underwriter), contains details of the sales transactions of institutional and retail customers. Although tracking can continue for as long as 120 days, the lead underwriter can request to stop it at any time, and the tendency is to stop it earlier. Even for IPOs that considerably increase in price, the practice is to track for 30 days. (The costs of using the DTC Tracking System are minimal and do not depend on the length of the tracking period.) In such cases, penalty bids might not be imposed, but investment banks like to collect the information for future use. If a customer has positions in the same security purchased in both an IPO and in the secondary market, then shares from the secondary market purchase are used to complete delivery first and are not considered flipped. The DTC IPO Tracking System allows monitoring in a book-entry method and also eliminates the need to distribute physical certificates. The Securities and Exchange Commission (SEC) approved the system reasoning that it should “further aid in the efficiencies of the clearance and settlement system because the IPO Tracking System should reduce costs, risks, and delays associated with the physical delivery of certificates (SEC Release No. 34-37208, May 13, 1996)”.
Side-payments

The firm-commitment contract exposes the underwriter to the overvaluation risks but does not allow her to benefit from undervaluation, causing underpricing. This asymmetry opens a possibility for profitable side-payments from issuers to underwriters to increase proceeds of both parties.

Let $p^*$ is the IPO price underwriter chooses if no side payments are offered. Denote by $p^{**}$, (with $\Delta p^* = p^{**} - p^*$) the price chosen by underwriter if side payments are offered. Consider an offer from issuer to pay $z^*(\Delta p^*)$ if $p^* < p$. It can be shown that in this case the underwriter will choose $p^{**} = p^* + z^*(1-k)\Delta$ i.e., she will increase the IPO offer price by $z^*(1-k)\Delta$.

The issuer’s proceeds (after making a $z$ dollars side-payment for every $1$ added by underwriter to the IPO price) are
$$\int_{p^*}^{p^{**}} \frac{1}{\Delta} dp$$

The optimal $z$ is $z^* = \frac{1}{2}$, the optimal side payment should be $\frac{(1-k)\Delta}{4}$ and gain in price $\Delta p = \frac{(1-k)\Delta}{2}$.

Interpretation: offering the underwriter $\frac{1}{2}*(\Delta p^*)$ (i.e., half of what the issuers are gaining) in case when the IPO is a “hot” one under the old price $p^*$, shall increases the payoffs for both issuers and underwriters.

Please pay attention that the largest impact on larger income to the issuer and underwriter are defined by size of volatility of the shares - as $\Delta p = \frac{(1-k)\Delta}{2}$.

We do not observe side-payments but we do observe use of warrants. Warrants are used mainly by small firms with high uncertainty for their future.

In about 50% of cases issuers give to the underwriters warrants – in addition to fee k. (See Dunbar(1995)). Warrants give the underwriter a stake in the upside of the newly-IPOed shares and thus mitigating the problem of underpricing. For example Dunbar(1995)) finds “… from 1980 to 1983 total offering costs, measured as underpricing plus underwriter compensation and expenses, are negatively related to the use of warrants in firm-commitment initial public offerings. For firms using warrants, average underpricing is 23% and would have been 36% without warrants.” [p. 61].
Nature of information and the asymmetric impact of “good news” vs “bad news” on the IPO price adjustment

Ritter points out that “…single variable that has the greatest explanatory power for first-day returns is the revision in the offer price from the midpoint of the original file price range. … If the offer price is revised down, on average there is very little underpricing. But if the offer price is revised upwards, there is on average fairly severe underpricing. Thus, the adjustment of the offer price can be used to forecast the first-day return, a pattern that is known as the partial adjustment phenomenon.”

Our model predicts this result and explains it from the underwriter’s expected-revenue maximization: All profit-maximizing price revisions (following new information learned during the road show) will impute $(1-k)\%$ of the newly-learned “bad news” into the revised IPO price, but only about $k\%$ of the new “good news”.

This result follows from the fact that optimal price $p^*$ responds differently to changes in $p_L$ and in $p_H$:

$$\frac{dp^*}{dp_L} = (1-k) > 0 \quad \frac{dp^*}{dp_H} = k > 0$$

Now consider the “good news” case $p_H \Rightarrow p_H + \Delta p_H$.

