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OPEN AUCTION Vs. BOOK BUILDING IPOs: U.S. EVIDENCE

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ABSTRACT

We derive theoretically that an open auction IPO results in higher IPO ofier price (less under- pricing) and more issuer proceeds than a traditional bookbuilding IPO, if maximizing issuer proceeds is the IPO objective. Our empirical results using the U.S. open auction IPO data underwritten by WR Hambrecht + Co and a 5-to-1 matching sample of the bookbuilding IPOs from 1998 to 2014 support this notion. Open auction IPOs are associated with statistically significant less underpricing for one day, one week, one month, two months, and three months post IPO. Bookbuilding IPO firms are more likely to register for and exercise the greenshoe option, and issue seasoned equity ofierings, consistent with our theoretical result that they raise sub-optimal amount of capital through the initial stage of IPO. Open auction IPOs also take longer to go public, amend S-1 files more frequently, and price IPO more conservatively relative to the previously suggested price ranges.

***Keywords*:** Open Auction IPOs, Bookbuilding IPOs, IPO Underpricing, Greenshoe Option

JEL: G23, G30, G32

Google shares took off, but the auction didn't. -CNBC (2014/08/19)

1. INTRODUCTION

Initial Public Offering (IPO) is a critical stage for firms after rounds of private funding to access public capital. Most IPOs are conducted through a traditional bookbuilding mechanism where underwriters have substantial discretion over share allocations and only certain investors have the chance to receive shares at the IPO issuance, but some IPOs are conducted through an open auction where every investor, either individual or institutional, has an equal chance to bid with less allocation discretion by the underwriters. Between the

two approaches, bookbuilding is more popular for decades in the U.S. and around the world (Benveniste and Spindt (1989); Benveniste and Wilhelm (1990); Sherman (2005)). The key distinguishing feature of bookbuilding is underwriters' discretion over allocations, a strong incentive and a unique mechanism to compensate investors who are willing to take the risk of investing in these less known firms for disclosing their information truthfully (Cornelli and Goldreich (2003); Sherman and Titman (2002)) in the primary market. These investors are usually better-informed institutional investors, and oftentimes are clients of the underwriters. In contrast, with less discretion assigned to underwriters, an open auction is deemed as accessible and more transparent, gathers interests from both institutional and individual investors before firms go public.

In the U.S., IPOs have been dominated by the traditional bookbuilding process that involves mostly institutional investors and occasionally a few well-off individual investors. Most individual investors are shut out from IPO share allocation process and can only resort to the secondary market to obtain shares of the issuing firm. The opaque nature of the bookbuilding process and the exclusion of ordinary individual investors have over the years caused outcries from the investing public and caught the attention of politicians as well. After Facebook's IPO in May 2012, Rep. Darrell Issa asked SEC for an overhaul of the IPO process because it was "substantially flawed". The Wall Street Journal (2012/5/28) also voiced a similar concern calling to level the IPO playfield. Even worse, with discretion to allocate shares at hand, underwriters may have incentives to allocate underpriced shares of hot IPOs to executives of clients to exchange for future business, as numerous scandals, such as Piper Jaffray's allocation to 22 corporate executives following the internet bubble has shown (Ritter (2011); Loughran and Ritter (2004)). The issue was allocated to primarily key executive officers of existing or potential Piper Jaffray investment banking clients (MarketWatch, 2004/07/12). It is incident such as this that traditional bookbuilding, the dominant approach of IPOs in the U.S. are viewed to not have treated investors in the same manner. Institutions, especially those that have previous close relation with underwriters, are more likely to receive shares, especially the perceived hot IPO shares.

In addition, IPO underpricing, the immediate jump (the so called 'pop') in the secondary market price, sometimes, right at the open of the first trading day, has not only affected the issuer in the sense of not being able to maximize the issuing proceeds, thus leaving a considerable amount of money on the table, but also impacted the individual investors who are forced to resort to the secondary market to obtain shares, paying the already-inflated price to the institutions who flip their allotted shares from the IPO. From 1980 to 2020, IPOs in the U.S. are priced an average 18.4% below the first day close according to Dr. Jay Ritter at site.warrington.ufi.edu/ritter/ipo-data. While the issuer may somewhat be compensated in a later seasoned equity offering (SEO) through the same underwriter(s) or gain favorable analyst coverage following the IPO as some literature suggests, the agony on the ordinary individual investors only intensifies when

the once 'hot' IPOs do not sustain in price in the long run. Ritter and Welch (2002) show that over three years, the average IPO underperformed the CRSP value-weighted market index by 23.4% and underperformed seasoned companies with the same market capitalization and book-to-market ratio by 5.1%.

In 1999, a San Francisco based firm, WR Hambrecht + Co, introduced in the United States an open nondiscriminatory (single price) auction mechanism for IPO underwriting. Such a mechanism allows everyone, big institutions and small individual investors to participate in the bidding of IPO shares equally and all winning bids pay the same price—the IPO offer price. This open auction format was adopted by equity IPOs in other countries, such as Singapore and Japan and is also the format of U.S. Treasury securities auctions. We conjecture that not only does the open auction allows every investor an equal opportunity at obtaining IPO shares, addressing the fairness issue in IPO share allocations, the increased allowed demand in the IPO bidding process (the primary market) should also lead to a higher pricing of IPO shares, thus potential to reduce IPO underpricing, enlarge shareholder base by issuing more shares, leave less money on the table and better maximize issuer proceeds from the IPO. In this sense, the open auction format of IPOs allows for the once-forbidden demand from small investors to be reflected and counted in the pricing stage, and this "demand" perspective is where we base our current research on, consistent with Lowry *et al.* (2017)'s statement of "if the auction mechanism is set such that the offer price equals the point where demand equals supply, then shares will not tend to be underpriced". What's more, auction typically charges a less percentage underwriting fee than traditional bookbuilding (4% vs. 6-7%, LAtimes, 2004/01/09), thus benefiting the issuer further, but not necessarily hurting the underwriter if the gross proceeds are increased.

In this paper, we attempt to go one step further and prove the conjectures above theoretically and test them empirically in the Section 4. In the theoretical derivations, with maximizing issuer proceeds as the IPO objective, we reach the conclusion that an open auction IPO does result in higher offer price (thus reduced IPO underpricing), more shares offered and higher issuer proceeds than a traditional bookbuilding IPO. Our theoretical findings are consistent with Degeorge *et al.* (2010), and Lowry *et al.* (2010), that open auction can be an effective alternative to traditional bookbuilding in IPOs. This is at odds with the popularity of bookbuilding IPOs over auction IPOs in the United States and globally, and we contribute this observation to the earlier notion by Loughran and Ritter (2004), Degeorge *et al.* (2007), and Lowry *et al.* (2017) that issuer proceeds maximization was not the objective of IPOs over the years, and is still not, today. While there are many reasons for firms to go public (Lowry *et al.* (2017)), the main objective could be different among firms. If issuer proceeds maximization is not the main objective, rather, say, developing and maintaining a good relationship with key investment banks (who serve in the IPO underwriting syndicate) for future positive analyst research coverage is, then it is not

surprising to see the popularity of the bookbuilding format where underwriters play a crucial role and have lots of discretion in share allocation. Our findings are consistent with the non-issuer-proceeds-maximization objective of IPOs.

Our theoretical derivation generates several testable implications which we examine empirically, through matching sample comparison. First, we empirically test if there is lower IPO underpricing from an open auction, than that from bookbuilding. Second, if IPO proceeds are larger for open auction IPOs than bookbuilding IPOs. Third, if a firm is more likely to exercise the greenshoe option and/or issue SEOs later if it goes public with a bookbuilding format rather than the open auction format, because it receives less than optimal amount of funding in the initial stage of the IPO, considering the more severe underpricing associated with the bookbuilding format.

Though theoretically, open auction IPOs are shown to have less underpricing and more proceeds, empirically, WR Hambrecht + Co was only able to underwrite, as a lead under- writer, 23 open auction IPOs from 1999 to 2013 while there were more than 2,000 traditional bookbuilding IPOs during the same time period according to Dr. Jay Ritter at https://site.warrington.ufl.edu/ritter/files/IPO-Statistics.pdf, demonstrating the dominance of bookbuilding IPOs in practice over the years. This limitation in sample size poses a big challenge in our empirical testing. Our data includes all the 23 auction IPOs and we create a 5 to 1 matching sample of 115 bookbuilding IPOs, and do find that open auction is more efiective in pricing IPOs: the issue to first-day open return, first-day close return, first-month return, three-month return and semi-annual return all display lower underpricing than those for bookbuilding IPOs. The pattern disappears after one year. Consistent with Lowry *et al.* (2010) and Degeorge *et al.* (2010), we find that these returns are less volatile for open auction than bookbuilding, suggesting post market stability. We also find that bookbuilding IPOs rely more on greenshoe options and SEOs as they register more and exercise more through the greenshoe options, and on average issue more and larger SEOs than open auction IPOs. In addition, compared with bookbuilding IPOs whose underwriters cater to demand for institutional investors only, open auction IPOs collect demand from both individual and institutional investors, thus take a little longer and revise the pricing a little more often, they are also able to price IPO more correctly and conservatively relative to pre-IPO price ranges documented in the preliminary prospectus. Bookbuilding IPOs still underprice more even though their IPOs are priced more aggressively relative to the suggested pre-IPO price ranges, again possibly due to the fact that not all the demand can be met at the IPO pricing.

