Why don’t IPO firms disclose a reservation price?

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Abstract

A significant proportion of IPOs filed with the SEC are withdrawn during bookbuilding when it becomes clear to the issuer that they will not achieve a minimum acceptable offer price. Why don’t issuers disclose this price at the outset? This question is important given that in many auction designs, including some for IPOs in other countries, a reservation price is formally posted, and the auction literature has shown that posting a reservation price can be optimal. We characterize the firms that would enjoy higher proceeds if their reservation price were disclosed and the firms that are better off with non-disclosure. We also identify a set of issuers that benefit most with ‘partial disclosure’ - the reduction in, but not elimination of, investor uncertainty surrounding a secret reserve price - a strategy that to our knowledge has not previously been admitted in the auction literature. We explain why the firms that would benefit from the disclosure of a reserve price are those least likely to file for an IPO in the first place, explaining why firms that do file are not observed to post a reservation price. Our results have implications for issuing firms and for regulators of primary equity markets where bookbuilding or economically equivalent auction mechanisms are used.

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I Introduction

In the United States and increasingly throughout the world, the dominant method by which firms initially offer shares to the public is a two-stage auction-like method, characterized by the bookbuilding process (Sherman, 2005; Ljungqvist et al., 2003). In this process, the investment bank solicits investor indications of interest upon which it then conditions share allocations and the final offer price. Papers that model this process (e.g., Benveniste and Spindt, 1989; Spatt and Srivastava, 1991; Biais and Faugeron-Crouzet, 2002) identify the need for the bank to provide, through the use of underpricing and discretion in allocations, incentives for investors to give truthful indications.

As in other auction settings, the issuing firm reserves the right to withdraw the equity from sale if the resulting offer price is unsatisfactory – in other words, if the issuer’s reservation value has not been met. The option to withdraw is not just a theoretical possibility; 20% of the IPOs filed between 1985 and 2000 were later withdrawn (Dunbar and Foerster, 2004). Explicitly recognizing the reality and relevance of this option, the SEC introduced in 2001 the public-to-private safe harbor Rule 155 and simultaneously amended Rule 477 to facilitate the withdrawal of registered offerings and the prompt pursuit of private equity. It is clear, therefore, that issuing firms approach the market with a reservation price in mind, below which they are not willing to complete the IPO. Recent theoretical (Busaba, 2005) and empirical (Busaba et al., 2001) work shows that the presence of such a price and the ability to withdraw increase IPO proceeds by reducing the cost of providing incentives for investors to truthfully report interest during the bookbuilding process.

In several primary markets for financial securities, the formal declaration of a reservation price by the seller is the norm. In France, Israel and Japan, for example, issuers in IPO auctions have been obliged to post a minimum acceptable offer price,1 and in U.S. corpo-

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1In France, the Offre à Prix Minimal (OPM) process for IPOs includes, as its name suggests, a reservation price which is set before investor bids are sought. Biais and Faugeron-Crouzet (2002) analyse the OPM process (formerly known as Mise en Vente) and show that it has similar properties to the bookbuilding process. Indeed they show how either process can implement the optimal mechanism. However, in their model, the issuer’s reservation value is never binding and so withdrawal of the IPO is not contemplated.

In Israel, at least during the period 1993-1996, IPOs were conducted as uniform price auctions and IPO prospectuses specified a minimum price (Kandel et al., 1999). In Japan, at least in the years 1989-1993, there existed a published lower limit to acceptable bids for each IPO auction (Pettway and Kaneko, 1996).
rate bond auctions organized by W.R. Hambrecht & Co., sellers routinely post a minimum acceptable bid. Yet we have no evidence that reservation prices are disclosed in the U.S. primary equity market. We ask whether issuing firms would enjoy higher IPO proceeds (lower underpricing) if their reservation prices were disclosed to investors at the commencement of the bookbuilding process.

In answering this question, we contribute to the understanding of an important yet neglected feature of the IPO market at a time when the Google IPO has stirred renewed interest in IPO mechanism design. We also contribute to the auction literature. Secret reserve prices are used, for example, in auctions for wine and art (Ashenfelter, 1989) and in timber auctions in the South of France (Elyakime et al., 1994), while reserve prices are commonly posted in internet auctions (Lucking-Reiley, 2000). On the largest auction website, eBay, sellers can choose at the outset whether to employ a posted or secret reservation price, yet empirical (Bajari and Hortaçsu, 2003) and experimental (Katkar and Lucking-Reiley, 2002) evidence is inconclusive as to which policy generates higher revenues to the seller. These observations, along with the fact that reservation price disclosure is the norm in several primary markets for financial securities, demonstrate the lack of unanimity amongst auction institutions or sellers as to whether reservation prices should be posted or kept secret.

Neither is there unanimity in the theoretical auction literature regarding the answer to this question. This literature studies reservation price disclosure policy within the framework of first-price and second-price auctions of indivisible goods and reaches conflicting conclusions depending on the auction setting considered and information environment assumed. While we discuss this literature in more detail in Section III, we note here that its conclusions do not extend in general to the public offering of financial securities, better characterized as a common value auction of a divisible good with multi-unit demands, and in particular to the bookbuilding process of selling IPOs in which the ‘auctioneer’ aggregates ‘bids’ to estimate the common value of the shares and then sets the offer price off this value. To our knowledge, ours is the first paper to address the question of reservation price disclosure in an environment characteristic of the U.S. primary market and in the context of the auction of a divisible good in general.²

²In the selling of an indivisible good using bookbuilding, our results regarding the optimality of reserve
In papers that model the bookbuilding process, the need to ensure truthful indications of interest arises because an investor holding positive information may otherwise be tempted to misrepresent this in the hope of receiving an allocation of shares at a price that does not fully reflect the information. Truth-telling is ensured, and proceeds maximized, by giving allocation priority to investors who reveal positive information and by underpricing the IPO when demand is strong. Busaba (2005) introduces into this environment the possibility of withdrawal of the IPO and shows that the existence of a non-trivial *publicly known* reservation price reduces investors’ incentive to misrepresent information, thereby reducing required underpricing.³

Consistent with this argument and recognizing that the issuer’s reservation value is not generally stated, Busaba et al. (2001) find a significant negative correlation between IPO underpricing and an imputed measure of what investors might ex ante perceive to be the issuer’s likelihood of withdrawal. An increase of 10 percentage points in this predicted likelihood (which has a standard deviation of 13 percentage points in their sample) is associated with a reduction in underpricing of up to 2.63 percentage points. Hence, for an issuer with an unconditional probability of withdrawal of 20% (the average in the data documented by Dunbar and Foerster, 2004), the saving in underpricing brought about by the ability to withdraw is a full 5 percentage points on average (a reduction in underpricing from 15% to 10%, for example, or a third of the average underpricing outside of the 1999-2000 bubble). This motivates our main question: Given that, when an issuer does *not* disclose a reservation price, investors will form probabilistic expectations on it, would that issuer enjoy improved IPO proceeds were the reservation price explicitly disclosed?