The “good news” should increase $p^*$ by $k\Delta p^*$, i.e., only $k\%$ of good news are incorporated into the adjusted price, whereas the average price went up by $\frac{1}{2}\Delta p^*$ and larger underpricing should follow an upward price adjustment. No such underpricing is expected to follow a downward adjustment of the IPO price: consider the “bad news” case $p_L \Rightarrow p_L - \Delta p_L$. In this case $p^*$ decreases by $(1-k)\Delta p^*$, whereas the average price goes down by $\frac{1}{2}\Delta p^*$ and underpricing should shrink. For case of $k=7\%$ and $\Delta p_L = -$1 vs $\Delta p_H = +$1, we conclude from (3a) and (3b) that the IPO price $p^*$ will increase by 7 cents for $1 of “good news” but it will decrease by 93 cents for each $1 of “bad news”. The ratio of these two derivatives is $\frac{\frac{dp^*}{dp_L}}{\frac{dp^*}{dp_H}} = \frac{(1-k) / k}$ and for $k=7\%$ it is equal to $\frac{.93}{.07} = 13.3$, i.e., the IPO offer price responds 13 times stronger to $1 of “bad news” than to $1 of “good news”.

The asymmetric impact of “good news” on the IPO price adjustment

16
The next exercise considers the changes when the uniform distribution becomes an “optimistic” one (case 1) and a pessimistic one (case 2). We start with a uniform distribution for p between $1 and $2 and calculate the expected underpricing under this distribution to be about 40%. Then we tilt the distribution towards the higher prices (Good news-case 1) but on the same support and calculate the expected underpricing under this distribution to be about 55%, a full 15% increase. Alertnavitely, we could tilt the distribution towards the lower prices (Bad news-case 2) but on the same support and calculate the expected underpricing under this distribution to be about 15%, a full 25% decrease.
The example shows that underpricing is increased following good news (from 40% to 55% in our example) and it shrinks (from 40% to 15%) in case of bad news. The result follows directly from the firm-commitment’s reward asymmetry.

**Empirical verification**

1. The theory predicts that fee should have significant negative impact on relative underpricing and that volatility- should have a significant positive impact on underpricing.

We run an OLS on all IPOs between 1980-2014 (8055 observations)

Table 1: Dependent Variable: relative underpricing. Adjusted R Square = 0.17

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>t Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.59569</td>
</tr>
<tr>
<td>fee</td>
<td>-0.17</td>
</tr>
<tr>
<td>fee-size</td>
<td>0.02</td>
</tr>
<tr>
<td>size</td>
<td>-0.01</td>
</tr>
<tr>
<td>vol</td>
<td>6.32</td>
</tr>
</tbody>
</table>

To sum up Table 1: As theory predicts, fee has a significant negative impact on relative underpricing and volatility- a significant positive impact on relative underpricing. Size (by itself) has no significant impact on underpricing but has an indirect impact via its influence on fee. (Aside: size and fees are negatively correlated for IPOs outside of $20MM-$80MM IPO sizes)

2. The theory predicts that fee should have significant and positive impact on the probability of a “cold” IPO. We run an OLS on all IPOs between 1980-2014 (8061Observations); Dependent Variable=1 if cold IPO and zero-otherwise (Adjusted R Square=0.043)

13 excluding the 6 IPOs that raised more than $5 B)
To sum up Table 2: As theory predicts, fee has a significant positive impact on relative underpricing. We will show below that size has a strong impact on size of fee—and we show that size (by itself) has no significant impact on probability of a cold IPO, but has an indirect impact via its influence on fee.

3. Theory predicts that expected gain/loss due to an IPOs decreases with the underwriting fee and increase with uncertainty about the market price. We run regression with gain/loss from IPO (but no consideration on fee) 8061 Observations; Adjusted R Square 0.11

<table>
<thead>
<tr>
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<th>t Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.3</td>
</tr>
<tr>
<td>FEE</td>
<td>0.089</td>
</tr>
<tr>
<td>Fee-size</td>
<td>-0.01</td>
</tr>
<tr>
<td>Size</td>
<td>-0.015</td>
</tr>
</tbody>
</table>

The Optimal Underwriting Fee

The current IPO literature focuses mainly on “… the demand for underwriting, without modeling the supply conditions that determine the equilibrium degree of underpricing”\(^{14}\) (p.360)’.

In this section we step back from the underwriter’s optimization given its fee to the issuer’s optimal choice of fee in the first place. In this optimization we take as given the number of shares to be floated, and ask what fee maximizes the issuer’s expected revenue.

Before analyzing the issuer’s choice, it helps to write down the underwriter’s and issuer’s revenue as a function of the fee and other parameters. The underwriter’s expected profits at its optimal price, given \(k\), are

\(^{14}\) “Equilibrium in the Initial Public Offerings Market” Jay R. Ritter
\[ U^*(k) = k q_0 (p_L + k \Delta) - \left( \frac{-k^2 \Delta}{2} \right) q_0 = q_0 (kp_L + \frac{\Delta k^2}{2}) \]

This is increasing in \( k \), so the underwriter always prefers a higher fee. The issuer’s expected proceeds, given \( k \) and the underwriter’s pricing given \( k \) are

\[ I(k) = (1 - k)q_0p^* = (1 - k)q_0(p_L + k \Delta) = q_0(k\Delta + (1 - k)p_L - k^2\Delta) \]