Our paper adds to the existing literature, such as Biais and Faugeron-Crouzet (2002), Kaneko and Pettway (2003), Sherman (2005), and Degeorge *et al.* (2010) on the optimal IPO mechanism debate from the theoretical perspectives. While bookbuilding may induce information production and price discovery (Benveniste and Spindt (1989); Benveniste

and Wilhelm (1990); Sherman (2005); Bertoni and Giudici (2014); Khurshed *et al.* (2014)), post-market analyst coverage (Degeorge *et al.* (2007)) and more flip from investors (Lowry *et al.* (2017)), open auction is associated with lower underpricing and return variation (Lowry *et al.* (2010); Degeorge *et al.* (2010)).

The rest of the paper is organized as follows. Section 2 summarizes past research on the main reasons behind IPO underpricing and reviews the current literature on auction IPOs. Section 3 theoretically derives and compares the IPO pricing, number of shares issued, issuer proceeds, probability of greenshoe option usage and SEOs between an open auction IPO and a traditional bookbuilding IPO. Section 4 provides empirical evidence with the open auction IPO sample and the 5-to-1 matching bookbuilding sample. Section 5 concludes.

2. IPO UNDERPRICING AND CURRENT LITERATURE ON OPEN AUCTION IPOS

2.1. Main Explanations on the Underpricing of Traditional IPOs

IPOs have been notoriously hard to price and the underpricing of IPOs has been equally persistent. Over the last 40 years, IPOs in the United States have been underpriced by 18% on average. This translates to more than $172.08 billion that companies have left on the table in the last 20 years. In the 1980s, the average first-day return on IPOs was 7.2%. It then doubled to 14.8% during 1990-1998, before jumping to 64.6% during the internet bubble years of 1999-2000 and then fell back to 14.8% from 2001 to 2020 (Dr. Jay Ritter at https://site.warrington.ufli.edu/ritter/files/IPO-Statistics.pdf). IPO underpricing is also a prolonged worldwide phenomenon. For example, Chambers and Dimson (2009) show that IPOs were underpriced by 3.8% from 1917 to 1945, 9.15% from 1946 to 1986, and 19% since 1986 in U.K.

Much research has been devoted to study the reasons behind this underpricing. Ritter and Welch (2002) provide an excellent review of IPO activities in the past decades. The main explanations on why IPOs are underpriced can be summarized in three aspects: information asymmetry, agency conflicts, and behavioral reasons. The most prominent explanation, information asymmetry states that underwriters have to underprice an IPO in order to attract investors due to lack of information on the issuing firm, thus higher risk. Otherwise, if there is no underpricing, investors will not invest to avoid winner's curse (Rock (1986)). Michaely and Shaw (1994) show that issues with lower information asymmetry, such as those underwritten by underwriters with higher reputation, have lower underpricing, consistent with Rock (1986). A related information theory states that in a bookbuilding process, underwriters use (at least a portion of) underpricing to compensate informed investors for revealing private information to underwriters during the process (Benveniste and Spindt (1989)). Consistently, Cornelli and Goldreich (2001) find that institutional investors who reveal information receive more allocations. Jenkinson *et al.*

(2018), studying a sample of 220 IPOs in Europe, also find information exchange between underwriters and institutional investors.

Ritter and Welch (2002) argue that asymmetric information is no longer the primary driver of IPO underpricing, instead, agency conflicts and nonrational (behavioral) reasons may have gained more grounds in explaining IPO underpricing in recent years. Among agency conflict theories, underwriter conflict of interest is prominent. Underwriters are found to underprice an IPO to reward themselves and their clients in return for future business. These clients are the institutions who are invited to participate in the bookbuilding process and many of whom are later allocated the underpriced shares, which are often flipped at higher prices when secondary market trading starts, though discouraged by underwriters. Chemmanur *et al.* (2017a) find underwriters discount offer price more to make more orders from commission-paying mutual funds eligible for IPO allocations, rewarding their brokerage clients. The underwriter's conflict peaked during the internet bubble years but continued till today even after lawmaker's post-bubble attempt to clean up such practice in the financial industry.

A reason in support of why issuing firms allow such a conflict of interest from underwriters is that even if a firm leaves some money on the table during the IPO, the firm can always finance more at its subsequent seasoned equity offerings (SEOs) once it gains the favor of its underwriting banks. Behavioral explanations argue that the intentional underpricing and the immediate subsequent jump in the secondary trading price are to attract media attention and to show the high demand the IPO shares enjoy to the public. Such a national or even international publicity effect can easily be worth millions, if not more.

In this paper, we acknowledge all the explanations above that contribute to the underpricing of traditional bookbuilding IPOs. We propose an explanation from the basic economics supply/demand point of view, amid the different mechanisms of the traditional bookbuilding process and the open auction process. We argue that the exclusiveness of bookbuilding IPOs to only institutions and well-off individuals, pushes some of the existing demand on the IPO shares to the secondary market and facilitates IPO underpricing and the immediate price jump in the secondary trading. Such 'forbidden' demand could have made the demand schedule more elastic before the shares go public and increased the offer price. This notion is consistent with Kandel *et al.* (1999) and Cornelli and Goldreich (2003) who find that the demand elasticity in the auction process (Kandel *et al.* (1999)) and the bookbuilding process (Cornelli and Goldreich (2003)) is positively correlated with the first-day return in IPOs. Proposing such an explanation does not mean open auction IPOs will not underprice, as Chiang *et al.* (2010) find that they do in Taiwan, but open auctions might help reduce IPO underpricing in the U.S., as shown by Derrien and Womack (2003) for France and Kaneko and Pettway (2003) for Japan, respectively. Such a once-forbidden-now-allowed demand perspective is also consistent with Lowry *et al.* (2017).

2.2. Current Literature on Auction IPOs

Academically, many studies (Benveniste and Spindt (1989); Benveniste and Wilhelm (1990); Spatt and Srivastava (1991); Sherman (2000) and Sherman (2005)), argue that bookbuilding IPOs can help the underwriter gather information efficiently while information gathering in open auctions may be affected by noisy uninformed individual investors. Chiang *et al.* (2010) study the complete bids of Taiwanese auction IPOs between 1995 and 2000 and find that institutions bid informed while individuals tend to bid uninformed, chase returns and overbid to free ride in uniform (same price) auctions. However, Biais and FaugeronCrouzet (2002) and Biais *et al.* (2002) show that a modified auction mechanism (let prices underreact to demand by setting the IPO price at a significant discount relative to the market clearing price) used in France, can extract similar information as bookbuilding. Empirically, Kandel *et al.* (1999) analyze the full demand schedules of 27 Israeli IPOs conducted as nondiscriminatory (uniform price) auctions and find that the demand curve is relatively flat at the clearing price, indicating high demand elasticity and great amount of information from the bidding investors. Degeorge *et al.* (2010) show that though there is free-riding by individual bidders in 19 U.S. open auction IPOs, the aggregate demand schedule is still elastic and informative as (uninformed) individuals only account for 16% in dollar demand and 13% in share offered. Lowry *et al.* (2010) also raise serious questions about the efficacy of the traditional bookbuilding IPO process in that not only do auction IPOs have less severe underpricing but also have less volatility than propensity-score matched bookbuilding IPOs in the U.S.

Degeorge *et al.* (2010) conduct an empirical analysis of the 19 open auction IPOs completed by WR Hambrecht + Co between 1999 and 2007 using detailed bidding data and conclude that open auction IPOs can be an effective alternative to traditional bookbuilding. They find that even though individual investors free ride the auction by overbidding as predicted by Jagannathan *et al.* (2009), such free rides do not hamper information gathering from the auction as the presumably informed institutions account for 84% of the dollar demand and 87% in share allocation, and the demand curve is elastic, *i.e.*, informative. In addition, flipping in the open auction IPOs is at most comparable to bookbuilding deals, but not more prevalent in "hot" deals, and the initial receivers of allocated shares in auction IPOs seem to hold their shares somewhat longer than in the bookbuilding IPOs. Derrien and Womack (2003) examine three different IPO mechanisms in France from 1992 to 1998 and find that the auction mechanism is associated with less underpricing and less money left on the table, a result echoed by Kaneko and Pettway (2003) who compare IPOs in Japan that are conducted through investor-priced auctions and underwriter-priced bookbuilding. All these attributes are desirable to the IPO issuer and the investing public and can be classified as the benefits of auction IPOs.

Designing an experimental examination of an IPO auction with a separate tranche of investors who can place orders without specifying a price, similar to the Treasury securities auction in the U.S., Schnitzlein *et al.* (2019) find that this mechanism will not only induce large bidders (potential institutional investors) to participate and reveal information, attract more smaller bidders (potential individual investors) to participate, make bidding less aggressive than pure auction, but also enjoy a lower price volatility and higher proceeds for issuers and thus underwriters. An exception is Kutsuna and Smith (2004) who compare Japanese bookbuilding IPOs with a hybrid auction IPOs where about half of the total offer was handled using discriminatory auction while the rest was sold at a price below the weighted average of successful bids from the auction and find that bookbuilding enables more accurate valuation of firms and reduces issuer costs (measured by fees plus underpricing) for large issuers. Auction is less costly for small issuers but appears to foreclose some small firms from issuing. Gucbilmez and Briain (2021) examine the bidding behavior of institutional investors in auction IPOs in China and find the majority of the institutions in the sample are occasional bidders, accounting for 2% of the total demand. Regular bidders represent less than 10% of the institutions and only a few of them are well-informed. Also using Chinese auction IPO data but applying a different informed bidders identifying approach, Chemmanur *et al.*(2017b) find information production by institutions, whose bidding information has predictive power for IPO short-term and long-term returns, and institutions receive greater IPO share allocations in better performing IPOs as compensation for their information production.