We employ a mechanism design approach to compare IPO proceeds when the firm’s reservation price is disclosed with the proceeds when it is kept secret. We abstract from the potential for conflict of interest between the investment bank and the issuing firm and maintain that a primary objective of any selling mechanism or auction is naturally to maximize

³In the rarely used ‘best efforts’ IPOs, which are priced before soliciting subscriptions from investors, offerings are cancelled if a minimum number of shares are not sold. Extending Rock’s (1986) fixed price model, Beatty and Ritter (1986) argue that this minimum sales constraint mitigates the winner’s curse faced by uninformed investors and reduces underpricing.
expected proceeds. We do not claim that ensuring information revelation by investors is the only determinant of IPO underpricing. Our analysis merely requires that an economically significant part of the observed underpricing be driven by information revelation, which is consistent with the empirical evidence outlined here and in Hanley (1993) and Cornelli and Goldreich (2001, 2003) among others.\(^4\)

In common with the other bookbuilding models and analogous to the common value auction setting in Vincent (1995), we also maintain that investors already know all of the information held by the issuer that is relevant to valuing the IPO, presumably uncovered by the banker’s due diligence effort, disclosed via the preliminary prospectus or presented during the roadshow. This implies that the issuer’s reservation price does not contain additional information relevant to the investor valuation of the shares. Furthermore, we make the natural assumption that if an issuer’s reservation price is not disclosed, investors form expectations of it which are unbiased on average. Our results, therefore, are not driven by signaling considerations or adverse selection, but rather by the effect of reservation price uncertainty on the incentives for informed investors to reveal information.\(^5\)

We find that when the issuer’s reservation price is sufficiently high relative to possible investor valuations, the issuer enjoys improved IPO proceeds if its reservation price is disclosed. Conversely, when the reservation price is sufficiently low, the issuer is better off if its reservation price is kept secret. Over an intermediate range of reservation prices, proceeds are maximized at a non-zero but finite level of uncertainty. This raises the novel empirical question of whether firms can or do take actions ex ante to control the degree of this uncertainty and may suggest a possible role in this regard for the filing range and other ‘soft’ information contained in the prospectus. To our knowledge, ours is the first paper on

\(^4\)There is a view that underpricing is driven by the need to compensate investors for information production, not information revelation (e.g., Booth and Chua, 1996; Sherman and Titman, 2002). Under this view, a higher ex ante likelihood of withdrawal would lead to higher required underpricing, which is inconsistent with what Busaba et al. (2001) find. It is likely that both information production and revelation can be binding in reality. The need to ensure information revelation necessitates that IPOs be underpriced, and the prospect of capturing this underpricing makes it worthwhile ex ante for some investors to become informed.

\(^5\)In an adverse selection paradigm, where investors pool together different reservation price types, we conjecture that the equilibrium would be one in which there is full disclosure by all types. Given the results in Busaba et al. (2001), the potential for reduced underpricing would give the ‘highest’ type an incentive to separate by disclosing. The ‘next highest’ type would follow suit, and so on. This equilibrium is inconsistent with what we observe in the U.S. IPO market, however.
any auction to admit the possibility of — and identify the potential benefits to — ‘partial’ disclosure of a seller’s reservation price.

Our results are driven by how the reservation price disclosure policy affects investors’ incentives to misrepresent information. The optimal bookbuilding mechanism gives allocation priority to investors who report strong interest, so an investor who downplays his interest generates a profit mostly when aggregate premarket demand turns out to be weak. However, conditional on possessing positive information, the investor assigns relatively lower probabilities to the weak demand states happening. The interplay between the lower conditional probabilities assigned to, and the higher profits available in, those states, along with the position of the issuer’s reservation price relative to these states, determines whether investors’ incentive to downplay interest is weakened or strengthened by the disclosure of the reservation price.

When the issuer’s reservation price is public knowledge, investors know exactly the states of demand (equivalently, would-be offer prices) in response to which the issue will be withdrawn, and compute the expected profits from downplaying interest accordingly. However, when the reservation price is secret, investors inevitably assign a positive likelihood to the issue being completed in some demand states that correspond to an offer price below the true reservation price but also assign a positive likelihood to the issue being withdrawn in some stronger demand states. The uncertainty in the level of demand in response to which the issuer will withdraw weakens an investor’s incentive to misrepresent information when the issuer’s reservation price corresponds to relatively weak demand states, yet strengthens this incentive when the reservation price is sufficiently high.

When studying the IPO results under the policy of disclosure, we consider the possibility that the issuer would overstate its true reservation price. We find, however, that overstatement is not optimal, in contrast to results from the classical auction literature (e.g., Riley and Samuelson, 1981; Elyakime et al., 1994; Vincent, 1995). Under the optimal bookbuilding mechanism, investors convey truthfully their indications and the selling price is set based on aggregate information, thereby eliminating the potential for a winner’s curse. Although overstating the reservation price would reduce the underpricing required to ensure truthtelling in this setting, the reduction would be outweighed by the possible loss of efficient transactions
the firm withdrawing when it would prefer to complete the offering ex post.

Having shown that issuers with a sufficiently high reservation price are better off disclosing it, we are confronted with the reality that such disclosure is far from commonplace in the U.S. IPO market. So, why don’t at least such issuers disclose their reservation price? We note that firms with high reservation prices are those least likely to attempt an IPO in the first place, given the cost of IPO initiation and these issuers’ low probability of exceeding their reservation prices. Rather, such firms are likely to remain private and stick with the very alternatives (credit, private equity, merger...) that make their reservation price high. This could explain why the firms that are observed attempting to go public do not usually disclose a reservation price. Empirically, these firms are likely to be those which we identify as better off under secrecy or ‘partial’ disclosure.

At first glance, our result for some firms that ‘secrecy is best’ may seem at odds with Milgrom and Weber (1982) who show, in a common value auction, that the seller improves proceeds by revealing all relevant private information. The paradox is resolved once we recognize that, while the issuer’s reservation price conveys no additional information regarding the aftermarket value of the firm, disclosing this price can further distort the investors’ incentive to reveal their own information during the premarket.

The remainder of the paper is organized as follows. The model is presented in Section II, along with the main results and empirical implications. Section III relates our results to those in the classical auction literature and highlights our contributions to that literature. Section IV summarizes and concludes. Proofs of propositions are in an Appendix.

II The Model

We draw on an information structure employed in Welch (1992), adapted to the model of the bookbuilding mechanism laid out in Benveniste and Spindt (1989). The issuing firm wishes to sell a fixed fraction of ownership in the form of $Q$ shares. There are $H$ risk neutral investors, each willing to buy any number of shares up to a maximum of $q$. For notational convenience, we normalize $q$ to 1 and the issue size to $Q = \frac{Q}{q}$. Therefore, each investor is able to buy up to $1/Q^{th}$ of the whole issue and actual allocations can be any fraction of 1.
In the model, $H > Q$, so there exist enough investors to take up the issue.

The necessity for the issuer to allocate the shares across a number of investors, potentially in discriminatory quantities, reflects the reality that it is rare for any investor to take more than a few percent of the available shares, perhaps due to institutional barriers on the dollar exposure to any single stock, or to issuer preference for dispersed ownership. It also highlights the divisible nature of the auctioned ‘good’. The special case where single investors contemplate taking up the whole issue, $q = Q$ and so $Q = 1$, reduces to a single-unit, indivisible good auction which we analyze later in subsections A and C.

Prior to beginning the issuing process, the firm and its banker know only that the per share aftermarket value, $V$, is uniformly distributed on the interval $[0, 1]$ with expected value $\frac{1}{2}$. The $H$ investors know this prior information but each observes a private signal on the value, $V$, which is independently drawn from a Bernoulli variable $\{L, U\}$. The investors’ information is naturally correlated with the aftermarket value, $V$, in that the probability that any investor draws a ‘$U$’ is just $V$. Therefore, measuring the number, $h \in \{0, 1, \ldots, H\}$, of $U$ signals held by the $H$ investors provides a more precise estimate of the true $V$. This updated estimate, by Bayes’ rule, is $V_h = \frac{h+1}{H+2}$, the expected aftermarket price conditional on $h$. The task of extracting and aggregating investor information – ‘bookbuilding’ – falls to the investment banker, who then publicizes the realized $h$ and sets a corresponding offer price, $P_h$. We shall often refer to the realization of $h$ as the ‘demand state’.

