The Persistence of IPO Book Building

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Abstract

Many academics and public figures have suggested that book building, the dominant process for holding IPOs, be replaced by a more transparent process. In this paper, I model the IPO process as a game of incomplete information, in which firms of heterogeneous quality are given a choice between book building or holding an auction. In the event of an auction, investors are given a choice between gathering costly information or bidding uninformed. I show that book building has the potential to offer higher expected revenues to high quality firms by ensuring that all investors have access to information. By doing so, the underwriter is able to collect the information rents which would have been gathered by the informed bidders, which it then splits with the firm.
The most common method of holding an Initial Public Offering (IPO) in the United States and much of the developed world is book building, in which a firm going public, or issuer, contracts with an investment bank, or underwriter, to manage the pricing and allocation of newly minted stock (Sherman, 2010). Yet book building’s reputation has been marred by scandals, with accusations of collusion between underwriters and investors against firms, or underwriters and investors against other investors. These scandals have led some academics, politicians, and journalists to question whether or not book building ought to be replaced by auctions. In the words of Lawrence Ausubel, an auction theorist and one of the leading proponents in favor of auctions over book building, “[f]ew practices seem more difficult to justify to the outsider than the current procedure for the issuance of equity securities” (Ausubel, 2002).

In this paper, I offer an explanation as to the endurance of book building in the face of potential competition from auctions. I do so by modelling the IPO process as a multi-stage strategic interaction among an issuer, an underwriter, and investors. The firm, which may be of high or low value, seeks to raise revenue by selling itself to uninformed investors. It may do so by selling itself directly via auction, or by employing an underwriter whose repeated business dealings with the investors allows for honest communication with them. If the firm chooses to auction, then the investors have the opportunity to purchase information about the firm’s value before placing their bid. Otherwise, the underwriter purchases the entire issue of new stock and sells it to the investors.

I show that the presence of this costly information results in relatively low expected auction revenues for high value firms. This is because there are always some investors who will not be willing to make the information investment, as they are unlikely to win shares and therefore unlikely to recoup their information costs. As a result, the underwriter is able to induce high value firms to book build by acting as an informed
middleman between the investors and the firm, splitting the information rents which would have been otherwise enjoyed by the informed investors.

One implication of my model is that book building is able to invade markets which rely on other IPO methods, which explains why auction IPOs are so rare in countries where they are not legally mandated. Another implication of my model is that auction markets may suffer from adverse selection, as high value firms’ preference for book building will leave only low value firms to auction. Since the dominance of book building results in a separating equilibrium, investors are able to infer a firm’s quality by observing whether or not they chose to book build. This suggests that some of the empirical literature which has found that auctions enjoy lower after-market volatility (Lowry, Officer, and Schwert, 2010) may suffer from selection problems.

The paper is organized as follows. In section 1, I provide background information on the various methods for holding IPOs as well as a review of the existing literature on the subject. In section 2, I formalize the setting and describe the base model in detail. In section 3, I present the results of the base model. In section 4, I discuss the implications of the base model, as well as some extensions, including the potential for adverse selection in the auction market. In section 5, I conclude.

1 Background and Literature Review

1.1 The Fundamental Problem of IPOs

There are several reasons why a company may choose to hold an IPO, but chief among them is to raise capital. In order for a firm to sell portions of itself, it needs some notion of its market value without any shares having been sold on the market – a nontrivial problem. If a company misjudges its value by setting the price too high, it will fail to sell all of its shares. If it misjudges by setting its price too low,
it will have left money on the table. Therefore, it is in a company’s best interest to undergo some process of price discovery before selling itself to the public. This price discovery is the essence of an IPO. Its goals are twofold – to find an accurate price while simultaneously maximizing firm revenue.

Unfortunately, book building does not have a good record with respect to either goal. With regard to revenue maximization, between 1965 and 2005 book built firms were underpriced by an average of 22%, implying that over a fifth of possible revenue went unexploited. This might be forgiven if the process of price discovery were efficient, but this does not seem to be the case, either; overall, the standard deviation of first month IPO returns was 55% over the period, with 2/3 of firms being underpriced and 1/3 of firms being overpriced; only about 5% of IPOs initial returns were between 20% and 25% (Lowry, Officer and Schwert, 2010). Further, book building requires restricting participation to a relatively small set of privileged investors – specifically, the large institutional investors who most frequently deal with the underwriting investment bank. This practice has been criticized for increasing the potential for collusion between parties, for unfairly excluding retail investors, and because restricting demand seems antithetical to the goal of maximizing revenue (Wilhelm, 2004).

As a result, a number of economists and regulators have questioned the value of book building in our economy. They have suggested, instead, that auctions would be a more reasonable method for selling new issues. As the ultimate goal of an IPO is to sell multiple units of an identical good to many buyers with potentially heterogeneous demand, auctions do seem to be a natural choice, as their efficiency and revenue properties are well studied. Perhaps more importantly, the pricing and allocation rules in an auction are transparent and predictable. With the advent of the internet, there is no longer a need to exclude small retail investors from the process.1

1In addition to Lawrence Ausubel (mentioned above), book building skeptics include William
In spite of the general pessimism surrounding book building, it has passed the most crucial test: it is still the most popular mechanism for selling new issues in nearly every country it has been tried. While some companies have attempted to use auctions to sell their issues, in general auctions have not gained much traction. Meanwhile, countries which have legally mandated other methods (including auctions) have seen book building take over once laws were liberalized (Sherman, 2006). Overall, book building remains the dominant method for selling new issues in North America and in many parts of the world.

1.2 The Institutional Details of Book Building

Book building represents a middleman relationship where the underwriter stands between the issuer and large institutional investors. Rather than selling the new issue directly to the general public via an auction or direct sale, the issuer sells the entire issue to the underwriter at a fixed price-per-share. The underwriter then allocates shares to the various large investment firms with whom it has frequent business. The allocation process is neither standardized nor transparent, and smaller retail investors complain that they are shut out of the process (Sherman, 2005).

A typical book built IPO proceeds in several steps. The process begins with the issuer contracting with an investment bank to act as their underwriter. In the most typical form of underwriting contract, the issuer and underwriter set a price floor at which the new stock must sell; if there is not enough demand to justify this price, the underwriter is obligated to purchase the unsold shares. Once a contract has been drawn, the underwriter may choose to form an underwriting syndicate – that is, the

Wilhelm of the University of Virginia, and Representative Darrel Issa (R-CA) who has suggested that underwriters “dictate pricing while only indirectly considering market supply-and-demand.” (http://www.thefiscaltimes.com/Columns/2012/06/22/Darrell-Issas-Misguided-Push-to-Fix-the-IPO-Process Date Accessed: April 19th, 2016). Ann E. Sherman of Notre Dame has meanwhile suggested that laws requiring underwriters to auction the stock during the allocation phase would be beneficial. The results of this paper suggest that she may be correct.
underwriter may choose to contact other investment banks with whom to share the issue. By including more underwriters, the lead underwriter can potentially obtain a higher price for the issue, as these additional underwriters will include their own clients in the process and therefore increase aggregate demand.

The underwriter then organizes a road show between the issuer and the large investors, during which the company makes its pitch to its new potential owners. During the road show, investors will communicate indications of their demand for the stock to the underwriter. Once the underwriter has collected all of the demand indications, he chooses a final offer price and purchases the entire issue.

From the perspective of the issuer, the IPO process is now complete. However, the underwriter must now allocate the newly purchased issue to its large institutional investors. The process by which this occurs is opaque and secretive, allowing for different investors to pay different prices per share. Given how opaque this process is, it is perhaps not surprising that there are many examples of abuse.

There are three salient features to this process which are captured by my model. First, by organizing the road show, the underwriter helps facilitate research into the company’s value. Second, the underwriter is selling the shares only to those investors with whom they have an ongoing business relationship, and therefore values its reputation for honest dealing. Third, the underwriter is only selling to large investors, and large investors presumably have higher total demand for the stock.