With the majority of the current research documenting the benefits of auction IPOs over bookbuilding IPOs, the bookbuilding IPO format still captures an overwhelmingly significant market share worldwide as shown in Degeorge *et al.* (2007). In France, auction IPOs are now virtually extinct while they were about equally split with bookbuilding IPOs in the 1990's. Kaneko and Pettway (2003) and Kutsuna and Smith (2004) show that in Japan, auction IPOs quickly disappeared when the bookbuilding format was introduced. As a matter of fact, Jagannathan *et al.* (2015) report that in virtually all countries where bookbuilding was introduced, preexisting mechanisms, such as auctions, have disappeared or lost significant market shares. In the United States, WR Hambrecht + Co, while vying to compete with the traditional bookbuilding underwriters, have had a hard time gaining meaningful market share despite support from findings of academic research and popular media who joined the league in calling for open auction IPOs over traditional bookbuilding IPOs, including Forbes on 2011/5/23 after the Linkedin IPO, Fortune Tech on 2011/12/14 and NYTimes on 2012/2/18. The traditional bookbuilding format still dominates the IPO underwriting market as there is no other open auction IPOs after WR Hambrecht + Co underwrote TruettHurst Inc in 2013. However, this does not necessarily mean firms do not like the auction method, as no firms are perceived to be willing to leave large amount of money on the table, unless they can achieve other goals. Though different from the open

auction we study here in this paper, the hybrid auction applied by Unity Software, DoorDash, and Airbnb, allowing the underwriters and the company to allocate stocks to institutional investors who bid at, or above the predetermined IPO price, became popular in 2020. However, it is still geared toward institutional not individual investors.

Loughran and Ritter (2004) propose that the issuer's objective function has changed over the recent years from proceeds maximization to increasing analyst coverage at the cost of leaving money on the table during the IPO. This finding is supported by Degeorge *et al.* (2007) who state that proceeds maximization is no longer the priority in IPO pricing in recent years. Instead, analyst research coverage is the new focus. Bookbuilding issues are more likely to be followed and positively recommended by lead underwriters (Degeorge *et al.* (2007)). Even unaffiliated analysts promote bookbuilding issues for chances of allocations of future deals from the underwriter, though such a promotion has not been found to carry any value to the issuing firm. The shift of focus to more favorable analyst coverage is partially related to the underwriting investment bank's conflict of interest mentioned earlier in this paper, as underwriters in bookbuilding IPOs can reward in-house analysts or client analysts with underpriced IPO shares in return for favorable research reports on the IPO firms the underwriter takes to public. In addition, the often presumed nonprice-related benefits that underwriters can give to issuers in a bookbuilding IPO such as post-IPO analyst coverage and number of market makers actually show no disadvantage for auction IPOs than bookbuilding IPOs. This finding casts further question into why issuers continue to choose bookbuilding IPOs over auction IPOs throughout the world.

3. THEORETICAL COMPARISON BETWEEN BOOKBUILDING AND AUCTION IPOS

3.1. Demand Schedules

In the theoretical derivation below, comparing a bookbuilding IPO with an open auction IPO, we start with a few assumptions about the IPO demand schedules. First, institutional demand stays the same in either the open auction format or the bookbuilding format, and the demand schedule from institutions is downward sloping with relatively high elasticity (flat rather than steep in the Price-Quantity plane, *i.e.*, institutional demand is informative as suggested by Degeorge *et al.* (2010)). In addition, the compensation to the underwriter is a constant percentage of the issuer gross proceeds. We then compare the demand schedule in an open auction IPO from aggregating the institutional demand schedule and the individual demand schedule at each price level, with that in a bookbuilding IPO where demand only comes from institutions. We denote demand that comes from those who are invited to participate in the traditional bookbuilding IPO as institutional demand, Q^i_{INS}, $i = 1$ to N institutional investors, and we denote demand from regular individual investors who are not invited as Q^j_{IND}, $j = 1$ to M individual investors. In a bookbuilding IPO, all Q^i_{INS} are

aggregated to Q_{INS} by the underwriter before pricing the IPO. In an auction IPO, all Q^i_{INS} and Q^j_{IND} are collected and aggregated to Q_{INSIND} before final IPO pricing. The assumption that each Q^i_{INS} stays the same in either format, that is, each institution's demand on the IPO shares does not change if, the process is bookbuilding or auction, does not consider the crowdout effect as documented by Jagannathan *et al.* (2009). We allow for the relaxation of this assumption later in this paper.

In Figure 1, the demand for a bookbuilding IPO (presumably from institutions and other large investors only) is downward sloping, represented by the loosely dashed line of αβ, with α and β being the intercepts on the *Q* and *P* axes, respectively. As price approaches zero, institutional investors can afford to bid more number of shares than what they are willing to bid on a single share as quantity approaches zero (1 share at the minimum). In another word, the demand curve from institutions is rather flat, as demonstrated by Degeorge *et al.* (2010)). Therefore, the institutional demand function is:

$$P = \beta - \beta/\alpha \times Q_{INS} \quad (1)$$

$$Q_{INS} = (\beta - P)/(\beta/\alpha) \quad (2)$$

Demand from individual investors in the IPO is demonstrated in Figure 1 by the densely dashed line, where γ and δ are the intercepts on the *P* and *Q* axes respectively. We do not make assumptions on whether γ > δ or δ > γ as long as both are positive, because individual investors tend to be uninformed and less rational, thus their demand may not be as informative and elastic as that of the institutions. However, we can assume that comparing the two demand schedules, γ > β, because individuals tend to overbid out of uninformedness

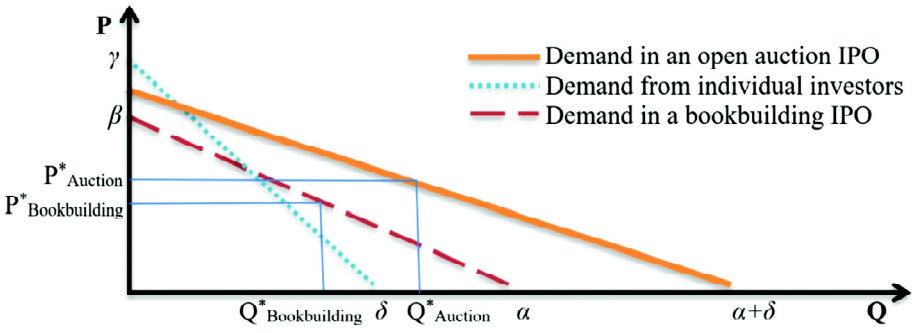

Figure 1: Demand Curves in a Bookbuilding IPO and an Open Auction IPO

This figure depicts investors' demand for shares in IPOs. The loosely dashed line ab represents the demand in a bookbuilding IPO (presumably from institutions and other large investors only). The densely dashed line dg represents the demand from individual investors that are not allowed to participate in a bookbuilding IPO but allowed in an open auction IPO. The solid line represents the demand in an open auction IPO.

or due to their free-riding tendency documented by Degeorge *et al.* (2010), institutional investors are informed and able to shave bids adequately (Chiang, *et al.* (2010)) and an increase in the divergence of opinion will increase the market clearing price (Miller, 1977). That is, individuals tend to bid very high in order to be sure to pass the clearing price and be guaranteed some allocation of shares due to the nature of a nondiscriminatory uniform auction that guarantees all winning bidders to pay the same price. The demand function from individual investors is:

$$P = \gamma - \gamma/\delta \times Q_{IND} \tag{3}$$

$$Q_{IND} = (\gamma - P)/(\gamma/\delta) \tag{4}$$

$$Q_{INSIND} = Q_{INS} + Q_{IND} = (\beta - P)/(\beta/\alpha) + (\gamma - P)/(\gamma/\delta)$$

$$= \alpha + \delta - (\alpha/\beta + \delta/\gamma) \times P \tag{5}$$

$$P = (\alpha + \delta)/(\alpha/\beta + \delta/\gamma) - 1/(\alpha/\beta + \delta/\gamma) \times Q_{INSIND}$$

$$= (\alpha + \delta)\beta\gamma/(\alpha\gamma + \beta\delta) - \beta\gamma/(\alpha\gamma + \beta\delta) \times Q_{INSIND} \tag{6}$$

We can see that the newly combined demand schedule from all institutions and all individuals in an open auction IPO remains linear and is flatter than either the institution's demand or the individual's demand. This combined demand curve in Figure 1 has the intercept on the Q axes as $\alpha + \delta$ (that is, when $P = 0$ in Equation (6), $Q_{INSIND} = \alpha + \delta$), and has the intercept on the P axes as $(\alpha + \delta)\beta\gamma/(\alpha\gamma + \beta\delta)$ when $Q = 0$.