Since $V$ is uniformly distributed on $[0, 1]$, the ex ante (‘prior’) probability of realizing any particular demand state, $h$, is just $\pi_h = \frac{1}{H+1}$. However, an informed investor possessing a $U$ signal updates its prior using Bayes’ Rule. This yields a posterior, $\pi'_h = \frac{2(h+1)}{H(H+1)}$, that exactly $h$ of the other $H - 1$ investors have received a $U$ signal, which is naturally increasing in $h$. For such an ‘optimistic’ investor the revised estimate of $V$ is $\frac{2}{H+1}$.

The challenge facing the banker during the bookbuilding process is to induce truthtelling on the part of investors. An investor with a $U$ signal understands how his indication of interest affects $P_h$ and has an incentive to misrepresent this signal in the hope of pushing down the offer price. To counter this incentive, the banker, whose objective is to maximize expected proceeds, $Q \sum_{h=0}^{H} \pi_h P_h$, adopts a price/allocation rule that satisfies the investors’ incentive compatibility constraint. This constraint weighs, for the investor holding a $U$
signal, the expected profits from truthfully declaring $U$ against the expected profits from misrepresenting the information as $L$. We denote by $q_{U,h}$ and $q_{L,h}$ the share allocations given to each investor who reveals $U$ and $L$, respectively, when $h$ investors in total have revealed a $U$ signal. An investor truthfully revealing $U$ when $h$ others also reveal $U$, receives an allocation, $q_{U,h+1}$, at a price, $P_{h+1}$, when the expected aftermarket value is $V_{h+1}$. On the other hand, if that same investor were to misrepresent the $U$ signal as ‘$L$’, he would receive an allocation, $q_{L,h}$, at a price, $P_h$. The ‘truthtelling’ incentive compatibility constraint can therefore be stated formally as

$$h=0 \sum_{h=0}^{H-1} \pi'_h (V_{h+1} - P_{h+1}) q_{U,h+1} \geq \sum_{h=0}^{H-1} \pi'_h (V_{h+1} - P_h) q_{L,h}$$

(1)

The pricing of the offering is also bound by the investors’ participation constraint – since $h$ is publicized at the end of bookbuilding, the offer price cannot exceed the ‘discovered’ value i.e., $P_h \leq V_h$ for $h \in \{0,1,\ldots,H\}$. This constraint also follows from SEC rules that any indications given by investors prior to the setting of the offer price are non-binding. Benveniste and Spindt (1989) show that the price/allocation schedule, $(P_h, q_{U,h}, q_{L,h})$ for $h \in \{0,1,\ldots,H\}$, that maximizes expected proceeds subject to the incentive compatibility and participation constraints is

<table>
<thead>
<tr>
<th>weak demand</th>
<th>strong demand</th>
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<td>$h &lt; Q$</td>
<td>$h \geq Q$</td>
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$$q_{U,h} \ (\text{receives priority}) \quad 1 \quad \frac{Q}{h}$$

$$q_{L,h} \ (\text{shares the remainder}) \quad \frac{Q-h}{H-h} \quad 0$$

Offer Price, $P_h$

$$V_h \quad V_h - u_h$$

(2)

where $u_h = V_h - P_h$ is an underpricing pattern across strong demand states, $h \geq Q$, which satisfies the truthtelling constraint with equality. In other words, at the optimum, (1) yields $u_h$ such that

$$h=0 \sum_{h=0}^{H-1} \pi'_h u_{h+1} q_{U,h+1} = \alpha \sum_{h=0}^{H-1} \pi'_h q_{L,h}$$

(3)
where \( \alpha = V_{h+1} - V_h = \frac{1}{H+2} \), is the marginal impact on expected value of the positive information revealed by one investor. Recalling that \( \pi'_h = \frac{2(h+1)}{H(H+1)} \) for \( h \in \{0, 1, ..., H - 1\} \), \( \pi_h = \frac{1}{(H+1)} \) for \( h \in \{0, 1, ..., H\} \), and \((h + 1) q_{U,h+1} = Q\) for \( h \in \{Q - 1, ..., H - 1\} \), the left hand side of equation (3) reduces to \( Q \sum_{h=Q}^{H-1} \pi_{h+1} u_{h+1} \). Hence, from the firm’s point of view, the total ex ante expected underpricing can be written as

\[
Q \sum_{h=Q}^{H} \pi_{h} u_{h} = \alpha \frac{H}{2} \sum_{h=0}^{H-1} \pi'_{h} q_{L,h} \tag{4}
\]

This level of underpricing reflects the prior expectation that \( \frac{H}{H} \) investors will have a \( U \) signal, each demanding a ‘truth-telling incentive’ equal to the benefit they could obtain if they misrepresented the \( U \) as \( L \). This benefit is the value, \( \alpha \), of one such signal multiplied by the allocation the investor could expect by reporting \( L \).

Intuitively, the optimal price/allocation rule minimizes underpricing by minimizing the expected benefit to downplaying interest. It achieves this by withholding when possible the allocation to investors revealing \( L \) and by not deliberately underpricing when such investors receive an allocation. Given the minimized level of total underpricing, per-share underpricing, \( u_h \), is reduced by giving allocation priority to truthful \( U \) investors, thereby ensuring \((h + 1) q_{U,h+1} = Q\) for \( h \in \{Q - 1, ..., H - 1\} \).

The bar graph in Figure 1 shows the allocations, \( q_{L,h} \), that will be received under the optimal bookbuilding procedure by an investor reporting \( L \) when \( h \) others report \( U \). An investor with a \( U \) signal but falsely reporting \( L \) will push valuations (and hence \( P_h \)) down by \( \alpha \). This investor benefits the most from the resultant mispricing in low demand states where his allocations are highest (e.g., \( q_{L,h} = \frac{Q}{H} \) at \( h = 0 \)). This benefit rapidly decreases with his allocations as the number of \( U \)’s declared, \( h \), increases, and it vanishes as this number reaches the full subscription demand level, \( Q \). However, this very investor’s posterior, \( \pi'_h \), for demand states is increasing in \( h \). As illustrated in Figure 2, these two factors combine to make the investor’s probability-weighted allocation function, \( \pi'_{h} q_{L,h} \), increasing then decreasing in the demand state, \( h \). From equation (4), the firm’s expected cost of underpricing is simply a multiple, \( \alpha \frac{H}{H} \), of the area represented by the bar graph in Figure 2.
A Introducing a disclosed reservation price

Having developed the optimal price/allocation rule (2) in a classical bookbuilding setting, we can now analyze the effect on IPO proceeds of the option to withdraw. Benveniste and Spindt (1989) implicitly assume that the firm will complete the IPO \textit{whatever} the level of premarket interest turns out to be and at whatever price this implies for the issue, yet the pervasiveness of IPO withdrawal makes it self-evident that non-trivial reservation prices exist and are high enough to be binding in a significant proportion of cases. As in Busaba (2005), we now introduce a publicly disclosed reservation price, \( V_R \), for the firm.\(^6\) This means that if the bookbuilding process leads to an offer price that does not strictly exceed \( V_R \), the firm will withdraw its IPO.\(^7\)

We assume that the issuer can credibly commit to withdrawing the IPO at or below its posted reservation price. This is in line with the classical auction literature (e.g. Riley and Samuelson, 1981; Horstmann and LaCasse, 1997; Vincent, 1995) in which it is typically assumed that the seller can commit to a set of auction rules. At any rate, it is not difficult to imagine simple commitment mechanisms for IPO withdrawal, enforced by regulation, investment bank reputation, or otherwise.\(^8\) We take the liberty at this stage to assume that a firm disclosing a minimum acceptable offer price will disclose its \textit{true} reservation price, and Proposition 1 subsequently proves that the issuer indeed has no incentive to overstate its reservation price.