Fig. 1: Timeline of a Book Built IPO
than retail investors. Each helps my model explain the prevalence of book building.

1.3 IPO Auctions

IPO auctions have historically existed in many countries. Sherman (2005) reports that auctions have been tried and ultimately abandoned in 11 countries. In many cases they were legally mandated, and then abandoned once securities laws were liberalized. Jagannathan, Jinryi, and Sherman (2010) further report that, out of the 46 countries which they surveyed, book building is becoming (or has become) the dominant IPO institution in 34 of them.\(^2\) In the United States, the egregious abuses by underwriters in the late 1990’s inspired the firm W.R. Hambrecht to offer IPO auction services; in the intervening period, they have managed over 30 IPOs using their auction method. Yet, in spite of the recent interest, IPO auctions have remained rare in the United States. The failure of auctions to survive competition from book building is an extremely important empirical feature of the IPO market, and one which suggests that there are strong market forces pushing issuers towards book building. In this paper, I suggest that this shift away from auctions is a result of information costs.

There are, in theory, many types of auction mechanisms available to issuers. In practice, however, most IPO auctions – including those managed by W.R. Hambrecht – make use of a uniform price mechanism.\(^3\) In a uniform price auction, many identical objects are sold for a single price; bidders submit demand schedules to the auctioneer,

\(^2\)India, which banned book building in 2005, is included in this count. Note that book building has not necessary competed away \textit{auctions} in all these countries, because in many countries direct sales were preferred to auctions before the advent of book building.

\(^3\)Unfortunately, the terminology used to describe auction formats is a bit muddled. The auction format typically used for IPOs is called a uniform price auction in the auction literature and a “Dutch” auction in the IPO literature. Auction theorists, meanwhile, reserve the term Dutch auction for a descending price auction for a single good. Throughout this paper, I employ the terminology which is standard in the auction literature.
who then chooses a price which sets quantity supplied equal to quantity demanded.\footnote{Since there are a discrete number of items, there is not a unique price – in a uniform price auction for \( Z \) units, any price which falls between the \( Z^{th} \) bid and \( Z + 1^{th} \) bid will set supply equal to demand.} Uniform price auctions are perhaps most famously used for auctioning T-bills, though they are used in other contexts as well.

However, one significant difference between auctioning T-bills and holding an IPO auction is the availability of information. T-bills are auctioned frequently, but investors’ expectations about the future value of T-bills typically change slowly. An investor can therefore form reasonable expectations about the value of a T-bill with minimal cost investment. This is not true in IPO auctions, where different companies may have very different business models or revenue expectations. Thus, in an IPO auction, acquiring information is much more costly for bidders.

### 1.4 Literature Review

The two seminal papers which address the role of book building in IPOs are Rock (1986) and Benveniste and Spindt (1989). These two papers are concerned more with the empirical presence of underpricing in the IPO market than whether or not book building ought to be replaced by auctions. They focus on book building as a mechanism for dealing with asymmetric private information between investors, but do not allow investors to gather information endogenously. Rock sees book building as a means of coaxing investors who are exogenously asymmetrically uninformed to take part in the IPO process, when they would otherwise suffer from a winner’s curse. Underwriters cross-subsidize in his model, selling at a lower price to the uninformed than the informed when a firm is high quality in order to compensate them for the losses they experience when an issuing firm is low quality. However, most of Rock’s results stem from the assumption that there are not enough informed investors to purchase
the issue in its entirety, and therefore undersubscription is guaranteed if uninformed
investors do not participate in the IPO. Benveniste and Spindt take a similar view,
but with modified assumptions, chief of which is that an all-inclusive premarket (like
an auction) is technologically unfeasible – a more defensible assumption in 1989 than
today.

More recently, the literature on book building has grown owing to the dotcom
bubble. A recent significant theoretical contribution is Sherman (2005), which mod-
els IPO auctions in a setting where investor information and investor entry are both
endogenous. Her model is similar to the one in this paper and arrives at a similar
conclusion. However, she does not model how investor beliefs about issuing compa-
nies are themselves endogenous to an issuer’s choice to book build or auction and,
therefore, the ways in which the IPO auction market may be unable to survive in the
presence of book building.

Ausubel (2002) goes so far as to claim that book building should be replaced by
auctions altogether. Specifically, he suggests it be replaced by the eponymous Ausubel
Auction, an auction for multiple goods with multiunit demand in which bidders are
able to “clinch” a unit as the price ascends. He shows the Ausubel Auction to be
efficient when bidders have independent private values. I do not explicitly model the
Ausubel Auction in this paper, as it has not (to my knowledge) ever been used in
practice. However, my model suggests that the advantage which book building enjoys
is independent of the auction mechanism employed, as my results are driven by the
fact that auctions do not exist in a vacuum. Rather, firms choose to hold an auction
or employ an underwriter based on which of the two offers higher expected benefits,
and the effects that information costs have on auction revenues in my model stem
from the participation constraints which bind all common auction formats.
2 The Model

I model the IPO process as a sequential move game among a firm, investors, and an underwriter. The firm, which is either high or low value, wishes to raise revenue by selling new stock. The underwriter, which observes the firm’s value, has the opportunity to act as a middleman by purchasing the issue and selling it to the investors. If the firm chooses not to sell to the underwriter, then the stock is sold to the investors directly via auction. A game tree is shown below:

The quality of the stock, $V$, is determined by nature according to the following distribution:

$$V = \begin{cases} 
  v_h \text{ with probability } \theta \\
  v_l \text{ with probability } 1 - \theta 
\end{cases}$$

with $v_h > v_l$. To avoid trivialities, I assume $0 < \theta < 1$. The realization of $V$ is known to the firm and underwriter at the start of the game, but not to the investors. The firm’s goal is to maximize the total revenue it receives for selling $Z$ shares of stock.\textsuperscript{5}

\textsuperscript{5}The assumption that an IPO firm wishes to maximize revenue (or profit, if there are costs) is
It is assumed that $Z$ is exogenous to the model, and that holding an IPO is costless for the issuer.

At the start of the game, the underwriter observes the firm’s value and makes a take-it-or-leave-it offer to purchase all $Z$ shares of stock at a price of $p_b$ per share. The firm can accept this offer or reject it. If it accepts the offer, then the firm receives payoff $p_bZ$. Otherwise, the firm must sell its stock at auction. The auction subgame and its resulting payoff are explored in detail in sections 2.1 and 3.1.

The underwriter’s objective is to maximize profit, which is determined by the sale price net the purchase price of the stock.

$$\pi(p_b, p_s) = Z(p_s - p_b)$$

where $p_s$ is the sale price to the investors. A detailed discussion of the underwriter’s incentives, and therefore how $p_b$ and $p_s$ are determined, must wait until section 2.2. However, it is clear that the underwriter must choose an offer price which is at least as high as what the firm expects to receive in the auction in order to convince the firm to accept. Whether or not he wishes to make an acceptable offer will depend on whether or not he can resell the stock to the investors at a higher price.

Investors value a unit of stock according to the following value function:

$$\phi(\delta_i, V) = \begin{cases} V + \delta_i & \text{if awarded a share of stock} \\ 0 & \text{otherwise} \end{cases}$$

where $\delta_i$ is the investor’s private value, drawn from a distribution $F$ with support over $[\underline{\delta}, \bar{\delta}]$. This value function is the dollar value that investor $i$ assigns to obtaining a unit of stock; thus, if he wins a share of stock and pays price $t$, then his net

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*See Sherman (2006) for a more in depth discussion.*
utility is $\phi(\delta_i, V) - t$. The precise nature of the price $t$ will depend on whether the investor is purchasing from the underwriter or within an auction, and may include an information cost. If purchasing from the underwriter, then $t = p_s$. Otherwise, $t$ is the price the investor must pay according to the auction rules, which are described in the next section. Note that investors are assumed risk neutral with respect to the private and public values.