This can be increasing or decreasing in \( k \); since the first derivative is \( \Delta - p_L - 2k\Delta \), and since the second derivative is negative, the revenue maximizing fee is

\[ k^* = \frac{\Delta - p_L}{2\Delta} \]

To this point the analysis has imposed no realism on the fee. In particular, it has not imposed any participation constraint on the underwriter. The underwriter will not accept a negative fee, and presumably has both fixed and variable costs to make up. Going back to the numerical example above, in that case \( k^* \) would be \((10-20)/(2*10) = -50\%\). The issuer would have to raise the fee just enough into positive territory to get the underwriter interested. By contrast, if \( \Delta \) were 22 rather than 10, \( k^* \) would be \((22-20)/(2*10) = 10\%\), and the implied revenue to the underwriter could have been more than enough to get it interested. More generally, since \( \Delta \) is large relative to \( \sigma/\sqrt{12} \), the volatility of the distribution of the market price, is large relative to \( p_L + \Delta/2 \), the mean of this distribution, and also since \( U^* \) is increasing in \( \Delta \), it follows that

Result:  Everything else equal, the underwriter’s participation constraint is binding if uncertainty about the market price is low enough, and not binding if uncertainty is high enough.

So when uncertainty is relatively low, the issuer pays just enough fee to get the job done, whereas when it is high, the issuer pays more than necessary, for the reason presented here: given the downside losses imparted by firm commitment, the underwriter needs more upside participation to price more aggressively, and this is a bigger concern when uncertainty is greater.

Another situation where the participation constraint is likely to bind is a small offering. That is, to the extent there are fixed costs to an IPO, the underwriter needs to earn more per dollar raised when fewer dollars are raised, obliging the underwriter to raise \( k \) above \( k^* \) to cover these costs. So the point here is simply that fixed costs mean higher fees for smaller offerings, it is that larger offerings are the ones where the underwriter gets more fee than necessary to address the agency problem that arises when uncertainty is sufficiently high. So we have
Result 10: If uncertainty and fixed costs are sufficiently high, then the participation constraint is binding if the offer is small but not if it is big.

**Profit maximizing behavior in negotiations between the issuer and the underwriter**

The participation constraint binding means that the underwriter has to cover at least her Average Costs. Assume that AC measures average cost per dollar of IPO when proceeds are proceeds \( pq_0 \). AC is a decreasing function of IPO size (due to large fixed costs etc.)

To sum up: The theory predicts that fee is a decreasing function of IPO proceeds for very small IPOs and for very large IPOs (in the first case because AC is very high, in the second because - in later case because volatility is lower (as compared to size). But issuer’s proceeds can be an increasing function of fee when \( \Delta > p_L \), i.e., when relative size of the IPO is small as compared to \( \Delta \). We check if IPOs with larger size (as compared to volatility) are less sensitive to changes in size – because the issuer might be interested to pay a higher fee. Following are 4 regressions of IPO fees vs IPOs size and volatility for following:

IPOs size up to $20MM ; IPOs size $20MM to $80MM ; IPOs size $80MM to $200MM and IPOs above $200MM

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>t Stat</th>
</tr>
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<tbody>
<tr>
<td>Intercept</td>
<td>30.6</td>
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<tr>
<td>( ln(size) )</td>
<td>-1.4</td>
</tr>
<tr>
<td>VOL</td>
<td>11.8</td>
</tr>
</tbody>
</table>

IPOs size $20MM -80MM (3398 observations): dependent variable - fee; Adjusted R Square= 0.04

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>t Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>8.54</td>
</tr>
<tr>
<td>( ln(size) )</td>
<td>-0.09</td>
</tr>
<tr>
<td>VOL</td>
<td>1.37</td>
</tr>
</tbody>
</table>
IPOs size $80MM-$180MM (1215 observations): OLS dependent variable - fee; Adjusted R Square=0.11.

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Intercept</th>
<th>Ln(size)</th>
<th>VOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>t Stat</td>
<td>13.88</td>
<td>-0.39</td>
<td>4.3</td>
</tr>
</tbody>
</table>

IPOs size above 180MM (820 observations): OLS dependent variable - fee; Adjusted R Square=0.59.