In the interests of clarity, we restrict the analysis to consideration of reservation prices \( V_R \in \{V_0, V_1, \ldots, V_{Q-2}\} \).\(^9\) This means that if the bookbuilding process yields a demand,
\( h \leq R \in \{0, 1, 2, \ldots, Q - 2\} \), then the corresponding value, \( V_h \leq V_R \), is insufficient for the firm to proceed and the firm will withdraw the IPO. We emphasize that \( V_R \) is locally independent of investor valuations of the offering, containing no additional information for investors on what the firm will be worth if its IPO is completed. Investor valuations of the issue are what they are, irrespective of the reservation price of the issuer. As in all bookbuilding models, we assume that all information held by the firm and its banker and relevant to the aftermarket value of the firm has already been made available to investors through the preliminary prospectus and during the roadshow.

The revised solution to the optimal price/allocation schedule simply adds an extra scenario to the above Benveniste and Spindt solution (2), namely \( q_{U,h} = q_{L,h} = 0 \) for ‘insufficient demand’ states, \( h \leq R \), as the IPO is withdrawn in such states (Busaba, 2005). The existence of these insufficient demand states reduces the profits that an investor can expect to make by pretending to have an \( L \) signal because it removes a number of ‘weak demand states’ in which this investor would otherwise receive an allocation. It also introduces the possibility that an investor’s pretence of \( L \) could tip ‘weak demand’ into ‘insufficient demand’. These diminished rewards to downplaying interest reduce the expected underpricing which needs to be offered by the firm to satisfy incentive compatibility. Re-writing the right hand side of equation (4) to take into account the eliminated profit opportunities in \( h \leq R \), the expected underpricing at the optimum becomes

\[
\alpha \frac{H}{2} \sum_{h=R+1}^{h=Q-1} \pi_h q_{L,h} \tag{5}
\]

The reduction in underpricing (relative to the case with no reservation price) has a value of \( \alpha \frac{H}{2} \sum_{h=0}^{h=R} \pi_h q_{L,h} \), and the firm’s expected cost of underpricing is simply a multiple, \( \alpha \frac{H}{2} \), of the truncated area represented by the bar graph in Figure 3.
In the special case of the single-unit \((Q = 1)\) auction, the incentives to misrepresent ‘\(U\)’ are greatly reduced by the increased competition among investors. In that case the only potential benefit from downplaying interest would come if the investor happens to be the only one holding \(U\) information and this happens with posterior probability, \(\pi_{h=0}' = \frac{2}{H(H+1)}\). Only then can the investor hope to obtain an allocation (if, for example, the allocation rule when all reveal ‘\(L\)’ is to assign the issue by lottery). Therefore, the disclosure of any non-trivial \((R \geq 0)\) reservation price removes the need for underpricing altogether.

**Would an issuer post an overstated reservation price?**

We now proceed to show that there is no incentive to misrepresent the reservation price - the posted reservation price is the firm’s true reservation value. First, there is clearly no incentive for the issuer to *understate* its reservation price, as that would require the issuer potentially to sell below its true reservation price. On the other hand, it has been shown in other auction settings (second-price auctions, for example) that there can exist benefits to posting an *overstated* reservation price (e.g., Riley and Samuelson, 1981; Vincent, 1995). So, in a bookbuilding auction, are there incentives for the firm to post an overstated reservation price?

To answer this question, we consider the costs and benefits accruing to the issuer were it to commit to a reservation price, \(V_W\), strictly *higher* than its true reservation price, \(V_R\). Recall expression (5) for the expected underpricing. The elimination of demand states \(\{R + 1, R + 2, \ldots W\}\) - which would otherwise have positive allocations, \(q_{L,h}\), to investors downplaying interest - causes a further reduction in the profits expected by these investors. The benefit to the issuer is, therefore, reflected in lower expected underpricing, a saving of

\[
\frac{H}{2} \sum_{h=R+1}^{h=W} \pi_{h}' q_{L,h}
\]

where, from schedule (2), \(q_{L,h} = \frac{Q-h}{\pi-h} - R\). On the other hand, by overstating its reservation price, the firm might find itself forced to withdraw an IPO even though investors were willing to pay more than its true reservation price. This happens in demand states \(h \in \{R + 1, R + 2, \ldots W\}\) and, for these states, the opportunity cost of withdrawing is the forgone surplus, \((P_h - V_R)\), namely \(\alpha (h - R)\) per share (since \(P_h = V_h\), for \(h = 0,1,\ldots, Q\)). Therefore, the ex ante
expected cost of overstating is
\[
\alpha Q \sum_{h=R+1}^{h=W} (h - R) \pi_h
\]

The following proposition states that this cost exceeds the expected benefit of reduced underpricing.

**Proposition 1** If the issuer overstates its reservation price by committing to withdraw in demand states above its true reservation demand, \( R \), namely in states \( h \in \{ R + 1, ..., W \} \) where \( W > R \), the expected forgone surplus is greater than the expected benefit of reduced underpricing,

\[
\alpha Q \sum_{h=R+1}^{h=W} (h - R) \pi_h > \alpha \frac{H}{2} \sum_{h=R+1}^{h=W} \pi_h q_{L,h} \tag{6}
\]

**Proof:** see Appendix.

This result means that the ability to post a reservation price would not be ‘abused’ by firms claiming reservation prices higher than their true reservation values. The result is quite intuitive. Consider the case when the issuer posts a reservation price that exceeds its true reservation price by the value, \( \alpha \), of one \( U \) signal. Formally, consider \( W = R + 1 \). In this case the issuer will withdraw the offering not only when \( R \) investors or fewer reveal a \( U \) signal (i.e., when \( h \leq R \)), but also when as many as \( R + 1 \) do. Withdrawing in this stronger demand state costs the issuer \( P_{R+1} - V_R \) per share in forgone surplus, or \( V_{R+1} - V_R = \alpha \) per share (since \( P_h = V_h \), for \( h < Q \)) for a total of \( \alpha Q \) ex post or \( \alpha Q \pi_{R+1} \) ex ante. The corresponding benefit arises because withdrawing in the \( R + 1 \) state eliminates yet one more state in which investors falsely claiming ‘\( L \)’ would make a profit, thereby reducing the underpricing required by these investors ex ante to forgo the profit opportunity created by downplaying interest. However, under the optimal allocation rule (2), any investor who reveals ‘\( L \)’ receives only a rationed allocation, \( q_{L,R+1} = \frac{(Q-R-1)}{(H-R-1)} < \frac{Q}{H} \) in the \( R + 1 \) state. This implies that an investor who downplays interest deliberately to push the offer price down by \( \alpha \), profits only by the fraction \( q_{L,R+1} \) of \( \alpha \) in this state. Since this investor assigns the conditional probability \( \pi'_{R+1} \) to the \( R + 1 \) state happening, all the firm can save by overstating its reservation price is \( \alpha \pi'_{R+1} q_{L,R+1} \) for every investor who happens to observe a \( U \) signal. Since, ex ante, only \( \frac{H}{2} \) investors are expected to observe ‘\( U \)’, and given that \( H q_{L,R+1} < Q \) and \( \frac{1}{2} \pi'_{R+1} < \pi_{R+1} \)
(since $R + 1 \leq Q - 1 < H - 1$), the total expected underpricing saved by the issuer if it commits to withdrawing in the $R + 1$ state is strictly less than the value it expects to lose from inefficiently withdrawing in that state. The cost of inefficient withdrawal in any state, $h$, above $R + 1$ will be the multiple $(h - R)$ of the cost associated with the $R + 1$ state. Hence, despite the prospect of reduced expected underpricing ex ante, no issuer will have an incentive to commit to withdrawing at would-be offer prices in excess of its true reservation price.