My choice of $\phi(\delta_i, V)$ captures that investor values are correlated, but not perfectly so. The public value may be though of as the stock’s intrinsic value, while the private value may be thought of as idiosyncrasies resulting from differing capital constraints, investor portfolios, or private information. Ultimately, $\delta$ provides some heterogeneity in bidder preferences, and the precise interpretation of $\delta$ is not critical to the basic intuition of model.

Overall, this extensive form game captures the essence of the IPO market. While the underwriter may offer to act as a middleman, it is the issuer who decides how to sell the issue. The firm will only book build if the underwriter can guarantee higher revenues than what the firm expects to receive at auction. Whether or not the underwriter can make such a guarantee will depend on bid behavior in the auction subgame, and what effect this behavior has on auction revenues.

2.1 The Auction Subgame

An auction is an opportunity for an investor to gain utility by acquiring a unit of stock, but only if he can bid appropriately in the face of other competing investors’ bid strategies. When choosing a bid strategy, bidders face a trade off between win probabilities and expected price paid. An investor must therefore choose a bid strategy – a function which maps the investor’s private value and information to the bid he submits – in order to maximize the expected value of his payoff $\phi(\delta_i, V) - t$ in the
face of the other investors’ strategies. As I also assume that investors may purchase information about the value of the company, an investor’s strategy must also include under what circumstances he purchases information.

I model an IPO auction as a uniform price auction. In a typical uniform price auction, bidders submit marginal value vectors over the number of units being sold. In my model, as a simplification, I assume that investors have single-unit demand, and therefore submit only one bid. The uniform price that bidders pay is the $Z+1^{th}$ highest bid, which sets supply equal to (reported) demand; this corresponds to the transfer $t$ paid by an investor should he win a share. An important consequence of the single-unit demand assumption is that, much like in a second price auction, truthful reporting of one’s value is always a best response given one is informed about the realization of $V$.\(^6\) As bidders only demand one unit, it is necessary to assume that there are more bidders than objects – i.e. $N > Z$. Note that the uniform price mechanism is individually rational – bidders must receive at least zero utility in expectation, as they can always bid zero.

Let $c$ be the cost of information acquisition. By expending $c$, a bidder knows $V$’s realization perfectly. Investors must choose to purchase information at the start of the auction, before submitting their bids. At this point, the only information available to them is their own private value $\delta$, the distribution of private values $F$, the distribution of $V$, the number of units of stock being sold $Z$, the number of bidders $N$, the cost of information $c$, and the fact that the company has chosen to auction. They do not have information about their rivals’ private values or information acquisition choices.

Thus, a strategy in this game is a set

\(^6\)This is not true of uniform price auctions in general. In a general uniform price auction, bidders have an incentive to shade their bids for the units they value less, as one of these bids may set the price they pay for the units they value more. Nonetheless, the assumption of single-unit demand is likely without loss of generality. The implications of multiunit demand are explored qualitatively in Section 4.3.
where $b_i(\delta_i, I_i(\delta_i), V)$ is investor $i$’s bid function in the auction as a function of their private value $\delta_i$, the public value $V$, and $I_i(\delta_i)$, an indicator function which is 1 if and only if $i$ purchases information and 0 otherwise. Note that, because all bidders are in the same information set ex-ante with respect to every parameter except $\delta_i$, any heterogeneity in strategy – including the choice of when to purchase information – must be driven purely by their knowledge of their own private value.

Define $u(b_i(\delta_i, I_i(\delta_i), V), V, c)$ to be the expected utility that bidder $i$ receives if he employs strategy $s_i$. The investor’s goal is to choose the strategy which maximizes this utility given the other bidder’s strategies $s_{j \neq i}$. A set of auction strategies are in equilibrium if no bidder has an incentive to change strategies. As the vast majority of this paper deals in expectations, for the sake of brevity I will frequently substitute the word “utility” for “expected utility”.

In the results section below, I will explore some of the necessary properties of an assumed symmetric pure-strategy BNE in this auction, and what those properties tell us about bid behavior and thus expected revenues. Before doing so, however, it is necessary to provide an introduction of the book building subgame, as this will be used to provide a basis for comparison.

2.2 The Book Builder’s Offer

In this section, I outline what governs the underwriter’s choice of $p_s$ and $p_b$, and therefore his expected profits. Unfortunately, the pricing and allocation process of book building is extremely opaque, and therefore difficult to model. The literature, however, agrees on three important points. First, underwriters sell only to investors
with whom they have repeated business dealings. Second, the investors to whom the underwriter sells are large institutional investors. Third, in the event that an issue is too large for a single underwriter to handle, underwriters syndicalize and purchase the issue as a group (Wilhelm, 2004).

On the basis of the first observation, I assume that the underwriter and investors can credibly communicate with one another. In practice, this means that the underwriter can credibly communicate the value of the company to the investors, and will accurately set supply equal to demand when reselling rather than attempt to price discriminate. On the basis of the second observation, I assume that the investor is able to sell to the entire market of $N$ investors. While this is unrealistic – underwriters only sell to their large clients, meaning retail investors are excluded from the book building process – it is certainly true that the underwriter sells to a subset of investors who have relatively high marginal values, which in the language of my model means that they have high private values (assuming that they are all equally informed about the common value). This is largely the same as selling to the entire body of $N$ investors, since it is generally in the book builder’s interests to allocate the shares to those with the highest willingness to pay. Nonetheless, in section 3.3 I discuss why the results of this model should hold for smaller markets, though without specifying values for $N$ and $Z$ or distributions of $F$ and $V$ it cannot be known precisely how many investors must be included in general.

Finally, on the basis of the third observation, I assume that the underwriter faces no capital constraints. I further assume that the underwriter is obligated to purchase either all $Z$ shares of the issue or none at all, as this is a contractual requirement in most book built IPOs. These assumptions, along with the assumption that the underwriter does not price discriminate, prevent the underwriter from taking advantage of any monopoly powers when reselling.
For the underwriter, the game proceeds as follows. Just like the investors, the underwriter begins the game knowing the distribution of private values $F$, the number of investors $N$, and the number of shares on offer $Z$. He does not know the precise realizations of the investors private values before making an offer to the firm. He does, however, observe $v$, the realization of the company’s value $V$. On the basis of this information, the underwriter makes a take-it-or-leave-it offer to the firm to purchase the entire issue, which the firm either accepts or rejects. If the firm rejects the offer, then the underwriter receives a payoff of zero. If the firm accepts the offer, then – as a result of the repeated interaction between the investors and the underwriter – the underwriter is able to resell the issue by choosing a price $p_s$ which sets supply equal to demand.

Note that, from the underwriter’s ex-ante perspective, in order to resell the entire issue he must set $p_s$ so that $E[\phi(\delta_Z, v)] \leq p_s \leq E[\phi(\delta_{Z+1}, v)]$; the underwriter expects that any price between the expectations of the $Z^{th}$ and $Z+1^{th}$ highest investor values will set supply equal to demand. For the purposes of easy comparison to the auction revenues, I will assume that the underwriter chooses the price associated with the $Z+1^{th}$ highest investor value. Therefore, from the underwriter’s ex-ante perspective, $p_s = E[\phi(\delta_{Z+1}, v)]$.

Thus, the underwriter’s must choose a strategy for making offers – a function $p_b(v, \delta)$ – which maximizes his expected profit. With the above information in hand, we can explicitly define the underwriter’s expected profit function for a given company type:

$$\pi(p_b(v, \delta), p_s) = Z \left( E[\phi(\delta_{Z+1}, v)] - p_b(v, \delta) \right)$$

As we shall see in the results section, the strategy which the underwriter employs when choosing an offer price will depend on what offer price he believes that firm
will accept, and whether he can then resell the firm for positive profit. This former expectation will depend on what occurs in the auction setting, as the firm will be willing to accept any offer price which exceeds expected auction revenues.