3.2. Slope Comparison of the Open Auction Demand Schedule with the Bookbuilding Demand Schedule

Equation (6) shows that the slope of the combined demand curve in an open auction IPO is $-\beta\gamma/(\alpha\gamma + \beta\delta)$, and Equation (1) shows that the slope of the bookbuilding IPO's demand is $-b/a$; both are negative because of the downward sloping feature of demand. To see which demand is flatter thus more elastic, we can compare the absolute value of the two slopes,

$$|Slope_{Auction}| - |Slope_{Bookbuilding}|$$

$$= \beta\gamma/(\alpha\gamma + \beta\delta) - \beta/\alpha$$

$$= (\alpha\beta\gamma - \alpha\beta\gamma - \beta 2\delta)/((\alpha\gamma + \beta\delta) \times \alpha)$$

$$= -\beta^2\delta/((\alpha\gamma + \beta\delta) \times \alpha) \tag{7}$$

Because α, β, γ, δ are all > 0, the difference in the absolute slope is < 0, which means the open auction demand schedule has a smaller slope than the bookbuilding demand, is flatter, more elastic, and presumably more informed. The slope of the solid line in Figure 1 is confirmed.

3.3. Issuer Proceeds Maximization

In this section, we solve for the optimal pricing and shares offered for bookbuilding and open auction IPOs from the perspective of maximizing issuer proceeds. We understand that pursuing more analyst coverage and other possible benefits from an IPO, rather than maximizing issuer proceeds, might be the empirical practice conducted in IPOs in recent years, but due to the un-quantification nature of pursuing analyst coverage, we resolve to issuer proceeds maximization for a theoretical IPO pricing base point from which, underwriters and the issuing firm can have their own discretion as to how much to deviate.

To maximize issuer proceeds, the underwriter needs to set the objective function as: $MaxP \times Q \times (1 - s\%)$, where $s\%$ is the average underwriting fee in percentage of the issuer gross proceeds ($s\% < 100\%$), which usually is around 7%. $s\%$ is assumed to be a constant in the objective function and does not change based on the resulted gross proceeds amount.

Therefore, in a bookbuilding IPO, the objective is to:

$$\begin{aligned} &\text{Max } (1 - s\%) \times P \times Q_{INS} \\ &= Max(1 - s\%) - (\beta - \beta/\alpha Q_{INS}) \times Q_{INS} \\ &= Max(1 - s\%) \times (-\beta/\alpha Q^2_{INS} + \beta Q_{INS}) \end{aligned} \tag{8}$$

First order condition for the maximization yields

$$\begin{aligned} &(1 - s\%) - (-2\beta Q_{INS}/a + b) = 0 \\ &Q^*_{INS} = Q^*_{\text{Bookbuilding}} = \alpha/2,\ P^*_{\text{Bookbuilding}} = \beta/2 \end{aligned} \tag{9}$$

In an open auction IPO, the objective is to:

$$\begin{aligned} &Max(1 - s\%) - P - Q_{INSIND} \\ &= Max(1 - s\%) - ((\alpha + \delta)\beta\gamma/(\alpha\gamma + \beta\delta) - \beta\gamma/(\alpha\gamma + \beta\delta) - Q_{INSIND}) - Q_{INSIND} \\ &= Max(1 - s\%) - (-\beta\gamma/(\alpha\gamma + \beta\delta) - Q^2_{INSIND} + (\alpha + \delta)\beta\gamma/(\alpha\gamma + \beta\delta) - Q_{INSIND}) \end{aligned} \tag{10}$$

First order condition for maximization yields:

$$\begin{aligned} &(1 - s\%) - (-2Q_{INSIND} - \beta\gamma/(\alpha\gamma + \beta\delta) + (\alpha + \delta)\beta\gamma/(\alpha\gamma + \beta\delta)) = 0 \\ &Q^*_{INSIND} = Q^*_{Auction} = (\alpha + \delta)/2,\ P^*_{Auction} = (\alpha + \delta)\beta\gamma/2(\alpha\gamma + \beta\delta) \end{aligned} \tag{11}$$

At optimization, the issuer's proceeds are maximized, the first order condition satisfied, and a market clearing price for the IPO issuing price is chosen as shown in Equation (9) for bookbuilding IPOs and Equation (11) for open auction IPOs, according to which the optimized number of shares to offer in each format of IPO is also selected, in the respective equation.

As we can see, more shares are offered in auction IPOs ($Q^*_{Auction}$) than in bookbuilding IPOs ($Q^*_{\text{Bookbuilding}}$) as $(\alpha + \delta)/2 > \alpha/2$ with $\delta > 0$.

3.4. Compare IPO Pricing

To compare the optimized IPO pricing under bookbuilding IPOs and open auction IPOs, we take the difference between the price in Equation (11) for auctions and that in Equation (9) for bookbuilding IPOs:

$$\begin{aligned} & P^*_{\text{Auction}} - P^*_{\text{Bookbuilding}} \\ &= (\alpha + \delta)\beta\gamma/2(\alpha\gamma + \beta\delta) - \beta/2 \\ &= \beta/2 - ((\alpha\gamma + \gamma\delta)/(\alpha\gamma + \beta\delta) - 1) \\ &= \beta/2(\alpha\gamma + \beta\delta) - (\alpha\gamma + \gamma\delta - (\alpha\gamma + \beta\delta)) \\ &= \beta\delta/2(\alpha\gamma + \beta\delta) - (\gamma - \beta) \end{aligned} \tag{12}$$

Because $\gamma > \beta$ and all $\alpha, \beta, \gamma, \delta > 0$ as assumed earlier, the above difference in IPO pricing will always be >0. That is, the IPO pricing from an open auction IPO format is, theoretically, always higher than that from a bookbuilding format (thus less possibility for underpricing) for the same IPO, if maximizing issuer proceeds is the objective.

3.5. Compare Issuer Proceeds

The higher IPO pricing together with the more shares offered translate to more issuer gross proceeds in an auction IPO than in a bookbuilding IPO. This can be confirmed by taking the difference between the two maximized issuer gross proceeds. In a bookbuilding IPO, the maximized issuer gross proceeds are:

$$\begin{aligned} & (1 - s\%) - P^*_{\text{Bookbuilding}} \times Q^*_{\text{Bookbuilding}} \\ &= (1 - s\%) - \alpha/2 - \beta/2 \\ &= (1 - s\%) - \alpha\beta/4 \end{aligned} \tag{13}$$

In an open auction IPO, the maximized issuer gross proceeds are:

$$(1 - s\%) - P^*_{\text{Auction}} \times Q^*_{\text{Auction}}$$

with $P^*_{Auction} > P^*_{Bookbuilding}$ and $Q^*_{Auction} > Q^*_{Bookbuilding}$, gross proceeds from the IPO are also larger in auctions than in bookbuilding IPOs. Figure 1 shows this result graphically. Maximizing issuer proceeds equals to maximizing the size of the rectangular spanned from the P and Q axes to the demand schedule. The optimal IPO price (P^*) and number of shares offered (Q^*) are both bigger in an auction IPO than those in a bookbuilding IPO with demand coming only from the institutions. As a result, the size of the rectangular P^*Q^*, the gross proceeds, is bigger in an open auction IPO than that in a bookbuilding IPO. The details are:

$$(1 - s\%) - P^*_{\text{Auction}} - Q^*_{\text{Auction}} - (1 - s\%) \times P^*_{\text{Bookbuilding}} - Q^*_{\text{Bookbuilding}}$$
$$= (1 - s\%) \times (\alpha + \delta)^2\beta\gamma/[4(\alpha\gamma + \beta\delta)] - (1 - s\%) \times \alpha\beta/4$$
$$= (1 - s\%)\beta/4 \times [(\alpha + \delta)^2\gamma/(\alpha\gamma + \beta\delta) - \alpha)]$$
$$= (1 - s\%)\beta/[4(\alpha\gamma + \beta\delta)] \times [(\alpha^2 + 2\alpha\delta + \delta^2)\gamma - \alpha^2\gamma - \alpha\beta\delta]$$
$$= (1 - s\%)\beta/[4(\alpha\gamma + \beta\delta)] \times (2\alpha\gamma\delta - \alpha\beta\delta + \gamma\delta^2) \quad (14)$$

Because of the assumptions that $s\% < 1$, $\gamma > \beta$ and $\alpha, \beta, \gamma, \delta$ all > 0, the above difference is positive as expected. That is, the maximized issuer gross proceeds from the open auction IPO are bigger than those from the bookbuilding IPO. In addition, if the underwriter's only source of profit from underwriting the IPO is the *s%* of the issuer gross proceeds, then the above pricing also maximizes underwriter profit, and issuer net proceeds, after subtracting underwriter commission.

3.6. Probability of SEOs, Greenshoe Option, and Pre-IPO Price Revision

In Section 3.5, we prove that the maximized issuer proceeds, gross or net, from an open auction format are bigger than those from bookbuilding format. In this section, we examine price revisions before the final setting of IPO offer price, and additional offerings at the IPO through the greenshoe option or post IPO. Assuming the total amount of capital desired to be raised is the same, because a larger proportion of the desired funding is not met through the bookbuilding format than through the auction format, bookbuilding IPO firms are more likely to use seasoned equity offerings (SEOs) and the number of SEOs can be more than that of firms using auction IPOs.