Given the result of Proposition 1, we need not concern ourselves with the possibility that an issuer who is better off with secrecy in comparison to ‘truthful’ disclosure would nevertheless be better off with disclosure if an overstated reservation price could be posted. Expression (5), therefore, represents the expected underpricing with the policy of disclosure, to which we compare the result in the next subsection.

We now turn our attention to the case where investors do not know the issuer’s reservation price with certainty.

B Keeping the reservation price secret

In this subsection, we examine the outcome of the IPO in a setting where the issuer does not disclose $V_R$, but investors form unbiased expectations of it. Our research question is motivated by the fact that U.S. issuers do not state their reservation prices explicitly. Yet Busaba et al. (2001) show empirically that some observable characteristics of issuing firms may be used by the market to assess the ex ante probability that the firm ends up withdrawing its IPO. Effectively, we can think of the market as forming expectations represented by a probability distribution on the firm’s reservation price. Even though we know little about how these expectations are ultimately formed, there is no reason to believe that investors should systematically overestimate or underestimate the issuer’s reservation price. Hence, we make the natural assumption that investor expectations are unbiased on average. We
represent investor expectations by a symmetric 3 point distribution as follows

<table>
<thead>
<tr>
<th>Reservation Price</th>
<th>Reservation Demand</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{R+r}$</td>
<td>$R + r$</td>
<td>$p$</td>
</tr>
<tr>
<td>$V_R$</td>
<td>$R$</td>
<td>$1 - 2p$</td>
</tr>
<tr>
<td>$V_{R-r}$</td>
<td>$R - r$</td>
<td>$p$</td>
</tr>
</tbody>
</table>

where the ‘reservation demand’ represents the state, $h$, where $V_h = V_R$. The uncertainty is characterized by the two parameters, $p \in [0, 1]$ and $r \in \{1, 2, \ldots\}$, determining respectively the weight on the tails of the distribution and the range of these tails. We focus our attention on $r$, since only changes in this parameter can affect whether secrecy is ‘better’ or ‘worse’ than disclosure. Changes in $p$ affect only the absolute degree to which one policy is better than the other. Subject to the level of $r$, investors calculate their truthtelling incentives based on the perceived probability of completion in each demand state, $h$. We denote by $\omega_h$, the probability that demand state $h$ is insufficient for the issue to proceed.

Thus

$$\omega_h = \begin{cases} 
1 & \text{for } h \leq R - r \\
1 - p & \text{for } R - r < h \leq R \\
p & \text{for } R < h \leq R + r \\
0 & \text{for } h > R + r 
\end{cases}$$

Since investors downplaying interest benefit only if the offering is completed, the truthtelling constraint (1) is adjusted accordingly. At the optimum (the optimal price/allocation schedule (2) still holds), the constraint (3) becomes

$$\sum_{h=Q-1}^{h=H-1} \pi_h u_{h+1} q_{U,h+1} = \alpha \sum_{h=0}^{h=Q-1} \pi_h (1 - \omega_h) q_{L,h},$$

and the expected underpricing cost to the firm is
\[ \frac{\alpha H}{2} \left[ p \sum_{h=R-r+1}^{h=R} \pi'_h q_{L,h} + (1 - p) \sum_{h=R+1}^{h=R+r} \pi'_h q_{L,h} + \sum_{h=R+1}^{h=Q-1} \pi'_h q_{L,h} \right] \]

providing \( R + 1 \pm r \) stays in the range \([0, Q - 1]\). More generally, allowing for \( r \) to become large enough to take us out of this range and noting that \( q_{L,h} = 0 \), for \( h \geq Q \), this can be rewritten as

\[ \frac{\alpha H}{2} \left[ p \sum_{h=\max(R-r+1,0)}^{h=R} \pi'_h q_{L,h} + (1 - p) \sum_{h=R+1}^{h=\min(R+r,Q-1)} \pi'_h q_{L,h} + \sum_{h=\min(R+r+1,Q)}^{h=Q} \pi'_h q_{L,h} \right] \tag{7} \]

Note that if \( p = 0 \), then there is no uncertainty in the reservation price and expression (7) reduces to expression (5), corresponding to a disclosed reservation price.

C Secret versus disclosed reservation prices

We can now compare the expected underpricing with full disclosure (expression (5)) and with secrecy (expression (7)). Compared to certainty on \( R \), uncertainty introduces for an investor downplaying interest the probability, \( p \), that he will enjoy profits in some lower states, \( h \in [\max(R - r + 1, 0), R] \), but in return removes the certainty that he will enjoy profits in some higher states, \( h \in [R + 1, \min(R + r, Q - 1)] \).

This trade-off is illustrated graphically in Figure 4. For example, if the market knows with certainty that the firm’s reservation demand is at \( R_1 \), the firm must offer expected underpricing equal to \( \alpha \frac{H}{2} \) multiplied by the area below the probability-weighted allocation function between the states \( R_1 + 1 \) and \( Q - 1 \), inclusive. In comparison, if \( V_R \) is not disclosed and the market estimates reservation demand might be at the point \( R_1 - r \) with some probability, \( p \), then an investor misrepresenting \( U \) as ‘\( L \)’ will expect a profit in some lower demand states, represented as the area below the probability-weighted allocation function between the states \( R_1 - r + 1 \) and \( R_1 \), inclusive. However, the investor perceives with the same probability that the reservation demand might be at the point \( R_1 + r \), in which case he will not profit in some demand states higher than \( R_1 \). This expected ‘lost’ profit is represented by the area below the allocation function between the states \( R_1 + 1 \) and \( R_1 + r \), inclusive.
Since the latter area is greater than the former, in this example, investors are worse off under this uncertainty because they expect lower underpricing as a reward for truth-telling. For precisely this reason, an issuer with reservation demand $R_1$ is better off when it is not disclosed. A similar argument explains why an issuer with ‘high’ reservation demand (such as $R_4$) is better off when its reservation price is fully disclosed, and these results are formalized in the following proposition.

**Proposition 2** Let $\Delta(r)$ represent the advantage to the issuer from maintaining secrecy about $V_R$, as a function of uncertainty, $r \in \{1, 2, \ldots\}$. Formally, $\Delta(r) = (5) - (7)$, or

$$\Delta(r) = \alpha \frac{H}{2} p \left[ \sum_{h=R+1}^{h=\min(R+r,Q-1)} \pi'_h q_{L,h} - \sum_{h=\max(R-r+1,0)}^{h=R} \pi'_h q_{L,h} \right]$$

which is positive (respectively negative) if underpricing is lower (respectively higher) under secrecy than under disclosure. Define $\hat{h} = H - \frac{1}{2} - \sqrt{(H+1)(H-Q) + \frac{1}{4}}$, then

i) for $R \leq \frac{Q}{2} - 1$: $\Delta > 0$ and $\Delta$ is monotone increasing in $r$.

ii) for $R \in \left(\frac{Q}{2} - 1, \hat{h}\right)$: $\Delta$ is initially increasing and then decreasing in $r$, attaining an internal global maximum at some $r = r^*$.

iii) there exists $\bar{h} \in \left(\frac{Q}{2} - 1, \hat{h}\right)$ such that

a) for $R \in \left(\frac{Q}{2} - 1, \bar{h}\right)$: $\Delta > 0 \ \forall r$

b) for $R \in \left(\bar{h}, \hat{h}\right)$: there exists $\bar{r}_R$ such that $\Delta < 0 \ \forall r > \bar{r}_R$.

iv) for $R \geq \hat{h}$: $\Delta < 0$ and $\Delta$ is monotone decreasing in $r$.