3 Results

In this section, I show one of the main results of the paper – that the failure of some investors to purchase information in the auction subgame reduces auction revenues for high value firms to the point that the underwriter is able to operate as an informed intermediary. I begin by considering the auction subgame and then proceed to the book building subgame.

3.1 Auctions in a Vacuum

The primary result presented in this section is that auctions present a problem for high value firms: there are always some bidders who would prefer to be uninformed in equilibrium. These bidders choose to be uninformed because they recognize that, given their private values and the equilibrium bid function, they are unlikely to win a unit of stock. As they are unlikely to win, they would rather not expend information costs, as these information costs are unlikely to be compensated. Additionally, these uninformed investors will submit lower bids than the investors who know that the company is high value. This is bad for a high value firm, as there is always a probability that one of these uninformed, low-bidding investors will set the price for the entire auction. Thus expected revenues are lower than if all bidders are informed, allowing the underwriter make a profitable offer to the firm. I will proceed by assuming that there exists a symmetric pure-strategy Bayesian Nash equilibrium (BNE) in the auction subgame, and then show that the necessary bounds on the behavior of
bidders will hold in this equilibrium.

Note that, strictly speaking, an investor’s beliefs about the probability of a company being high value given that it has chosen to hold an auction are endogenous to this model; if investors have a strong prior belief that only low value companies hold auctions, for example, this will affect their expected value of the company with the subgame. However, the results of this model do not depend on any particular beliefs about what sorts of firms choose to hold auctions. Specifically, if \( \Theta_A \) is the probability that a firm is high quality given that it is holding an auction, then all I require is that \( \Theta_A \in (0, 1) \). For the purposes of this section, I assume that \( \Theta_A = \theta \) — that high value firms auction in the same proportion that they exist in nature. I explore the implications of relaxing this assumption in section 4.1.

We begin by considering how investors bid. As it is always a best response for an informed bidder to reveal their value in a uniform price auction with single unit demand, we know that informed bidders – those who purchase information in equilibrium – will submit their values \( \phi(\delta_i, V) \) as bids. With that in mind, I can write out an incomplete expression of the equilibrium bid function:

\[
\begin{align*}
    b(\delta_i, \mathbb{I}(\delta_i), V) &= \begin{cases} 
        b^U(\delta_i, V) & \text{if } i \text{ is uninformed} \\
        v_h + \delta_i & \text{if } V = v_h \text{ and } i \text{ is informed} \\
        v_l + \delta_i & \text{if } V = v_l \text{ and } i \text{ is informed}
    \end{cases}
\end{align*}
\]

The portion of the equilibrium bid function \( b^U(\delta_i, V) \) which specifies how uninformed bidders behave is central to the results of this paper, and is explored in greater detail below. As I am assuming that this equilibrium is symmetric, in an abuse of notation it will often be convenient to abbreviate \( b(\delta_i, \mathbb{I}(\delta_i), V) \) as simply \( b_i \) and \( b^U(\delta_i, V) \) as \( b^U_i \) when there can be no confusion as to what these mean. However, it is important to note that these refer to functions rather than numbers.
A condition of the equilibrium is that \( b(\delta_i, \Pi(\delta_i), V) \) must be both piecewise strictly increasing and piecewise continuous in the private value \( \delta_i \). That is, \textit{within the sets of informed and uninformed bidders}, a bidder with a higher private value will submit a higher bid in equilibrium. This is obvious when the investor is informed, as \( b(\delta_i, 1, v_h) = v_h + \delta_i \) and \( b(\delta_i, 1, v_l) = v_l + \delta_i \), and these clearly move one-to-one with \( \delta_i \). This is less obvious if the investor is uninformed. However, it is a necessary condition of any symmetric pure-strategy BNE that equivalently informed investors have monotonic bid functions in their private values.\(^7\)

With this partial characterization of the equilibrium bid function, we can write out a fuller expression of an investor’s expected utility in equilibrium:

\[
u(b_i, V, c) = max\{u^U(b_i, V), u^I(b_i, V) - c\}
\]

where \( u^U(b_i, V) \) is expected uninformed utility and \( u^I(b_i, V) - c \) is expected informed utility, each conditional on his rivals’ strategies in equilibrium. Whether or not an investor purchases information in equilibrium – and therefore whether they will bid informed or uninformed – will depend on which of these two utilities is higher in equilibrium.

One can express \( i \)'s uninformed utility in terms of \( V, \delta_i, \) and the expected equilibrium bids:

\[
u^U(b_i) = Pr(b_i > b_{Z+1}) \left( E[V | b_i > b_{Z+1}] + \delta_i - E[b_{Z+1} | b_i > b_{Z+1}] \right)
\]

\(^7\)Consider two bidders \( i \) and \( j \) who have access to the same information, where \( \delta_i > \delta_j \). Since they are equally uninformed, the only difference in their expected utility arises from the differences in their private values. Because \( i \) has a higher private value than \( j \), we know (in an abuse of notation) that \( u_i(b_j) > u_j(b_j) \), which implies that bidder \( i \) would prefer to submit a higher bid than \( b_j \) to maximize his expected winnings. See Krishna (2002) for a more complete treatment of the necessary conditions which one must place upon equilibrium bid functions.
where $b_{Z+1}$ is the $Z + 1^{th}$ highest bid (i.e. the price setting bid). Note that, from bidder $i$’s perspective, $b_i$ is known while $b_{Z+1}$ is a random variable. Specifically, $b_{Z+1} = V + \delta_{Z+1}$, where $\delta_{Z+1}$ is the order statistic relating to the $Z + 1^{th}$ highest draw from $F$. Thus, in the uninformed utility above, $Pr(b_i > b_{Z+1})$ is bidder $i$’s ex-ante probability of being awarded a share, $E[V|b_i > b_{Z+1}]$ is bidder $i$’s expected value of the company conditional on having been awarded a share, and $E[b_{Z+1}|b_i > b_{Z+1}]$ is bidder $i$’s expected value of the price setting bid conditional on having been awarded a share. This latter term is the price that he expects to pay for a share of stock in the auction.

Since both the realizations of $V$ and $\delta_{Z+1}$ factor into the realization of $b_{Z+1}$, a winning bidder cannot be sure that he has been awarded a share as a result of having one of the $Z$ highest private values. It may be the case that he outbid another bidder who had a higher private value, but who also happened to be informed, knew that the company was low value, and therefore submit a lower bid. That is, for some uninformed bidders in equilibrium, competition with informed bidders means that the probability of winning a unit of low value stock is greater than the probability of a company being low value to begin with. The probability of such a “bad win” ensures that $E[V|b_i > b_{Z+1}] \leq E[V]$; bidder $i$’s expected value of the stock conditional on winning a share in equilibrium is less than or equal to the unconditional expected value of the stock.

Informed utility can be expressed similarly to uninformed utility:

$$u^I(b_i) - c = \theta Pr(b_i > b_{Z+1}|v_h) \left(v_h + \delta_i - E[b_{Z+1}|b_i > b_{Z+1}, v_h]\right)$$

$$+ (1 - \theta) Pr(b_i > b_{Z+1}|v_l) \left(v_l + \delta_i - E[b_{Z+1}|b_i > b_{Z+1}, v_l]\right) - c$$

The interpretation of the variables is the same, though the probabilities and expected values are now conditioned on the company’s type, as the company’s type is now
known. The important point is that the investor is now able to adjust his probability of winning based on the company’s value — in particular, he is able to avoid the “bad win” described above. However, whether or not information is worth purchasing depends on one’s probability of winning in equilibrium; there is no reason to purchase information about the value of a good which one is unlikely to win in the first place.

Having established the notation and some of the necessary properties of a symmetric pure-strategy BNE, the main auction result — the bound on expected auction revenues — is built in several stages. First, I establish that there is no symmetric pure-strategy BNE in which every bidder purchases information, nor (given sufficiently low information costs) any symmetric pure-strategy BNE in which every bidder bids uninformed. I then show that the bidder with the lowest possible private value does not purchase information. These three small results are established in order to show that there exists an entire interval of investors who do not purchase information — enough to affect expected revenues.