Similar to the rationale behind SEOs, the use of the greenshoe option follows suit. The greenshoe option is another tool a firm can use to obtain more capital at the later stage of its IPO, through issuing additional shares when the market demand for its IPO shares is greater than expectation. The difference is, unlike SEOs, which could be issued years later, the greenshoe option should be applied within 30 days after the IPO. Based on our analysis above, we conjecture that bookbuilding IPOs are more likely to register for and exercise greenshoe options than auction IPOs. We will test both implications on SEOs and the greenshoe option in the empirical analysis in Section 4.

As a firm prepares for its IPO, underwriters and the firm need to file a prospectus with the SEC, describing its business and potential risks to investors. In the prospectus, a price range indicating the minimum and maximum anticipated IPO offer price is listed. As underwriters collect more information from potential investors, they can revise the offer price range to be above or below the previously indicated levels. According to Hanley (1993), the relation of the final IPO offer price and the initial price range in the prospectus can predict future returns. Firms with positive revisions in the offer price will have more

shares issued and greater first day pop (IPO underpricing). Since bookbuilding underwriters only collect demand from institutional investors while auction underwriters have demand from both institutional and individual investors, the latter can understand the entire market demand better and be more likely to set up the price "accurately", though likely with more adjustments in price revisions. At the same time, as auction underwriters have to collect demand from a broader investor base, both institutional and individual investors, it will take a longer time to take firms public and more times to revise firms' S-1 files. We will test these implications empirically in the Section 4 as well.

3.7. Crowd-out Effect

So far, we assume that the demand of institutional investors, Q_{INS}, is independent of the IPO format and stays the same no matter the IPO is conducted via traditional bookbuilding or open auction. However, there is evidence that individual investors are more prone to free ride, that is, they will bid high while knowing they will pay the same price with institutional investors if their bids are accepted (Degeorge *et al.* (2010)). Under this condition, institutional investors may choose to bid for fewer shares in open auction IPOs compared to their committed purchase in bookbuilding IPOs because of the potential higher final price driven by individual investors. In other words, there could be a crowd-out effect, the effect of which may vary among firms because institutional investors may be more informative about or more interested in certain firms. To take consideration of the crowd-out effect, we denote the crowd-out effect by a percentage X, that is, institutional demand will drop from Q_{INS} in bookbuilding IPOs to $X \times Q_{INS}$ in open auction IPOs, with $1 > X > 0$. Thus, the combined demand in an open auction IPO will be:

$$Q_{INSIND} = XQ_{INS} + Q_{IND} = X(\beta - P)/(\beta/\alpha) + (\gamma - P)/(\gamma/\delta) = X\alpha + \delta - (X\alpha/\beta + \delta/\gamma) \times P$$

$$P = (X\alpha + \delta)/(X\alpha/\beta + \delta/\gamma) - 1/(X\alpha/\beta + \delta/\gamma) \times Q_{INSIND}$$

$$= (X\alpha + \delta)\beta\gamma/(X\alpha\gamma + \beta\delta) - \beta\gamma/(X\alpha\gamma + \beta\delta) \times Q_{INSIND}$$

In an open auction IPO with the crowd-out effect considered, the objective is to:

$$Max(1 - s\%) \times P \times Q_{INSIND}$$

$$= Max(1 - s\%) \times ((X\alpha + \delta)\beta\gamma/(X\alpha\gamma + \beta\delta) - \beta\gamma/(X\alpha\gamma + \beta\delta) - Q_{INSIND}) - Q_{INSIND}$$

$$= Max(1 - s\%) \times (-\beta\gamma/(X\alpha\gamma + \beta\delta) \times Q^2_{\text{INSIND}} + (X\alpha + \delta)\beta\gamma/(X\alpha\gamma + \beta\delta) \times Q_{INSIND})$$

First order condition for maximization yields:

$$(1 - s\%) - (-2Q_{INSIND} - \beta\gamma/(X\alpha\gamma + \beta\delta) + (X\alpha + \delta)\beta\gamma/(X\alpha\gamma + \beta\delta)) = 0$$

$$Q^*_{INSIND} = Q^*_{\text{AuctionCrowdout}} = (X\alpha + \delta)/2,\ P^*_{\text{AuctionCrowdout}} = (X\alpha + \delta)\beta\gamma/[2(X\alpha\gamma + \beta\delta)]$$

Then the IPO issue price difference between the open auction format with the crowdout effect and the bookbuilding format is

$$(X\alpha + \delta)\beta\gamma/2(X\alpha\gamma + \beta\delta) - \beta/2$$

$$= \beta/2 \times [(X\alpha\gamma + \gamma\delta)/(X\alpha\gamma + \beta\delta) - 1]$$

$$= \beta/[2(X\alpha\gamma + \beta\delta)] - (X\alpha\gamma + \gamma\delta - (X\alpha\gamma + \beta\delta))$$

$$= \beta\delta/[2(X\alpha\gamma + \beta\delta)] - (\gamma - \beta)$$

Because $\gamma > \beta$ and all $\alpha, \beta, \gamma, \delta > 0$ as assumed earlier, the above difference in IPO pricing will continue to be > 0. Thus, even individual investors crowd-out some institutional investors in an open auction IPO, the IPO price is still higher than that from bookbuilding, if maximizing issuer proceeds is the objective of the issuers. That is, our finding still holds after considering the crowd-out effect. The only exception is that the participation of individual investors significantly lowers the interest and demand of institutional investors, resulting in lower aggregated demand from both individual and institutional investors and violating our $\gamma > \beta$ assumption. Under that situation, the open auction IPO fails to attract enough institutional investors to bid.

3.8. Consider Underwriter Fee Difference between Bookbuilding and Open Auction IPOs

In the analysis above, we assume the proportion of the underwriter compensation, *s%*, in IPO gross proceeds for auction or bookbuilding IPOs is the same. Indeed, they are different as bookbuilding underwriters typically charge 7% (Lowry *et al.* (2017)) to sell stocks while WR Hambrecht + Co, the only underwriter applying the open auction approach, typically charges 4% as a lead manager and 5% as a co-manager. To examine whether our conclusions still hold, we use $s_1\%$ to represent what bookbuilding underwriters charge as a percentage and $s_2\%$ for auction underwriters, and assume $s2 < s1$ in general. In a bookbuilding IPO, the maximized issuer net proceeds are:

$$(1 - s_1\%) \times P^*_{\text{Bookbuilding}} \times Q^*_{\text{Bookbuilding}}$$

$$= (1 - s_1\%) \times \alpha/2 \times \beta/2$$

$$= (1 - s_1\%) \times \alpha\beta/4$$

In an open auction IPO, the maximized issuer net proceeds are:

$$(1 - s_2\%) \times P^*_{\text{Auction}} \times Q^*_{\text{Auction}}$$

$$= (1 - s_2\%) \times \beta\gamma(\alpha + \delta)/[2(\alpha\gamma + \beta\delta)] \times (\alpha + \delta)/2$$

$$= (1 - s_2\%) \times (\alpha + \delta)^2\beta\gamma/[4(\alpha\gamma + \beta\delta)]$$

The difference between the two types of IPOs is thus,

$$(1 - s_2\%) - (\alpha + \delta)^2\beta\gamma/[4(\alpha\gamma + \beta\delta)] - (1 - s_1\%) - \alpha\beta/4 \quad (15)$$

Equation (15) must be greater than 0 as $(\alpha + \delta)^2\beta\gamma/4(\alpha\gamma + \beta\delta)$ is greater than $\alpha\beta/4$ as shown in deviations leading to Equation (14), and $(1 - s_2\%)$ is greater than $(1 - s_1\%)$. Thus, after we consider the fee spread charged by bookbuilding underwriters and auction underwriters, we conclude that the issuer net proceeds are still larger for auctions. IPO pricing should still be higher in open auctions than in bookbuilding IPOs because it has nothing to do with the underwriter proportion of the gross proceeds.

3.9. Other Considerations

Compared to open auction, bookbuilding is an IPO format that develops a closer relationship between issuers and underwriters. First, underwriters charge a higher fee than that in an open auction. Second, more prominent underpricing makes it easier for the underwriters to reward their clients, especially these long-term clients. Third, issuers can also benefit from such a close relationship, such as follow-up positive recommendation covered by lead underwriters (Degeorge *et al.* (2007)). With such a closer relationship between underwriters and issuers in bookbuilding IPOs, we conjecture that firms that select bookbuilding IPOs to go public may receive more post-IPO protection than auction IPOs, that is, they are less likely to be unsuccessful. In addition, if the underwriters have clients that are open and able to make acquisitions, the issuer could be a potential target of these clients, indicating higher likelihood of being acquired for bookbuilding IPOs firms. We will test these two conjectures empirically in the Section 4 as well.

4. EMPIRICAL FINDING

4.1. Data and Descriptive Statistics

We obtain data on all 23 open auction IPOs conducted by WR Hambrecht + Co as the lead underwriter in the U.S. from 1999 to 2013. The open auction method was first applied in the IPO of Ravenswood Winery Inc in 1999, a year in the red hot dot.com era. WR Hambrecht + Co solicits bids publicly from potential investors, including price and the number of shares they wish to purchase. After confirmation of bids and close of auction, WR Hambrecht + Co determines a "clearing price", or the highest price at which all offered shares can be sold. After the setting of the "clearing price", the offer price is established, which could be less than or equal to, but not exceed the clearing price. for example, the "clearing price" of Google's auction IPO is close to $100, but underwriters dropped the price to $85 per share at the last minutes. If more shares are bid than offered, shares will be allocated on a pro rata basis without any favoritism to any investor (institutional or individual).