**Proof**: see Appendix.

The interpretation and explanation of the proposition is quite intuitive. Figure 4 shows the ‘low’ and ‘high’ ranges of reservation prices identified in parts i) and iv) of the proposition. Figure 5 takes representative reservation prices from each range and shows the advantage/disadvantage of maintaining uncertainty, $r$, versus full disclosure (represented by $r = 0$). For any given true reservation price, $V_R$, the issuer enjoys maximum IPO proceeds when uncertainty, $r$, is at the level that maximizes $\Delta$.

Part i) indicates that firms with a sufficiently low reservation price (e.g., corresponding to reservation demand $R_1$ in Figures 4 and 5) are unambiguously better off at higher levels.
of reservation price uncertainty. These firms have reservation prices that correspond to demand states over which the probability-weighted allocation function is increasing. As \( r \) increases, the additional doubt created for investors downplaying interest - that they can make profits in some higher demand states - outweights the additional hope instilled that they can make profits in some lower demand states.\(^{10}\) These firms would be strictly worse off if their reservation prices were disclosed to investors.

Part iv) indicates that firms with a sufficiently high reservation price (e.g., corresponding to reservation demand \( R_4 \) in Figures 4 and 5) are unambiguously better off at lower levels of reservation price uncertainty. These firms have reservation prices that correspond to demand states over which the probability-weighted allocation function is decreasing. As \( r \) increases, the additional hope created for investors downplaying interest - that they can make profits in some lower demand states - outweights the additional doubt created that they can make profits in some higher demand states. These firms would be strictly better off if their reservation prices were disclosed to investors, i.e., with \( r = 0 \).

Part ii) indicates that in an intermediate range of reservation prices (e.g., corresponding to reservation demands \( R_2 \) and \( R_3 \) in Figures 4 and 5), IPO proceeds are maximized at some non-zero but finite level of uncertainty (e.g., \( r^*_2 \) and \( r^*_3 \) respectively, in Figure 5). These firms have reservation prices that correspond to demand states over which the probability-weighted allocation function is increasing. As \( r \) increases at low levels of uncertainty, the additional doubt created for investors downplaying interest - that they can make profits in some higher demand states - outweights the additional hope instilled that they can make profits in some lower demand states. However, because these firms have \( R > \frac{Q}{2} - 1 \), certainly once \( r \) reaches \( Q - R - 1 \) further increases in \( r \) create no new investor doubts of profits in higher demand states, yet continue to create new hopes of profits in low demand states (until \( r \) reaches \( R \)).

\(^{10}\)The humped shape of the probability-weighted allocation function is driven partially by the conditional state probability, \( \pi_{h}^{r} \), which is increasing in \( h \), at least at low levels of \( h \). This general feature of the posterior beliefs can result from any of a large set of priors, although we find the ‘dispersed priors’ feature of the uniform prior distribution (used in Welch, 2002) intuitively appealing and analytically tractable. It is conceivable that, under prior beliefs on \( V \) that allocate extremely high probability density on the lowest values, the posterior, \( \pi_{h}^{r} \), could be non-increasing in \( h \), at least at low levels of \( h \), meaning that an investor with positive information still assigns higher probabilities to the lowest demand states than to the successively higher ones. If such extreme circumstances were to exist, \( \pi_{h}^{r}q_{L,h} \) might be decreasing in \( h \), for all \( h \), in which case all issuers, including those the lowest reservation prices, would be better off under disclosure. This is inconsistent with what we observe, however.
Part iii) further subdivides this intermediate range into two regions, highlighting the optimal disclosure policy in each. Part a) indicates that when $R$ falls in the lower part of this range (e.g., $R_2$ in Figures 4 and 5), the issuer is strictly better off with any positive level of reservation price uncertainty, rather than with full disclosure. Such firms would always be strictly better off if their reservation price remained secret. Part b) indicates that when $R$ falls in the upper part of this range (e.g., $R_3$ in Figures 4 and 5), there exist higher levels of uncertainty (e.g., those above $\bar{r}_{R_3}$ for an issuer with reservation price $R_3$ in Figure 5) compared with which the issuer is strictly better off with full disclosure. However, part ii) indicates that for cases a and b of part iii), were the issuer able to alter the uncertainty, it would maximize proceeds by ‘partially’ disclosing its reservation price i.e., by reducing, but not eliminating, investor uncertainty surrounding $R$ (e.g., by choosing uncertainty $r^*_3$ for an issuer with reservation price $R_3$ in Figure 5).

In the special case of a single-unit ($Q = 1$) auction, we showed in subsection A that the disclosure of any non-trivial ($R \geq 0$) reservation price removes the need for underpricing altogether, as it eliminates all profit opportunities from misrepresenting information. Keeping such a reservation price secret, in comparison, maintains some hope for investors that they may profit from downplaying interest. In the single-unit case, therefore, it is unambiguously in the issuer’s best interests to disclose the reservation price. Our contrasting result in the multi-unit ($Q > 1$) case is driven by the prospect that investors misrepresenting information can still receive allocations, even in the presence of a non-trivial disclosed reservation price.

The result, for issuers in an intermediate range of reservation prices, that ‘partial disclosure’ of $V_R$ might be optimal, raises the intriguing possibility that issuers might take actions ex ante to influence how much uncertainty investors have vis-à-vis their reservation price. Informal indications to the investment banker or to investors during the roadshow could be used to offer guidance as to where an issuer’s reservation price might lie. Such signals would obviously be difficult to detect or measure empirically. Leone, Rock and Willenboorg (2003) find that increased specificity in the preliminary prospectus disclosure ‘intended use of proceeds’, is associated with lower underpricing. This is consistent with a desire, perhaps by a subset of their sample firms, to provide guidance that reduces investor uncertainty concerning the reservation price. Another avenue for partial disclosure may be available in markets
such as Australia or Canada (where bookbuilding is practiced), where issuers have the option to release earnings forecasts as part of the IPO filing. Disclosing earnings forecasts might enable investors to estimate more precisely the position of the issuer’s reservation price, for example in cases where this price is tied to the issuer’s own opinion about its worth. Alternatively, guidance could be given by the positioning and width of the filing range disclosed in the prospectus.\textsuperscript{11} We leave it to future research to formalize and test these predictions.

D Why \textit{don’t} we observe issuing firms posting reservation prices?

Our results can explain why we do not observe reservation price disclosure in the U.S. IPO market.\textsuperscript{12} Proposition 2 shows that full disclosure of a reservation price is in the interests only of IPO firms with reservation prices that are \textit{high} relative to possible investor valuations. However, such firms are likely to be absent from the IPO market. These firms have a low likelihood of achieving an offer price in excess of \(V_R\) and so, given the significant direct and indirect costs of initiating an IPO, they are the firms \textit{least} likely to seek an IPO in the first place, preferring to stick with the very alternatives (credit, private equity, merger...) that make their IPO reservation price so high. This would be consistent with the majority of firms \textit{observed} filing for an IPO having reservation prices in the range where maintaining some reservation price uncertainty is optimal.

III Relation to Classical Auction Literature

In this section, we discuss the relation and contribution of our paper to the auction literature. Several papers study in a theoretical framework the policy of reserve price disclosure, but results vary with the auction format considered and the information setting assumed. For example, in a private value, first-price auction used to model timber auctions in the South

\textsuperscript{11}Since 2001, the SEC generally finds acceptable a filing price range of up to the greater of $2 or 20\% of the lower limit of the price range (Barkaskey, 2005).