Lemma 1: There does not exist a symmetric pure-strategy BNE in which \( I(\delta) = 1 \ \forall \delta \in [\hat{\delta}, \bar{\delta}] \).

Proof: Proof is by contradiction. Assume that information purchase is part of the equilibrium strategy \( \forall \delta \in [\hat{\delta}, \bar{\delta}] \). Observe that \( v_h + \hat{\delta} < v_h + \delta_i \), and \( v_l + \hat{\delta} < v_l + \delta_i \ \forall \delta_i \in [\hat{\delta}, \bar{\delta}] \). That is, \( b(\hat{\delta}, 1, v) < b(\delta_i, 1, v) \) for all possible private values \( \delta_i \neq \hat{\delta} \). Therefore, a bidder with private value \( \hat{\delta} \) never wins a share in equilibrium, and thus receives \( u(b, V, c) = -c \). As he could do better by not purchasing information and submitting the lowest possible bid, this cannot be an equilibrium.

Now that I have shown that not every bidder can be informed in equilibrium, I
will show that, given an appropriate cost of information, not every bidder can be uninformed in equilibrium. This should be intuitive; if the stock’s value is highly variant and information about its value is cheap, then it should be the case that some investors would purchase information in order to protect themselves against overpaying. I prove this by assuming that there is an equilibrium in which nobody purchases information, and then show that being informed results in a strictly greater payoff than being uninformed for a bidder with private value $\bar{\delta}$. Thus, if $c$ is less than the difference between the two payoffs, there will be some bidders who purchase information in equilibrium.

**Lemma 2**: For any $V$ and non-degenerate $F$, there exists a $c > 0$ such that some types of investor purchase information in a symmetric pure-strategy BNE.

**Proof**: See appendix.

Lemma’s 1 and 2, imply that, given appropriate information costs, some but not all bidders purchase information. This is not enough to bound expected auction revenues as it is necessary to show that an uninformed bidder must set the price with non-negligible probability. To this end, I use the above lemmas to characterize who purchases information and who does not. Specifically, I show that a bidder with the lowest possible private value will not purchase information, and then use this result to show that there is an entire interval of bidders who do not purchase information.

**Lemma 3**: In any symmetric pure-strategy BNE in this setting, an investor with private value $\delta_i = \bar{\delta}$ will not purchase information.

**Proof**: See appendix.
The intuition behind lemma 3 is as follows: the fact that the equilibrium bid function is piecewise monotonically increasing ensures that a bidder with the lowest possible private value will never outbid an uninformed bidder, and the fact that \( v_h + \delta < v_h + \delta_j \) for every \( j \) ensures that he will only outbid an informed bidder if the company is low-value, guaranteeing negative utility. Thus, in order to maintain non-negative expected utility, a bidder with the lowest possible private value must shade his bid as low as is necessary to ensure that he has zero probability of winning in equilibrium.

Lemma 3 allows us to establish that there is an entire interval of investors at the bottom of the distribution who do not purchase information in equilibrium. This is because the incentives of a bidder with a private value very close to \( \delta \) has nearly identical incentives to a bidder with private value \( \delta \). Therefore, given non-zero information costs, this bidder would not want to purchase information either. The presence of such an interval of uninformed bidders ensures that there is a non-zero probability of an uninformed bidder setting the price.

**Proposition 1:** There exists a private value \( \delta_c > \delta \) such that any bidder with private value \( \delta_i \leq \delta_c \) does not purchase information in equilibrium.

**Proof:** From Lemma 3, we have that \( \underline{\delta} \) does not purchase information, which implies that \( u^U(b) > u^I(b) = -c \). Since \( u(b(\delta, I(\delta), V)) \) is continuous in \( \delta \), there exists \( \varepsilon > 0 \) such that \( u^U(b_i) \geq u^I(b_i) - c \) \( \forall \delta_i \in [\underline{\delta}, \delta + \varepsilon] \). Define \( [\underline{\delta}, \delta_c] \) to be the largest such interval, and we have our result.

---

\[^8\text{It may not be immediately obvious that } u(b(\delta, I(\delta), V)) \text{ is continuous in } \delta. \text{ However, it is a necessary equilibrium condition that there be no jumps in utility. Observe that, since } u(b_i, V, c) \text{ is defined over its whole domain and there are no discontinuities in } b_i \text{ aside from jump discontinuities, the worst sort of discontinuity which might appear in } u(b_i, V, c) \text{ is a jump discontinuity. In an abuse of notation, assume that there is a jump discontinuity at } u(b(\delta_i)) \text{ in equilibrium. Since } F \text{ is continuous on } [\underline{\delta}, \delta], \text{ a jump discontinuity implies that } \exists \delta_j = \delta_i - \varepsilon \text{ such that } u(b(\delta_j)) - u(b(\delta_i)) > \varepsilon. \text{ In this case, } j \text{ would prefer to submit } b(\delta_i) \text{ as his bid, as doing so would allow him to take advantage of this jump in utility which is greater than the difference in private values. Therefore, } j \text{ is not best responding, and we do not have an equilibrium.}

---
Thus, with proposition 1, we have that there is an entire interval of possible investors at the bottom of the distribution of types who do not purchase information in equilibrium because their probability of winning is too low to recoup their information costs. We would not expect these uninformed investors to submit high bids, as they must protect against the winner’s curse – the possibility of beating an informed investor who knows the company is low value. This intuition is formalized in proposition 2.

Proposition 2: If \( \delta_i \in [\hat{\delta}, \delta_c] \), then \( i \) submits \( b^U(\delta_i, V) = E[V|b_i > b_{Z+1}] + \delta_i \), where \( E[V|b_i > b_{Z+1}] \leq E[V] \).

Proof: As all bidders with private values below \( \delta_i \) are uninformed in equilibrium, there can be no “free-riding” on the information acquisition of other bidders; if the price is set by a bidder with a lower private value, then the price conveys no information about the value of the company. Therefore, \( E[V|b_i > b_{Z+1}] + \delta_i \) properly accounts for the winner’s curse and is a best response. This gives us the first half of the proposition.

Let \( \delta_i \in [\hat{\delta}, \delta_c] \). There are two reasons investor \( i \) might win in equilibrium: either

1. \( \delta_i > \delta_{Z+1} \implies b_i > b_{Z+1} \)

2. \( \delta_i < \delta_{Z+1} \) but bidder \( Z+1 \) is informed, \( V = v_l \), and it just so happens that \( b^l(\delta_i, V) = v_l + \delta_{Z+1} < b^U(\delta_i, V) \) in equilibrium

This implies that

\[
E[V|b_i > b_{Z+1}] = Pr(\delta_i > \delta_{Z+1})E[V|\delta_i > \delta_{Z+1}] + Pr(b_i > b_{Z+1}|\delta_i < \delta_{Z+1}, V = v_l)v_l
\]
Because $V$ and $\delta_i$ are independent, $E[V|\delta_i > \delta_{Z+1}] = E[V]$ and $Pr(b_i > b_{Z+1}|\delta_i < \delta_{Z+1}, V = \upsilon_i) = \theta Pr(b_i > b_{Z+1}|\delta_i < \delta_{Z+1})$. Thus,

$$E[V|b_i > b_{Z+1}] = Pr(\delta_i > \delta_{Z+1})E[V] + \theta Pr(b_i > b_{Z+1}|\delta_i < \delta_{Z+1})\upsilon_i$$

This is strictly less than $E[V]$ when $Pr(b_i > b_{Z+1}|\delta_i < \delta_{Z+1}) \neq 0$, giving us the second half of our result.

\[\square\]

The results of propositions 1 and 2 can be succinctly restated as follows: there are a non-negligible number of bidders who will never purchase information in equilibrium (as their probability of being awarded a share is too low), and these bidders submit relatively low bids when faced with high value companies. The expected revenues in an auction are the product of price and quantity, weighted by the probability of a given price. The probability of a given price is determined by the probability that the price-setting bid falls within a particular part of the distribution of types. Thus, we can infer from propositions 1 and 2 that the non-negligible probability that an uninformed bidder sets the price will affect expected revenues. Specifically, for a high value firm, the presence of these bidders will lower expected revenues. This insight is formalized in proposition 3.