A firm's founding date is obtained from site.warrington.ufl.edu/ritter/files/foundingdates.pdf. IPO dates, assets before IPO, and SIC code are from COMPUSTAT. In addition, we obtain returns from the IPO offer price to the first day opening price, the closing price of the first day, first week, first month, first quarter, first six months, and first year from The Center for Research in Security Prices (CRSP). For other related information such as pre-IPO price range of IPO pricing, pre-IPO price revision and seasoned equity offerings, we download from Bloomberg terminals and supplement by programmatically scraping firms' SEC S-1 filings.

Table 1 reports the descriptive statistics. IPO underpricing is measured by the percentage change in stock price from the IPO offering price to the first-day closing price. The first day return ranges from Nogatech Inc's –21.61% to Andover.net's 252%, an astonishing exception that severely skews the sample mean to the right. We remove Andover.net in our future analysis as robustness check. The removal of Andover.net does not change the average firm age at IPO or total assets much, it does, as expected, change the average IPO Underpricing from 12.68% to 1.80%, with the median underpricing staying at around 50 bps. Open auction IPO firms are distributed in a variety of industries while about one fifth of them are in the Computer Programming industry. Mean firm age at IPO is 12.02 years and 10% of open auction IPO firms are younger than 5 years old when they go public. Over the sample period, year 2005 thrived with five open auction IPOs, which could be due to Google's open auction IPO debut in August 2004. No firms went public during 2009-2012 with WR Hambrecht + Co led open auctions, possibly resulting from the poor economy after the 2008 financial crisis. 17 out of 23 open auction IPOs are small firms with total assets before IPO less than $100 million.

To compare the difference between open auction and traditional bookbuilding IPOs, we match each open auction IPO with five bookbuilding IPOs based on four characteristics: firm age, IPO date, firm size (total assets), and industry (SIC code). To be included in the matching sample, bookbuilding firms must share at least two digits SIC code with the auction firm to make sure they are in the same broad industry. Bookbuilding firms are ranked according to the remaining constraints and the sum of ranking is used as the criteria to select the best five matching firms. Panel A in Table 2 shows the statistics of the sample open auction IPOs and their matching bookbuilding IPOs (with the extreme outlier Andover.net and its matching firms removed). A quick overlook of these two groups of firms indicates that they are of similar offer size, firm size, and offer price with insignificant differences, indicating good matching, though firms with the open auction IPOs are 5.77 years significantly younger, due to the limitation of our sample. Consistent with Degeorge *et al.* (2010) and Lowry *et al.* (2010), open auction IPOs are associated with less underpricing for one day, one week, one month, two months, three months, and six months, all statistically significant with most *p*-values under 5%. Auction's 1.57% to bookbuilding's 15.24% in offer-to-first-day-open return, auction's 1.8% to bookbuilding's 16.76% in offer-to-first-

Table 1: Descriptive Statistics for U.S. Auctioned IPOs 1999-2013

This sample of open auction IPOs is conducted by WR Hambrecht + Co as the lead underwriter from 1999 to 2013. *Founding* is the firm founding year from Jay Ritter's website, and July 1st is assumed to be the exact date when *Firm Age at IPO* is calculated. *IPOdate* is the date a firm goes public. *Assets* is firm's total assets the year before IPO, *Industry* is the industry in which a firm operates, and all are from Compustat. *Underpricing* is the percentage change in stock price from the IPO ofier price to the first-day closing price.

Firm	*Founding*	*Ipodate*	*Industry*	*Assets (M)*	*Underpricing (%)*	*Firm Age at IPO*
Truett–Hurst	2007	20130619	Wine	14.08	–5.33	6.0
Rackspace Hosting	1998	20080807	Cmp Programming	301.81	–19.92	10.1
NetSuite Inc	1998	20071219	Cmp Sys Design	48.05	36.54	9.5
Clean Energy Fuels	1997	20070525	Auto Dealers	136.93	0.33	9.9
Interactive Brokers	1977	20070504	Security Brokers	32,081	4.3	29.9
Fortunet Inc	1989	20060131	Games & Toys	11.05	0.56	16.6
Traffic.com Inc	1998	20060125	Cmp Programming	54.98	1.25	7.6
Dover Saddlery	1975	20051117	Mail–Order Houses	26.76	2.5	30.4
Avalon Pharma	1999	20050929	Biological Pds	29.29	–9.62	6.3
CryoCor Inc	2000	20050713	Electromedical Apparatus	7.49	–1.18	5.0
Morningstar Inc	1984	20050502	Cmp Programming	213.36	8.38	20.8
BofI Holding Inc	1999	20050314	Savings Instn,Fed Chartered	405.04	0	6.1
Google Inc	1998	20040819	Cmp Programming	871.46	18.04	5.7
New River Pharma	1996	20040805	Pharmaceutical Preparations	0.64	–6.25	8.1
Genitope Corp	1996	20031029	Biological Pds	11.99	11.11	7.3
RedEnvelope Inc	1997	20030924	Mail–Order Houses	22.13	3.93	6.2
Overstock.com	1997	20020530	Mail–Order Houses	21.71	0.23	4.9
Briazz Inc	1995	20010502	Eating Places	14.41	0.38	5.8
Peet's Coffee & Tea	1966	20010125	Misc Food Preps	39.61	17.19	34.6
Nogatech Inc	1993	20000518	Semiconductor	6.58	–21.61	6.9
Andover.net Inc	1992	19991208	Advertising	14.44	252.08	7.5
Salon.com	1995	19990622	Cmp Programming	7.81	–4.76	4.0
Ravenswood Winery	1976	19990408	Wine	15.98	3.57	22.8
Mean(with Andover)				1,493	12.68	11.83
Median(with Andover)				22.13	0.56	7.5
Std. Dev. (with Andover)				6,670	53.56	9.24
Mean(without Andover)				1,561	1.80	12.02
Median(without Andover)				24.44	0.47	7.45
Std. Dev. (without Andover)				6,819	12.31	9.41

Table 2: Difference Between Bookbuilding and Open Auction IPOs

This table reports summary statistics on the 22 open auction IPOs (Columns 7-12) and their 5-to-1 matching bookbuilding IPOs (Columns 1-6) from 1998 to 2014 in the U.S., with the outlier Andover.net and its matching firms removed. In Panel A, for every variable, $Mean_{dif}$ is the difference in mean between bookbuilding and open auction IPOs. *p-value* is the significance level of $Mean_{dif}$. *Age* is the number of years since incorporation at the IPO date. *Asset* is total assets before going public. *Ret_open* and *Ret_day1*, *Ret_w1*, *Ret_m1*, *Ret_m2*, *Ret_m3*, *Ret_m6* and *Ret_year1* are the percentage change of stock price from IPO offer price to the market opening price, and the closing price of the first day, the first week, first month, second month, third month, sixth month, and first year, respectively. *Acquired* is 1 if the firm is acquired (including taken private) within 1 year of IPO and 0 otherwise. *Bankrupt* is 1 if the firm is delisted from major exchange to OTC market, go out of business, or file for Chapter 11 or Chapter 7 within 1 year of IPO. *Bankrupt5* is defined the same as *Bankrupt*, but for the period of five years after the IPO. For variables related to greenshoe option, *Primary Shares*(*M*) is the number of newly issued shares the underwriters have the option to sell under a greenshoe provision and *Primary Exercised*(*M*) is the number of newly issued shares the underwriters sold upon exercise of the greenshoe option. *Registered Value*(*M*) is the value of shares registered in greenshoe and *Value exercised*(*M*) is the value of shares exercised through greenshoe. *Seo_size* is the total amount of capital a firm raised from its seasoned equity offerings. *Seo num* is the number of seasoned equity offerings. Panel B reports variables scraped from S-1 and amendment filings. *Day_S1_IPO* is the number of days between the S-1 filing date and the IPO date. *Amend_num* is the number of S-1 amendment filings, while *Amend_Note* is the same number after we remove explanatory note amendment files. *Range_mid1* is the midpoint of the first available price range from S-1 or S-1 amendment divided by IPO offer price, and *Range_midL1* is the ratio of the last available price range midpoint to IPO offer price. *Cap_to_size* is the last price range midpoint times number of shares offered, then divided by the IPO offer size. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Panel A: Difierence Between Auctioned Firms and Bookbuilding Firms

	Bookbuilding						*Auction*						*Difference*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*
Variable	*N*	*Mean*	*Median*	*SD*	*Min*	*Max*	*N*	*Mean*	*Median*	*SD*	*Min*	*Max*	$Mean_{dif}$	*p-value*
Day_S1_IPO	110	99	86	63	0	329	22	120	98.5	70	60	358	–21	0.103
Amend_num	110	4.36	4	1.8	0	10	22	5	5	1.66	2	8	–0.64*	0.058
Amend_Note	110	3.92	4	1.55	0	9	22	4.45	4.5	1.37	2	8	–0.53*	0.056
Range_mid1	110	1.09	1	0.31	0.24	2.2	22	1.19	1.14	0.31	0.55	2.17	–0.097*	0.095
Range_midL1	110	1.05	1	0.2	0.30	1.75	22	1.14	1.14	.19	0.67	1.5	–.095*×	0.02
Cap_to_size	110	1.016	.97	0.27	0.64	2.19	22	1.12	1.13	0.33	0.59	2.17	–0.113*	0.076