\textsuperscript{12}Venture Capital backed firms often are subject to an anti-dilution clause which protects the VC against potential dilution arising from the subsequent issue of equity at any price \textit{lower} than the last round of funding. While this could be considered a credible commitment, it is a commitment to a reservation price that is typically much lower than the IPO’s expected offer price.
of France, Elyakime et al. (1994) find that disclosing a reserve price increases revenues to the seller. However, this setting does not resemble the bookbuilding method of selling IPOs.

In a setting closer to ours, Horstmann and LaCasse (1997) study a common value auction in which secret reserve prices exist because the seller has information about the asset’s value that he cannot credibly convey to the buyers. For the seller of a high value item, signaling this information by withdrawing when bids are low and then waiting before re-auctioning is more effective than signaling by posting a reserve price, under the assumption that the information is likely to become known in the period before re-sale. Such behavior may be reasonable in a context where withdrawal is a strategic precursor to re-offering in order to achieve significantly higher revenues second time around (as is frequently the case with oil and gas tracts, according to Porter (1995)). However, this cannot be the motivation for most IPO withdrawals, since only 9% of withdrawn IPOs subsequently return to market (Dunbar and Foerster, 2004). Furthermore, our model is typical of bookbuilding models in having whatever relevant information the issuing firm possesses revealed to investors as a result of due diligence by the banker, strict disclosure requirements by the SEC, and direct communications with investors during the roadshow. Therefore, the need for signaling is not applicable to our setting.

Perhaps most relevant to our paper is Vincent (1995), who studies a common value auction, where the seller’s reserve price contains no value-relevant information but where the indivisible good is sold by the second-price rule. The seller decides whether or not to post a reserve price ex ante, knowing only the distribution from which that reserve price will be drawn. Vincent finds that the decision to post or not depends on the particular reserve-price distribution assumed. In the special distributions that lead to secrecy being optimal, the intuition is as follows. Posting a reserve price discourages bidders with lower valuations from participating, once they understand they have zero probability of winning the auction. This can lead to lower revenues to the seller since the absence of bidders weakens the linkage between the asset’s value and the price paid by the winner. Furthermore, if the reserve price turns out to be higher than the second highest bid, the winner must pay the reserve price, even when this price exceeds the winner’s updated valuation of the asset given the remaining bids. The potential for overpayment exacerbates the winner’s curse, causing further efficient
exchanges to be lost as some bidders exit the auction while others shade their bids further in equilibrium.

In comparison, the bookbuilding mechanism is not a second-price auction; the banker uses the book to estimate the aftermarket price (common value) and sets the offer price accordingly. Because the offer price never deliberately exceeds the ‘discovered’ common value, there is no winner’s curse. Investors with low prior valuations are not discouraged when a higher reservation price is posted because they can still receive an allocation of shares in a completed offering at a price that fairly reflects aggregate information.

Another addition to the literature our paper makes is the result that in a bookbuilding auction environment, if a seller posts a reserve price it will post its true reserve price. This result, which contrasts with results in the classic auction literature (e.g., Riley and Samuelson, 1981; Elyakime et al., 1994; Vincent, 1995) that sellers have an incentive to overstate their reserve price, is also driven by the distinguishing features of the optimal bookbuilding mechanism we have outlined.

We are aware of no research comparing secret versus announced reservation prices in auctions that resemble the process through which IPOs are priced and sold in the U.S. and in many markets abroad. Neither are we aware of research considering the possibility that a seller, in any auction setting, might wish to ‘partially disclose’ its reservation price by reducing uncertainty but without full disclosure. Along with our ‘no-overstatement’ result, these are our main contributions to the auction literature.

### IV Summary and Conclusion

Why don’t firms attempting to go public disclose their minimum acceptable offer price at the commencement of the bookbuilding process? In many auction designs, including some for IPOs in other countries, a reservation price is formally posted, and the auction literature has shown that posting a reservation price can be optimal. Moreover, a significant proportion of IPOs filed with the SEC are subsequently withdrawn due to weak investor interest, indicating that firms tapping the primary equity market have a reservation price in mind that is non-negligible. Recent papers show that the presence of a significant reservation price and the
ability to withdraw in the face of low offer prices increase expected proceeds to the issuer by reducing the underpricing necessary to conduct a successful bookbuilding effort.

Using a mechanism design approach, we analyze the effect of the issuer’s decision to disclose or conceal its reservation price on investors’ incentive to reveal their interest during bookbuilding. We assume that when the issuer does not disclose a reserve price, investors form unbiased expectations on it, regardless of whether that price is low or high. Therefore, our results are not driven by an adverse selection problem where issuers with high reservation prices are pooled with those having low reservation prices and, therefore, might prefer disclosing their ‘type’.

We find that firms with reservation prices that are low relative to possible investor valuations would enjoy higher proceeds were their reservation prices kept secret. On the other hand, firms with high relative reservation prices are better off with full disclosure. Interestingly, we find that if issuers were to disclose a reserve price, they would have no incentive to overstate their true reservation price. This contrasts with results from the classic auction literature. Our analysis also reveals that issuers with reservation prices in an intermediate range maximize proceeds under ‘partial disclosure’ – the reduction in, but not elimination of, investor uncertainty surrounding a secret reserve price. The strategy of partial disclosure, which to our knowledge has not previously been admitted in the auction literature, leads to novel empirical implications regarding actions that an issuer might take ex ante to affect the extent of investors’ uncertainty surrounding the issuer’s reservation price.

The firms we identify as potentially benefiting under a policy of full disclosure, those with high reservation prices, are precisely those firms least likely to file for an IPO in the first place, given the significant direct and indirect costs of initiating an IPO and the low likelihood for these firms of completing the offer. Our results are therefore consistent with the observation that firms filing for an IPO in the U.S. do not typically disclose a reservation price and can, as a result, explain why institutions have arisen in which maintaining reservation price uncertainty is the norm.

Our results have implications for issuing firms and for regulators of primary equity markets where bookbuilding or economically equivalent auction mechanisms are used. To the extent that jurisdictions outside the United States oblige issuers to post a minimum accept-
able offer price, and depending on the auction mechanism employed and the relative level of issuer reservation prices, such regulations may be suboptimal for some or all of the firms offering securities to the public.
References


Figure 1: The allocation, $q_{L,h}$, to an investor revealing bad information, as a function of the demand state, $h$. 

$q_{L,h}$

'demand state, $h$

Q

H

'H' demand

'weak' demand

0

1

2

strong' demand

b^−1 Q

H
Figure 2: The probability-weighted allocation, $\pi'_{h}q_{L,h}$, to an investor misrepresenting good information as bad, as a function of the possible demand states, $h$. When multiplied by $\alpha^{H/H_{2}}$, the area under the humped function yields the expected underpricing under the optimal bookbuilding mechanism when there is no option to withdraw.
Figure 3: The probability-weighted allocation, $\pi'_h q_{L,h}$, to an investor misrepresenting good information as bad, as a function of the possible demand states, $h$, truncated below the issuer’s reservation demand, $R$. When multiplied by $\alpha H^2$, the area under the humped function to the right of the truncation point yields the expected underpricing, expression (5), under the optimal bookbuilding mechanism when the issuer withdraws in states $h \leq R$. 
Figure 4: The probability-weighted allocation, $\pi'_h q_{L,h}$, to an investor misrepresenting good information as bad, as a function of the possible demand states, $h$. Reservation demands $R_1 \in [0, \frac{Q}{2} - 1]$, $R_2 \in (\frac{Q}{2} - 1, \hat{h})$, $R_3 \in (\hat{h}, \bar{h})$, $R_4 \in (\hat{h}, Q)$ illustrate respectively Parts i) - iv) of Proposition 2. The solid line at $h = R_1$ shows the truncation in $\pi'_h q_{L,h}$, when $R_1$ is disclosed. The shaded area between $R_1$ and $R_1 - r$ shows the additional allocation expected with probability $p$ when $R_1$ is not disclosed. The shaded area between $R_1$ and $R_1 + r$ shows the allocation ‘lost’ with probability $p$ when $R_1$ is not disclosed.
Figure 5: Issuer’s advantage (in terms of IPO proceeds) to maintaining uncertainty versus disclosing its reservation price. This advantage, $\Delta(r)$, is defined as the underpricing with certainty (expression 5) less the underpricing with uncertainty (expression 7), and is shown as a function of that uncertainty, $r$, at four distinct levels of reservation demand, $R_1, R_2, R_3$ and $R_4$ to illustrate respectively Parts i) - iv) of Proposition 2. For clarity the functions are drawn as a continuous function of $r$, although $r$ actually takes discrete integer values.
A Proof of Proposition 1