**Proposition 3**: The expected revenue for a high-value firm in this auction is bounded above by $R_h = Z(Pr(\delta_{Z+1} \leq \delta_c)E[V] + Pr(\delta_{Z+1} > \delta_c)\upsilon_h + E[\delta_{Z+1}])$.

**Proof**: As a consequence of Proposition 1, we have established that there exists an interval $[\delta_c, \delta_c]$ at the bottom of the distribution of private values in which investors do not purchase information, and bid $b^U(\delta_i, V) \leq E[V] + \delta_i$. All other investors in
the distribution will submit bids $b_i \in [v_i + \delta_i, v_h + \delta_i]$, as anything outside this interval is a dominated strategy regardless of the realization of $V$.

Consider the following alternative bid function:

$$
\beta(\delta_i; V) = \begin{cases} 
E[V] + \delta_i & \text{if } \delta_i \in [\delta_i^L, \delta_i^R] \\
v_h + \delta_i & \text{otherwise}
\end{cases}
$$

Note that $\beta(\delta) \geq b(\delta) \ \forall \delta$ in our domain. Define $f_{Z+1}$ to be the probability density function of the $Z + 1^{th}$ draw from $F$ (that is, the $(N - Z)^{th}$ order statistic of $F$). If we calculate the expected revenues of the auction under this alternative bid function $\beta(\delta_i, v_h)$, we find

$$
R_h = Z \left( \int_{\delta_i^L}^{\delta_i^R} (E[V] + \delta) f_{Z+1} d\delta + \int_{\delta_i^R}^{\delta_i^L} (v_h + \delta) f_{Z+1} d\delta \right)
$$

Integration and rearrangement yield the desired result.

\[\square\]

In words, if an informed bidder sets the price, then revenues are $Z(v_h + \delta_{Z+1})$, which is the number of shares times the price per share. If an uninformed bidder sets the price, then revenues are at most $Z(E[V] + \delta_{Z+1})$. Taking an expected value over these two possibilities gives us Proposition 3. This is this revenue bound which book building is able to defeat.

An intuitive and economically interesting way of thinking about this result is to note that investors will only purchase information if they can expect to collect information rents from doing so. As information purchase is a sunk cost by the time bids are chosen, the information rent manifests itself in the form of a probability that the price will be set by a bidder who does not know that the company is high
value. The underwriter is able to act as an informed middleman because he is able to circumvent this information problem and split these information rents with the firm. Note that if these information rents cannot be collected by investors in an auction mechanism, then they have no incentive to inform themselves. This suggests that this problem cannot be overcome by designing an auction method which is tailored to this setting, as the problem arises from the necessity that bidders receive at least zero utility in expectation.

Note that we can easily set a lower bound on auction revenues for low value companies by considering how every bidder would bid if they were informed: $b_i = v_l + \delta_i$. This implies that minimal auction revenues for a low value company are $R_l = Z(v_l + \delta_i)$. This lower bound will be important for section 4.1, where I consider the potential for adverse selection in the auction market.

### 3.2 The Book Builder Dominates

Now we return to the underwriter and examine his optimal choice given the auction setting above – the stiffest competition from auctions that he could ever expect to encounter. I show that, even when faced with this competition and even under the strict constraints placed on his actions during the resale process, the underwriter is able to make positive profits when purchasing high value companies.

*Proposition 4*: When faced with a high value company, the underwriter maximizes his profits by purchasing the issue at the expected auction price.

*Proof*: In order for a high value company to accept the underwriter’s take-it-or-leave-it offer, the underwriter must offer at least the revenue that the company would expect to earn if it auctioned. If we treat the upper bound found in Proposition 3 as the actual auction revenues, then $p_b Z \geq R_h$. The purchase price is minimized if the
underwriter binds this inequality and sets \( p_b = \frac{R_h}{Z} \), and \( Zp_b \) is thus the lowest cost at which the underwriter can purchase the issue.

In order for the underwriter to be willing to bear this cost, however, it must be the case that he expects to receive greater revenue when reselling. Recalling that the underwriter is required to resell the issue at the price \( p_s = v_h + \delta_{Z+1} \), the maximal expected profit is

\[
\pi(p_b, p_s) = \max\{Z(v_h + E[\delta_{Z+1}]) - R_h, 0\}
\]

Therefore if \( Z(v_h + E[\delta_{Z+1}]) - R_h > 0 \) then the underwriter maximizes profits by setting the minimal offer price that the issuer is willing to accept and purchasing the company; otherwise, he must set some lower price which the issuer will reject. Substituting in \( R_h \) from above,

\[
Z(v_h + E[\delta_{Z+1}]) - Pr(\delta_{Z+1} \leq \delta_c)E[V] - Pr(\delta_{Z+1} > \delta_c)v_h - E[\delta_{Z+1}]
\]

And thus,

\[
\pi(p_b, p_s) = ZPr(\delta_{Z+1} \leq \delta_c)(v_h - E[V])
\]

From proposition 1, we know that \( Pr(\delta_{Z+1} \leq \delta_c) > 0 \). Therefore the entire term is positive, and the underwriter makes positive profit by purchasing the company and selling it to the investors.

\[\Box\]

The final equation above is the expected underwriting spread for selling a high value company, and its interpretation should be intuitive. The fact that there is al-
ways some probability that the price-setting bidder in the auction subgame will be uninformed allows the underwriter to offer higher revenue by overcoming the information asymmetry. This is ultimately an information rent that an informed bidder in the auction would expect to collect on average. Recalling that the expected auction revenue used to generate the underwriting spread is actually an upper bound, in practice profits will be even greater than what is implied by proposition 4.

In proposition 3 I established an upper bound on auction revenues for high value firms, and have now shown in proposition 4 that this bound can be exceeded by the book builder. Note that I have also established a lower bound on auction revenues for low value firms which is less than or equal to what the book builder would be willing to offer. Thus, high value firms prefer to book build, while low value firms are at best indifferent.

This implies that high value companies will always prefer to book build, while low value companies are indifferent to book building when auction revenues are at their minimum (perhaps because information costs are prohibitive, or investors believe that...
all auctioned companies are low value.) Therefore, we should expect book building to be a resilient, and even invasive, institution.

3.3 Demand Restriction

The model presented in above is open to a criticism: the IPO auction market and the book building market are different sizes. I have assumed that the underwriter sells to the same $N$ investors that would show up to the auction. In fact, the auction is open to many investors – namely retail investors – who are shut out of the book building process. Since a larger number of bidders should increase auction revenues, how can we be certain that the underwriter will be able to offer higher revenues when they are selling to smaller market?

It happens that the model presented here is robust to including fewer investors, up to a point. The underwriter adds value to this market by forcing all investors to “bid” from the same information set. This value may be greater than the marginal benefit of adding an additional bidder. That is, if $K$ is the number of bidders which are shut out of book built IPOs who might have showed up for an auction, then the value added by the book builder for overcoming the information problem need only be greater than the expected difference in revenues which results from including $K$ fewer bidders. For reasonable values of the relevant parameters, we should frequently expect this to be the case, especially if $N$ is large.\footnote{To attach some relative sizes to $N$ and $K$, large institutional investors held 37.1\% of the US stock market in 1996 (Gompers and Metrick, 2001), and this figure had been consistently increasing since the 1980’s. Thus, as a very rough first approximation, we might expect $K$ to be 63\% of $N$. Of course, institutional investors are generally more likely to take part in an auctioned IPO than other investors, and as such we should expect the actual percentage to be quite a bit smaller than that.} For large $N$, the marginal benefit of an additional bidder is quite small, while the difference between $v_h$ and $E[V]$ remains substantial.