Panel B: Revisions Before IPO Final Pricing

	Bookbuilding						*Auction*						*Difference*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*
Variable	*N*	*Mean*	*Median*	*SD*	*Min*	*Max*	*N*	*Mean*	*Median*	*SD*	*Min*	*Max*	$Mean_{dif}$	*p–value*
Age	110	17.7	8	23.73	1	146	22	12.02	7.45	9.41	4	34.6	5.77*	0.06
Asset	110	1,542	45	7,479	0.96	52,071	22	1,561	24.44	6,819	0.64	32,080	–18.85	0.99
Ofierprice	110	13.14	12	5.42	3.5	31	22	15.77	11.25	16.47	6	85	–2.63	0.47
Ofiersize	110	258.73	65.13	961.34	2.58	8,680	22	196.29	36.36	457.84	10.5	1,916	62.44	0.64
Ret_open	110	15.24	6.25	40.52	–11.76	405.36	22	1.57	0.75	6.47	–20	17.66	13.67***	0
Ret_day1	110	16.76	8.74	39.05	–15.97	363.84	22	1.8	0.47	12.31	–21.61	36.54	14.96***	0
Ret_w1	110	22.69	7.24	59.05	–20.71	404.57	22	1.46	–0.22	23.17	–46.35	50	21.23***	0.01
Ret_m1	110	29.07	14.34	62.93	–37.14	301.14	22	–2.8	0.04	22.47	–48.19	38.89	31.87***	0
Ret_m2	110	23.62	12.93	58.65	–47.06	316.12	22	–7.17	–14.24	36.83	–65	69.54	30.8***	0
Ret_m3	110	26.83	8.87	69.34	–94.73	274.01	22	–2.17	–13.05	52.36	–71.75	114.78	29**	0.03
Ret_m6	110	26.45	5.57	98.19	–96.36	715.18	22	–4.57	–16.37	64.52	–88	199.38	31.02*	0.07
Ret_year1	109	11.3	1.74	68.41	–96.73	268.58	22	9.56	–11.53	100.58	–86.31	322.5	1.74	0.94
Acquired	110	0.53	1	0.5	0	1	22	0.36	0	0.49	0	1	0.17	0.14
Bankrupt	110	0.24	0	0.43	0	1	22	0.36	0	0.49	0	1	–0.12	0.30
Bankrupt5	110	0.16	0	0.36	0	1	22	0.32	0	0.48	0	1	–0.16	0.14
Primary Shares (M)	110	1.11	0.39	3.35	0	28	22	0.36	0.38	0.31	0	1.14	0.75**	0.02
Primary Exercised (M)	110	0.55	0	2.01	0	20	22	0.17	0	0.30	0	1.14	0.38*	0.06
Registered Value ($M)	91	36.64	8.63	116.34	0	868	22	7.49	4.81	7.98	0	28.13	29.15**	0.02
Value Exercised ($M)	96	18.98	6.3	68.49	0	620	22	3.17	0	6.79	0	24.18	15.81**	0.03
Seo_num	110	0.23	0	0.46	0	2	22	0.09	0	6.79	0	1	0.14*	0.08
Seo_size	110	56.92	0	189.67	0	1,241	22	3.89	6	13.61	0	59.62	53.03***	0.01

day-close return, and auction's 1.46% to bookbuilding's 22.69% offer-to-first-week return with all *p-values* close to 0 are examples of the significantly less severe underpricing of open auction IPOs. In medium terms ranging from one month to six months, open auction IPOs witness reverse in stock price, while bookbuilding IPO firms' prices continue to rise, with significant increasing differences until it disappears one year post IPO. Auction underpricing from the offer price to one week till six months post IPO also has less variance, as its return standard deviations are lower than those for bookbuilding IPOs.

Results on underpricing in Panel A Table 2 confirm that firms applying the traditional bookbuilding IPO format suffer from more severe IPO underpricing than open auction IPOs as documented in our theoretical derivations in Section 3.4. They are also conjectured to be more likely to use the greenshoe option and issue seasoned equity offerings than open auction IPOs as we will see in the later part of Panel A Table 2. Accompanied with many IPOs, the greenshoe option is a legal mechanism that allows for an additional 15% of company shares at the offer price to be sold within 30 days after the IPO date if market demand is above expectation and secondary market price exceeds the offer price. The option allows for stabilization of the post-IPO market price when public demand exceeds expectations.

Because traditional bookbuilding IPOs are presumed to have not satisfied all the demand from the overall market including both institutional and individual investors, our theoretical derivations in Section 3.6 imply that these bookbuilding firms are more likely to both register for and exercise greenshoe options. This is evidenced in the later part of Panel A Table 2. Greenshoe 'Primary Shares' is the number of newly issued shares the underwriters have the option to sell (*i.e.* the registered shares) and 'Primary Exercised' is the number of newly issued shares the underwriters sold upon exercise of the greenshoe option. We can see that bookbuilding firms register more (1.11m shares vs. 0.36m shares) and exercise more (0.55m shares vs. 0.17m shares) through the greenshoe option than open auction firms with *p-values* of 2% and 6% respectively. The registered greenshoe value ($36.64m vs. $7.49m) and exercised greenshoe value ($18.98m vs. $3.17m) are also significantly greater for bookbuilding firms than open auction IPOs with p-values of 2% and 3% respectively. While bookbuilding firms benefit from the greenshoe option, the significant difference with open auction IPOs may also indicate that bookbuilding IPOs have less demand reflected and satisfied through the primary market than auction IPOs, the base argument for our study in this paper. In addition, in one year after the IPO, bookbuilding firms on average issue more SEOs than open auction firms (0.23 times vs. 0.09 times) and the SEO offer size is greater for bookbuilding firms ($56.92m vs. $3.89m), statistically significant at the 10% and 1% levels, respectively, while the probability of being bankrupt or being acquired show insignificant difference between auction and bookbuilding firms, indicating a similarity in firm health.

As open auction underwriters collect demand from both institutional and individual investors, we conjecture from our theoretical derivations in Section 3.6 that open auction IPOs take longer to finally go public and amend S-1 files more frequently than bookbuilding IPOs that are only open to the selected few. In Panel B of Table 2, we obtain all the filing dates and price ranges from IPO S-1 and S-1 amendment filings. Consistent with our conjecture, open auction IPOs take 21 more days than bookbuilding IPOs (120 days vs. 99 days) to take firms public. The number of amendment files from open auction IPO firms is greater than that from bookbuilding IPO firms as well (5 vs. 4.36) with a p-value of 0.058. The significant difference remains if we remove those non-demand-change 'explanatory note' amendments (4.45 vs. 3.92 with a p-value of 0.056).

The change of price range and its midpoint relative to the final IPO offer price allow us to explore the pricing pattern over time during the IPO process, from order collection to finally being public. In our sample, IPO final pricing is adjusted lower compared to the initial price range in S-1 or the last revised price range in S-1 amendment for both bookbuilding and open auction IPOs. The ratio of the first and the last filed price range midpoint over the IPO offer price is 1.09 and 1.05 for bookbuilding IPOs vs. 1.19 and 1.14 for open auction IPOs, with p-values of 0.095 and 0.02 respectively. Open auction IPOs price more conservatively relative to pre-IPO ranges, which could be due to the fact that demand of both institutional and individual investors has been collected. In contrast, bookbuilding underwriters tend not to discount much because individual investors' demand, which has not been collected and filled, is expected to support the IPO offer price. Together with our empirical finding that open auction IPOs have less underpricing than bookbuilding IPOs, our theoretical conjecture from Section 3.6 is confirmed. The offer size revision ratio, 'captosize', which measures the ratio of the last price range midpoint times the number of shares offered to IPO offer size, shows us a similar pattern: open auction IPOs, which reflect the total demand of the market better than bookbuilding IPOs, lower the offer size more relative to pre-IPO suggestions, as individual demand is accounted for. Specifically, open auction IPOs' offer size is 12% less than the amount indicated by the last price revision before the IPO, while bookbuilding IPOs' offer size is only 1.6% less, with the difference being statistical significant at a *p-value* of 0.076.

4.2. Regression Analysis

In this section, we test the effect of the underwriting approach (traditional bookbuilding vs. open auction) on IPO underpricing and other characteristics using the following set of OLS regressions crosssectionally on the sample of 22 auction IPOs, matched with 110 bookbuilding IPOs, after excluding the outlier Andover.net.

$$\text{Under pricing}_i = \alpha + \beta_1 \text{Auction}_i + \beta_2 \text{Assets}_i + \beta_3 \text{Age}_i + \beta_4 \text{Adjust}_i + \beta_5 \text{Year}_i + \beta_6 \text{Industry}_i + \tilde{o}_i$$

For underpricing, we use all eight intervals measured from the IPO offer price to the first day open price till the first-year close price. The key independent variable is $Auction_i$, which is a dummy variable (1 for open auction IPOs and 0 for bookbuilding IPOs). We include the variable $Adjust_i$ for price revision of the final offer price from what was initially filed in the SEC S-1 file, as pre-IPO offer price adjustment can predict future returns (Hanley (1993)). Adjust is 1 if the revised offer price is above the initial price range, 0 if the revised offer price is within the price range, and -1 if the revised offer price is below the price range. We also test the effect of IPO format on other dependent variables, offer size, SEO size, SEO number, greenshoe primary shares, greenshoe primary exercised and post-IPO Status in Panel B of Table 3. The Year dummy variable is 1 for 2005, the year with most open auctions in the sample, and 0 for the rest. The industry dummy variable is 1 for tech firms and 0 for other firms. We also control for age and size of firms.