For $h \geq R + 1$ we have

$$
\frac{\alpha H}{2}\pi_h q_{L,h} - \alpha(h - R)Q\pi_h = \alpha \frac{1}{H + 1} \left( (h + 1) \frac{(Q - h)}{(H - h)} - (h - R)Q \right) < \alpha \frac{1}{H + 1} \left( (h + 1) \frac{(Q - h)}{(H - h)} - Q \right) < 0
$$

since $(h + 1) \frac{Q - h}{H - h} < (h + 1) \frac{Q}{H} < Q$  

B Proof of Proposition 2

$$
\Delta(r) = \frac{\alpha H}{2}(H + 1) \left[ \sum_{h=R+1}^{h=\min(R+r,Q-1)} \pi_h q_{L,h} - \sum_{h=\max(R-r+1,0)}^{h=R} \pi_h q_{L,h} \right]
$$

can be written

$$
\Delta(r) = \frac{\alpha p}{(H + 1)} \left[ \sum_{h=R+1}^{h=R+r} A(h) - \sum_{h=R-r+1}^{h=R} A(h) \right]
$$

where

$$
A(h) = \begin{cases} 
0 & \text{if } h < 0 \\
\frac{(h+1)(Q-h)}{(H-h)} & \text{if } 0 \leq h < Q \\
0 & \text{if } h \geq Q
\end{cases}
$$

In particular we note $A(0) = \frac{Q}{H}$ and $A(Q - 1) = \frac{Q}{(H - Q) + 1}$ hence $A(Q - 1) > A(0)$

The impact of increasing reservation price uncertainty from $r - 1$ to $r$ is to introduce positive probability (from the perspective of investors) that withdrawal might occur in state $(R + r)$, whilst introducing positive doubt (removing the 100% certainty) that withdrawal will necessarily occur in state $(R - r + 1)$. The increase in $\Delta$ (increase in IPO proceeds caused by decrease in required expected underpricing) is therefore a multiple of the expression $A(R + r) - A(R - r + 1)$.

When $R - r + 1 < 0$, then $A(R - r + 1) = 0$ and this expression is non-negative and
when \( R + r \geq Q \) then \( A(R + r) = 0 \) and our expression is non-positive. When \( R - r + 1 \) and \( R + r \) are both ‘in range’, then

\[
A(R + r) - A(R - r + 1) = \frac{((R + r) + 1) (Q - (R + r))}{(H - (R + r))} - \frac{((R - r + 1) + 1) (Q - (R - r + 1))}{(H - (R - r + 1))} = 2 \left( r - \frac{1}{2} \right) \frac{(R + \frac{1}{2})^2 + Q + 2H \left( \frac{Q}{2} - (R + 1) \right) - \left( r - \frac{1}{2} \right)^2}{(H - (R + \frac{1}{2}))^2 - \left( r - \frac{1}{2} \right)^2}
\]

Note that the denominator \((H - (R + \frac{1}{2}))^2 - (r - \frac{1}{2})^2 = (H - (R - r + 1))(H - (R + r))\) is positive and \((r - \frac{1}{2})\) is positive for \( r = 1, 2, \ldots \)

i) for ‘low’ reservation demands, \( R \leq \frac{Q}{2} - 1 \), we need to show that \( A(R + r) - A(R - r + 1) > 0 \).

ii) for ‘intermediate’ reservation demands, \( R \in \left( \frac{Q}{2} - 1, \hat{h} \right) \), we need to show that \( A(R + r) - A(R - r + 1) > 0 \) for ‘small’ \( r \) and then \( A(R + r) - A(R - r + 1) < 0 \) for ‘large’ \( r \).

iv) for ‘high’ reservation demands, \( R \geq \hat{h} \), we need to show that \( A(R + r) - A(R - r + 1) < 0 \)

For i) this is trivial once \( r > R + 1 \) for then \( A(R - r + 1) = 0 \). And when \( r \leq R + 1 \) then the expression is certainly positive because \((R + \frac{1}{2}) \geq (r - \frac{1}{2})\) and \(\frac{Q}{2} - (R + 1) \geq 0\)

For ii) and iv) \( R > \frac{Q}{2} - 1 \) and so when \( r = Q - R \) our expression reduces to \( A(Q) - A(R - Q + R + 1) = -A \left( 2 \left( R - \left( \frac{Q}{2} - \frac{1}{2} \right) \right) \right) < 0 \) i.e. our expression is certainly negative for the ‘highest’ \( r \).

Furthermore, the term \((R + \frac{1}{2})^2 + Q + 2H \left( \frac{Q}{2} - (R + 1) \right) - \left( r - \frac{1}{2} \right)^2\) is monotone decreasing in \( r \), having at most one zero on the interval \( r \in [1, Q - R] \)

At \( r = 1 \) the term takes the value

\[
\left( R + \frac{1}{2} \right)^2 + Q + 2H \left( \frac{Q}{2} - (R + 1) \right) - \left( 1 - \frac{1}{2} \right)^2
\]
which can be written

$$(\hat{h} - R) \left( H - \left( R + \frac{1}{2} \right) + \sqrt{(H + 1)(H - Q) + \frac{1}{4}} \right)$$

where \( \hat{h} = H - \frac{1}{2} - \sqrt{(H + 1)(H - Q) + \frac{1}{4}} \)

Thus, when \( R < \hat{h} \) our expression is positive at \( r = 1 \), monotone decreasing and becoming negative for high \( r \).

And when \( R > \hat{h} \) our expression is negative at \( r = 1 \), remaining so for all higher \( r \).

Part iii) follows from continuity: when \( R = \frac{Q}{2} - 1 \), \( \Delta > 0 \) from Part i) and when \( R \geq \hat{h} \), \( \Delta < 0 \) from Part iv). Using Part ii) we know that when \( R > \frac{Q}{2} - 1 \), \( \Delta \) starts to decrease for large \( r \), but we argue it will remain positive when \( R \) is at the lower end of the intermediate range. However as \( R \) approaches \( \hat{h} \), the upper end of the intermediate range, we argue that \( \Delta \) must become negative for large \( r \).

We note here for reference the following facts:

1. \( \hat{h} \in \left( \frac{Q}{2} - 1, Q - 1 \right) \), \( \hat{h} \to Q - 1 \) as \( H \to Q \) and \( \hat{h} \to \frac{Q}{2} - 1 \) as \( H \to \infty \).

2. As a continuous function, \( \pi_h^q \) reaches its internal maximum at \( h^* = H - \frac{1}{2} - \sqrt{(H + 1)(H - Q)} \) where \( h^* \in \left( \frac{Q}{2} - 1, Q \right) \), \( h^* \to Q \) as \( H \to Q \), and \( h^* \to \frac{Q}{2} - \frac{1}{2} \) as \( H \to \infty \).

3. \( \hat{h} \in (h^* - 1, h^*) \)