Additionally, the investors who take part in a book built IPO are large institutional
investors, and we should expect them to have higher marginal values for the stock, perhaps because they face fewer capital constraints. In terms of this model, having a higher marginal value (given that everybody is informed) translates to have a higher private value. Therefore, the investors who take part in a book built IPO should be those who would have been awarded shares regardless of whether or not other investors are shut out of the process. In fact, as the underwriter has some control over which investors enter into his trusted circle, it is reasonable to expect that the underwriter would choose those who have the deepest pockets and tend to demand the most stock. As a result, we should not expect that there would be a significant drop in revenue as a result of demand restriction.

4 Discussion and Extensions

In the model above, I show that information asymmetry about a common component of IPO firm values can result in inefficient auction outcomes because some investors prefer to bid uninformed. While some of the previous literature has suggested this might be the case (Wilhelm, 2004), nobody else has, to my knowledge, modeled this directly. Perhaps the more interesting result is that information costs reduce revenue not because signals are redundantly gathered (as one might expect), but rather because information acquisition is discouraged for some types of bidders.

Each of the assumptions above is drawn from existing literature. The notion that repeated interaction between investors and the underwriter allows for honest communication between the two parties is noted by Rock (1986), Wilhelm (2004), Sherman (2004), and several others. The assumption that underwriters face no capital constraints and can always bring a sufficient number of investors to bear is justified by their penchant for syndicalization, as noted by Wilhelm (2004) and Jagannathan and Sherman (2005). Further, the idea that the underwriter engages in some sort of
a screening process is likewise supported by several of the sources mentioned above. In particular, Lowry and Schwert (2004) find that publicly available information is almost entirely priced into an IPO stock at opening, which implies that either the underwriter engages in some sort of information investment which is passed on to the investors, or the book building process somehow encourages such information gathering from investors. My paper assumes the former, while several past papers (e.g. Rock, 1986) have assumed the latter.

My assumption that the underwriter will choose the price which sets supply equal to demand, and therefore deal “fairly” with the investors, seems to elide the significant principal-agent issues which underlie book building as a practice. However, while these restrictions in favor of fair-dealing serve more as a robustness check than a necessary assumption. A rational underwriter will only “cheat” investors – by, say, lying or price discriminating – when doing so increases his overall profits (present and future). If he is cheating investors, the increase in profits must come in the form of increased revenues. Increased revenues means that the underwriter has even greater room to maneuver when choosing the purchase price – he can offer an even higher price to the firm while still maintaining positive profits, allowing him to exceed the revenue bound on auctions even further.

In my model I further assume that the underwriter enjoys first-mover advantage. This assumption likewise serves as a robustness check. If a firm must seek out an underwriter (say, at a cost), then this decision will be dependent on whether or not the firm expects to be screened. If the underwriter can credibly commit to screening every company, then no low value firms will ever seek out an underwriter. However, in reality the underwriter might be able to do better than this by adopting a mixed screening strategy to minimize information costs while still shutting out an appropriate percentage of low quality companies in expectation. Combining the above insights with the possibility that the underwriter may not deal fairly with investors,
and the principal agent issues which are so common to book building emerge.

One should note that this model is consistent with the presence of IPO auctions in the real world. The model predicts that information costs would prevent some investors from purchasing information about the company, but the magnitude of this effect will clearly depend on the magnitude of the costs. The companies who have chosen to hold IPO auctions – e.g. Google Inc., Peet’s Coffee, and Overstock – are companies who already had well-established brands and easily identifiable revenue streams. We should expect that it would be less costly for an investor to learn the value of these companies. As such, expected auction revenues should not be significantly less than what the underwriter can provide, meaning non-revenue considerations may have dominated in these cases.

Additionally, my result suggests that much of the IPO auction literature which has focused on designing an optimal IPO mechanism misses the point. Book building arises as a result of underwriter’s capacity for information transmission; as long as some bidders in an auction will choose to be uninformed, the underwriter will have an opportunity to make a better offer to high value firms. Further, the choice of some bidders to avoid information acquisition results from the fact that some bidders are unlikely to be awarded a unit, and this could only be overcome by somehow forcing all bidders to acquire information. However, forcing all bidders to purchase information would require that some bidders enter into an auction with negative expected utility – the mechanism would not be individually rational. It is unclear whether or not this could be accomplished, or even should be attempted, in practice.

4.1 A Lemon’s Market for Auctioned Companies

It is worth noting that proposition 4 implies adverse selection in the auction market. Recalling that I have defined $\Theta_A$ as an investor’s subjective probability that a
company is high value given that it is holding an auction, in any Perfect Bayesian equilibrium of the overall game $\Theta_A$ must be zero. This is because we know that the underwriter will always benefit from purchasing high value companies, and the high value companies similarly benefit from being purchased by the book builder, as $p_b > R_h$. Thus, high value companies do not choose to auction, and $\Theta_A > 0$ cannot be supported in equilibrium.

Thus, since we have been consistently comparing the auction subgame in a vacuum to book building, these results are robust to all sorts of off-equilibrium path beliefs. The underwriter can only offer low value companies revenues which are comparable to an auction when investors expect only low quality companies to hold auctions; if investors believe that there is some probability (even a small one) that an auctioned company will be high value, these beliefs will increase auction revenues for low value companies beyond what the underwriter would be willing to offer. While profits may not be the only motivation for underwriters to purchase a firm, and while revenues may not be a firm’s only consideration when choosing an IPO method, we should nonetheless expect the results of this paper to hold.

As there are only two types of firms rather than a continuum of types, this is not the traditional lemon’s market result, as a traditional lemon’s market relies on a continuum of types. However, if we assume that $V$ is drawn from a continuous distribution, then a true unwravelling would occur. Firms with the highest common values would choose to employ an underwriter, which would reduce $\Theta_A$ and therefore reduce auction revenues for the new “high” types of the auction subgame. These new “high” types would now have an incentive to employ an underwriter, repeating the process. Ultimately, only the lowest types would prefer to auction.

This lemon’s market result additionally offers a different interpretation of a commonly cited empirical observations about auction price stability. Lowry, Officer and
Schwert (2010) found that American companies which held IPO auctions experienced lower aftermarket price volatility. This empirical observation is also noted Darrien and Womack (2003) and Degeorge, Derrien and Womack (2006), who compared book built IPOs to IPO auctions in the French market, where they also exist side-by-side. However, the possibility of adverse selection within the auction market impacts the interpretation of these empirical results; if only low value companies auction, and therefore only low value companies are expected to auction, then investors can infer a company’s value without needing to invest in information. This would cause IPO auctions to appear to have better pricing characteristics, but this is a feature which would not hold if they were mandated. The paradoxical result is that an empiricist may be better off comparing book built IPOs in countries where auctions are unpopular to auctions in a country where they are mandated to avoid any such selection issues.

4.2 Auctions with Multiunit Demand

One might question whether the above results will hold if bidders have true multiunit demand for stocks. In such an auction, rather than having a single private value, each investor would have a multitude of private values which correspond to each marginal unit of purchased stock. As a result, investors would submit bid vectors corresponding to each desired unit.

In general, we should expect the above results to hold even in a case of multiunit demand, though it would be necessary to add a couple of additional assumptions. First, it would be necessary to assume that investor private values are declining in the number of units that they receive. This would give investors the sort of downward sloping demand that we should expect from increasing borrowing costs or increasing opportunity cost. We would also have to make the obvious assumption that infor-
formation costs cannot be fully compensated by winning only a few units of stock – information costs can be neither too large nor too small. It would also be convenient (though perhaps not strictly necessary) to assume that the private value corresponding to each investor’s first unit of stock is zero, and declining thereafter.

With these assumptions, we would arrive at a multiunit auction in which an investor’s decision to purchase information relies on their total demand compared to other bidders. That is, an investor who has a rapidly decreasing marginal value for units of stock would not likely win many units in equilibrium, and would therefore not be willing to purchase information. Such rapidly decreasing marginal value would correspond to a low private value in the single-unit demand case above.