Table 3 presents the regression result. Coefficients of the Auction dummy on IPO underpricing are all significantly negative at at least the 10% significant level for all intervals up to 3 months post IPO, indicating lower underpricing for open auction IPOs than bookbuilding IPOs, confirming the sample statistics in Table 2 and our theoretical derivations in Section 3.4 of chapter 1. Consistent with Hanley (1993), partial adjustment of IPO offer price can predict post-IPO returns in that positive adjustments are significantly correlated with short-term IPO underpricing (up to 1 month). Specifically, if the IPO offer price is revised above the initial price range, returns in the first day, first week and first month are significantly higher. The overall significantly positive coefficients on the Industry dummy indicate higher underpricing for tech firms. Firm age and size at IPO and Year dummy remain mostly insignificant, similar to the results from descriptive statistics in Table 2. In Table 3 Panel B, Assets are positively associated with IPO offer size, new greenshoe shares issued and exercised through the greenshoe provision. Inconsistent with the earlier finding in descriptive statistics in Table 2, variables on SEOs and the greenshoe option are insignificantly related with the IPO format on the OLS or ordered logit and logit regressions in Panel B of Table 3. We attribute their insignificance to the small sample size relative to the number of independent variables in the multi-variable regressions.

5. CONCLUSION

I n this paper, we first theoretically derive the optimal IPO pricing, number of shares ofiered and issuer proceeds with the objective of maximizing issuer proceeds for both a traditional bookbuilding IPO and an open auction IPO. We find that theoretically, IPOs will be priced higher in an open auction format than in a bookbuilding format, together with more number of shares issued and higher issuer proceeds. The higher pricing of an IPO in open auctions leads to lower underpricing of the IPO and a smaller pop in price when the stock starts trading in the secondary market. The theoretical implications are evidenced with our

Table 3: Regression analysis

This table shows OLS regression analysis in Panel A and Columns 1–5 of Panel B. Ordered Logit model and logit model are applied in Column 6 and 7 of Panel B, respectively. Dependent variables in Panel A are IPO returns from IPO offer price to the market opening price, and the closing price of the first day, the first week, first month, second month, third month, sixth month, and first year, respectively. For Dependent variables in Panel B, *Offersize*, *Seo_Size*, and *Seo_Num* are the IPO offer size, size of aggregate SEOs, and number of SEOs. *Primary Shares*(*M*) is the number of newly issued shares the underwriters have the option to sell under a greenshoe provision and *Primary Exercised*(*M*) is the number of newly issued shares the underwriters sold upon exercise of the greenshoe option. *Status* is 1 for a firm going bankrupt or being delisted from a major exchange, 2 for a firm being acquired or taken private, and 3 for the rest. Independent variable *Asset* is total assets before going public and *Age* is the number of years since incorporation at the IPO date. Dummy variable *Auction* is 1 for open auction IPOs and 0 for bookbuilding IPOs. The *Year* dummy variable is 1 for 2005, the year with most open auction IPOs in the sample, and 0 for the rest. The *Industry* dummy variable is 1 for tech firms and 0 for other firms. *Adjust* is 1 if the revised offer price is above the initial price range, 0 if the revised offer price is within the price range, and –1 if the revised offer price is below the price range. *Adjust_out* is 1 if the revised offer price is out (either above or below) of the initial price range, and 0 if the revised offer price is within the initial price range.

Panel A: Return–Related Variables Regression

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
	Ret_open	*Ret_day1*	*Ret_w1*	*Ret_m1*	*Ret_m2*	*Ret_m3*	*Ret_m6*	*Ret_year1*
Auc	–13.62	–15.04*	–21.64*	–33.44**	–32.35**	–32.24**	–33.96	–2.18
	(0.10)	(0.05)	(0.07)	(0.01)	(0.02)	(0.04)	(0.11)	(0.90)
Ln(at)	–2.34	–2.53	–4.41	–4.98*	–1.47	–4.44	–9.98**	–0.09
	(0.21)	(0.15)	(0.10)	(0.09)	(0.62)	(0.20)	(0.04)	(0.98)
Age	–0.02	–0.01	0.06	–0.02	–0.18	–0.12	0.31	0.23
	(0.93)	(0.95)	(0.80)	(0.94)	(0.53)	(0.73)	(0.49)	(0.54)
Adjust	19.00***	21.68***	24.21***	19.71**	4.40	–3.43	11.90	–28.08**
	(0.00)	(0.00)	(0.00)	(0.03)	(0.62)	(0.74)	(0.40)	(0.02)
Year_dummy	–6.99	–5.80	–14.17	–14.47	–13.22	–24.78*	–19.97	–17.46
	(0.35)	(0.41)	(0.19)	(0.22)	(0.27)	(0.08)	(0.30)	(0.27)
Ind_dummy	16.54**	18.84***	36.02***	35.47***	14.60	25.23*	61.66***	18.69
	(0.02)	(0.01)	(0.00)	(0.00)	(0.20)	(0.06)	(0.00)	(0.21)
Cons	22.91***	24.56***	34.36***	44.90***	32.22**	46.46***	51.65**	5.70
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)	(0.74)
R^2	0.17	0.23	0.21	0.20	0.08	0.10	0.14	0.07
adj. R^2	0.131	0.189	0.170	0.156	0.037	0.059	0.100	0.021
F	4.26	6.06	5.44	5.01	1.82	2.35	3.41	1.47
N	131	131	131	131	131	131	131	130

Panel B: Other Dependent Variables Regression

	(1) *Offersize*	*(2)* *Seo_size*	*(3)* *Seo_num*	*(4)* *PrimarySh*	*(5)* *PriExercised*	*(6)* *Status*	*(7)* *Adjust_out*
Auc	70.58	–39.96	–0.12	–0.09	–0.09	–0.54	–0.92
	(0.70)	(0.32)	(0.25)	(0.90)	(0.83)	(0.33)	(0.12)
Ln(at)	209.81***	4.02	–0.02	0.79***	0.43***	–0.05	0.11
	(0.00)	(0.66)	(0.43)	(0.00)	(0.00)	(0.70)	(0.34)
Age	2.91	1.52*	0.00*	–0.00	–0.01	0.07**	–0.02
	(0.46)	(0.08)	(0.08)	(0.99)	(0.24)	(0.02)	(0.17)
Adjust	30.99	27.43	0.08	0.03	0.08	0.31	–0.50
	(0.80)	(0.31)	(0.23)	(0.94)	(0.76)	(0.45)	(0.15)
Year_dummy	–127.55	–30.19	–0.07	–0.14	0.06	0.41	0.07
	(0.44)	(0.41)	(0.43)	(0.81)	(0.86)	(0.44)	(0.88)
Ind_dummy	–106.80	65.55*	–0.00	–0.77	–0.19	2.02***	0.25
	(0.50)	(0.06)	(0.96)	(0.16)	(0.59)	(0.00)	(0.58)
_cons	–630.42***	2.01	0.26***	–2.02***	–1.05***		–0.94*
	(0.00)	(0.96)	(0.01)	(0.00)	(0.01)		(0.06)
R^2	0.29	0.10	0.05	0.27	0.17		
adj. R^2	0.255	0.058	0.007	0.239	0.125		
F	8.41	2.34	1.16	7.68	4.05		
N	131	131	131	129	129	131	131

empirical sample of open auction IPOs matched 1:5 with bookbuilding IPOs in the U.S. during 1998 and 2014.

Bookbuilding firms register and exercise more through the greenshoe option than open auction firms. The registered greenshoe value and exercised greenshoe value are also signif cantly greater for bookbuilding firms than open auction IPOs. While bookbuilding firms benefit from the greenshoe option, the significant difierence with open auction IPOs may also indicate that bookbuilding IPOs have less demand refiected and satisfied through the initial stage of the IPO than auction IPOs, the main argument for our study in this paper.

In addition, in one year after the IPO, bookbuilding firms on average issue more SEOs than open auction firms and the SEO ofier size is greater for bookbuilding firms. For price revision, open auction IPOs price more conservatively relative to pre-IPO ranges, which could be due to the fact that demand of both institutional and individual investors has been collected.

Our findings are consistent with Degeorge *et al.* (2010) and Lowry *et al.* (2010), that auction IPOs can be an efiective alternative to traditional bookbuilding. This is at odds with the popularity of bookbuilding IPOs over open auction IPOs in the United States and globally, and we contribute this observation to the notion by Loughran and Ritter (2004) and Degeorge *et al.* (2007) that issuer proceeds maximization is no longer the objective of IPOs.

While open auction is disappearing, bookbuilding is still the dominant choice when firms go public. One potential reason is that bookbuilding can ofier a more stable demand (through underwriter relationship with clients), which is critical for firms with serious information asymmetry (*i.e.* young or small firms). We hope our research can shed further light on IPO format and ofier an alternative perspective in explaining IPO underpricing.

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