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Intercept</th>
<th>LN(size)</th>
<th>VOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>t Stat</td>
<td>24.59</td>
<td>-0.96</td>
<td>6.13</td>
</tr>
</tbody>
</table>

Conclusions: size and volatility are two explanatory variables for IPO fees when IPOs are small (less than $20MM) or very large (above $180MM)- but have very weak explanatory power for IPOs with size between $80MM-$180MM

[Aside: An interesting aside has to be mentioned: if fixed costs for large IPO issues are smaller (per share issued), then we might observe in data that larger IPOs will have smaller fees and (according to our theory) larger underpricing. On the other hand, if larger deals are done by higher-reputation investment banks, then we can get a spurious correlation between the bank’s reputation and its underpricing practices; Ritter points out that “…some underwriters persistently underprice their IPOs more than others …but these high underpricing underwriters have gained market share over time.”]
The graph below allows visualizing this discussion.
A broader discussion of the “7 percent solution” conundrum

Chen and Ritter in a classical Y2000 article show a large prevalence of 7% fee in almost all of IPOs with $20MM-$80MM proceeds. Assuming presence of economies-to-scale in the IPO process, the 7% fee raises questions of unfair competition and exploitation of smaller issuers by powerful investment bankers.

We study the phenomena and show that the 7% solution is limited to the a particular size of IPOs, that size has a strong explanatory power for fees in IPOs with less than $20MM or larger that $200MM. The medium-size IPOs may be the range where the issuers are interested in higher fees—to increase the IPO price (as our theory would predict). If this is the case, the 7% solution is not anti-competitive but rather a solution that both underwriters and issuers find optimal given the uncertain environment in which they operate.

The empirical regularities of the “7% solution”

1. Size: the “7% solution” is prevalent among IPOs of $20-$80 MM and varies with IPO size for IPOs smaller than $20MM and larger than $180MM.

The table below shows percentage of IPOs that have a fee different from 7%—e.g., only 28% of IPOs larger than $20MM do not have a 7% fee, but full 83% larger than $120MM do not have a 7% fee

<table>
<thead>
<tr>
<th>Probability</th>
<th>Description</th>
<th>Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>.77</td>
<td>prob of &quot;not 7%&quot; for less than 20MM</td>
<td>2628 cases</td>
</tr>
<tr>
<td>.28</td>
<td>prob of &quot;not 7%&quot; for more than 20MM</td>
<td>5400 cases</td>
</tr>
<tr>
<td>.54</td>
<td>prob of &quot;not 7%&quot; for more than 80MM</td>
<td>2000 cases</td>
</tr>
<tr>
<td>.62</td>
<td>prob of &quot;not 7%&quot; for more than 100MM</td>
<td>1600 cases</td>
</tr>
<tr>
<td>.7</td>
<td>prob of &quot;not 7%&quot; for more than 120MM</td>
<td>1300 cases</td>
</tr>
<tr>
<td>.83</td>
<td>prob of &quot;not 7%&quot; for more than 180MM</td>
<td>800 cases</td>
</tr>
</tbody>
</table>

2. Volatility: the more volatile IPOs have highest percentage of the 7% fees—a full 92% of top 1000 IPOs (by volatility), but only 45% of bottom 500 IPOs (by volatility) have a 7% fee
Similarly, size has great explanatory power for fee size in case of very small IPOs (up to $20MM) or very large IPOs (above $200MM) - with R-sq. of 0.47 and 0.59, respectively but has practically no explanatory power of $20MM - $200MM range IPOs—see table below.

<table>
<thead>
<tr>
<th>size of IPO</th>
<th>Number of IPOs</th>
<th>Adjusted R Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than $20MM</td>
<td>2679</td>
<td>0.47</td>
</tr>
<tr>
<td>$20-$80</td>
<td>3345</td>
<td>0.02</td>
</tr>
<tr>
<td>$80-$200</td>
<td>1340</td>
<td>0.08</td>
</tr>
<tr>
<td>&gt;$200MM</td>
<td>713</td>
<td>0.59</td>
</tr>
</tbody>
</table>

y = -1.409ln(x) + 30.604
R² = 0.4684
The three graphs above exhibit the strong relationship between size and fee for small IPOs and large IPOs (where size explains most of fee variance) vs. size and fee for medium-size IPOs (where size does not explain variance in fees). The next chapter will try to explain why this is the case.


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Built an operation in commodity derivatives and secured a leadership position for Barclays in this area. Organized, staffed and
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Established commodity risk management at Continental. Designed and structured a variety of commodity-related products and marketed
them worldwide. Recognized as a leading specialist in commodity risk management; dozens of conference presentations and published
articles, interviews with UP, Reuters and CNN.
1989 - 1991

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Priced, structured and designed new interest rate and cross-currency derivative products.
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PUBLICATIONS
A Neoclassical Model of Managed Distribution Plans: Theory and Evidence” JFQA [forthcoming]
A Liquidity-based Theory of Closed-End Funds (with Richard Stanton and Jacob Sagi), RFS, 2009
Initial Public Offering Patterns in Closed-end Funds, June 2004, SSRN
A Positive Theory of Closed-End Funds as an Investment Vehicle, January 2003, SSRN

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