All in all, we should expect the results of such a model to have the same tenor as the conclusions above; some bidders would not purchase information because they expect to receive relatively low surplus, and these bidders may set the price in equilibrium. The risk that an informed bidder might set the price would drive down expected revenues. A book builder with the capacity to overcome the information costs would be able to act as a middleman and split the information rents with the firm.

One interesting question which does not translate to the simpler model, however, is to what degree bid shading would occur in such an auction. It is a well-known property of uniform price auctions that bidders have an incentive to report bids which are lower than their actual marginal values for later units of the objects being sold. This is because there is always some probability that one of these later bids will ultimately set the price. While this possibility should not affect the results of my model, how this bid shading would interact with information purchase is an interesting question and a potentially fruitful topic for future research.
5 Conclusion

In this paper, I have examined an extensive form game in which an issuer wishes to sell units of stock to investors who face costly information about firm quality. I have shown that the presence of costly information prevents informed bidding by some investors. As there is a non-zero probability that one such uninformed investor sets the price in the auction, expected auction revenues are relatively low for high value companies. Underwriters exploit this imperfection by using their reputations with large institutional investors to act as a middleman. This causes high value companies to employ an underwriter instead of auctioning. The underwriter thus shares with the firm the information rents which would have otherwise been collected by the informed investors.

These results suggest that calls to replace book building with auctions are premature. Unless there is some way to ensure that all bidders are symmetrically informed, the uniform price auction will always suffer from this issue. It is also unclear how an alternatively designed mechanism could overcome this problem, as the requirement that investors non-negative utility in expectation ensures that any bidder with a low probability of winning in equilibrium will prefer to be uninformed. One might instead try to ban information acquisition, but it is difficult to imagine how this could be accomplished in practice, or even whether this would be truly desirable.

These results also suggest that some of the commonly cited statistics about aftermarket price stability for US IPO auctions may be misleading. Once investor beliefs are truly endogenized, then adverse selection arises in the auction market, as investors expect that only low value firms will choose to auction. Thus, investors can know that an auctioned company is low value without having to invest in information. Therefore, book building’s presence in the market effectively eliminates the information asymmetry for low value companies. This effect is not captured if one compares US
IPO auction aftermarket volatility directly to book built aftermarket volatility, as it fails to account for the selection problem inherent in the firm’s choice of using one method or the other.

This model makes no attempt to model the principal-agent relationship between underwriters and clients, competition between underwriters, or the syndicalization which occurs between underwriters and what affects such syndicalization might have on competition. Nonetheless, this paper presents a plausible story as to why underwriters may be able to thrive in a market such as this one at the expense of auctions, and goes a long way towards explaining the relative rarity of IPO auctions across the world.
Appendices

A Proof of Lemma 2

Assume that bidding uninformed is the equilibrium strategy $\forall \delta \in [\underline{\delta}, \bar{\delta}]$. Because everybody is symmetrically uninformed about the value of the company, there can be no winner’s curse or other effects resulting from asymmetric information. Thus the bidders are effectively competing in an independent private value auction. We can therefore specify the precise equilibrium bid function for every $\delta_i$:

$$b(\delta_i, 0, V) = E[V] + \delta_i$$

Consider a bidder with private value $\bar{\delta}$. Substituting the above bid function into $u^U(\bar{b})$ and noting that $Pr(\bar{\delta} \geq \delta_i) = 1 \ \forall i$, we see that

$$u^U(\bar{b}) = \bar{\delta} - E[\delta_{Z+1}]$$

Applying the same process to $u^I(\bar{b})$, we see that

$$u^I(\bar{b}) - c = \theta \left( v_h + \delta_i - E[V] - E[\delta_{Z+1}] \right) + (1 - \theta) Pr(v_l + \bar{\delta} \geq E[V] + \delta_{Z+1}) \left( v_l + \delta_i - E[V] - E[\delta_{Z+1}] | v_l + \bar{\delta} > E[V] + \delta_{Z+1} \right) - c$$

Consider $u^I(\bar{b}) - u^U(\bar{b})$, the difference in expected utility between being informed and uninformed. With some helpful rearrangement,

$$u^I(\bar{b}) - u^U(\bar{b}) = \theta (1 - \theta) (v_h - v_l) + (1 - \theta) (\bar{\delta} - E[\delta_{Z+1}]) + (1 - \theta) Pr(v_l + \bar{\delta} > E[V] + \delta_{Z+1}) \left( v_l - E[V] + \bar{\delta} - E[\delta_{Z+1}] | v_l + \bar{\delta} > E[V] + \delta_{Z+1} \right)$$
First note that each term in this expression is exogenous to the model, depending only on either $V$ or $F$. Second, observe that this expression is strictly positive. The probability $Pr(v_l+\delta > E[V]+\delta_{Z+1})$ is non-negative, the probability $\theta$ is non-zero by assumption, $v_h - v_l$ and $v_h - E[V]$ are positive by assumption, and both $\delta - E[\delta_{Z+1}]$ and $\delta - E[\delta_{Z+1}|v_l+\delta > E[V]+\delta_{Z+1}]$ are necessarily positive because $\delta$ is the greatest possible private value.

Therefore, $u^I(b) - u^U(b) > 0$, and so there exists a $c > 0$ such that $u^I(b) - u^U(b) > c$. Given such a $c$, $\delta$ would rather purchase information (among others). Thus, given such a $c$, there is no BNE in which nobody purchases information.

\[\Box\]

## B Proof of Lemma 3

Proof is by contradiction. Assume that there exists a BNE in which a bidder with private value $\delta$ purchases information. Define $\Lambda \in [\underline{\delta}, \delta]$ to be the set of all private values which are associated with bidders who purchase information in equilibrium.

Because the informed equilibrium bid function is strictly increasing in $\delta$, it must be that $Pr(b_b > b_i | \delta_i \in \Lambda) = 0$; a bidder with private value $\delta$ must always lose to all other informed bidders.

Additionally, it must be the case that $Pr(b_b > b_i | v_l) = 0 \forall i$; if the company is low value, he will lose to all other bidders, whether they are informed or not. This is because, when $V = v_l$, his informed bid is $b_b = v_l + \delta$. But $b_b < v_l + \delta_i \leq b_i \ \forall \delta_i \neq \delta$, because $b_b$ is the lower than the lowest undominated bid for every other bidder.

Thus, we have that the bidder with private value $\delta$ is always outbid by informed bidders, and always outbid by uninformed bidders when the company is low value. In
order to prefer being informed, he must be recouping his information costs by winning against uninformed bidders when the company is high value with some non-negligible probability. That is, it must be the case that \( Pr(b > b_i \mid \delta_i \notin \Lambda, v_h) \neq 0 \).

Define \( \delta_u \) to be the infimum of \( \Lambda \). Observe that \( Pr(b_u > b_i \mid \delta_i \notin \Lambda) = 0 \); this bidder will always be beaten by uninformed bidders, as he has the lowest value among the uninformed bidders and the uninformed bid function is strictly increasing in type. Additionally, per the above, it must be the case that \( Pr(b_u > b \mid v_h) = 0 \) as a condition of \( \delta \) purchasing information. Again, since informed bids are strictly increasing in type, this implies that \( Pr(b_u > b_i \mid \delta_i \in \Lambda, v_h) = 0 \). Thus, \( \delta_u \) only wins when the company is low value.

However, \( \delta_u \) values the stock more than \( \delta \). This implies that, if \( \delta \) is willing to purchase information, he must also be willing to purchase information and submit a bid \( b_u \geq \delta \). That is, by mimicking \( \delta \)'s strategy he could win high value companies with the same probability that \( \delta \) enjoys, which would necessarily increase his expected utility. Thus, we have a contradiction; not everybody is best responding, and so this cannot be an equilibrium.

\[ \square \]
References


