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WHY DON'T ISSUERS CHOOSE IPO AUCTIONS? THE COMPLEXITY OF INDIRECT MECHANISMS

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ABSTRACT

At least 25 countries have used IPO auctions, but most have since abandoned them. We argue that this is because auctions, being indirect mechanisms, require a level of sophistication above that of many investors. Through suitably calibrated examples, we show that even sophisticated investors can make mistakes while bidding in auctions, especially when facing uncertainty about the number and type of bidders, and such mistakes impose costs on other participants. We provide empirical support for our arguments. IPO auctions have been plagued by unexpectedly large fluctuations in the number of participants, return chasing investors, and high-bidding free riders. Our analysis suggests that a direct mechanism that resembles a transparent version of book building would be preferable to auctions.

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1. Introduction

Book building is the primary method through which initial public offerings (IPOs) are brought to the market in the United States. The book building method gives the underwriter substantial discretion over allocations. A number of papers have appeared in the academic literature showing that, under certain circumstances, the greater control and flexibility of the book building method that comes with that discretion can provide substantial benefits to issuers[1]. However, when agents are given discretion, there is always the potential for abuse, and the numerous scandals following the internet bubble suggest that such abuses have occurred in practice[2]. Thus it appears that there are both advantages and disadvantages to the discretion that is given to underwriters by the book building method. [3]

An ongoing debate in the academic literature examines whether the advantages outweigh the disadvantages, especially when compared to sealed bid auctions that give little discretion to underwriters. Auctions are relatively more transparent, giving little discretion to the auction administrator, and are consequently less subject to manipulation and abuse[4]. The auction method is old and well established, and has been particularly successful for government debt, particularly US Treasury securities.

In this paper we provide a comparative review of international IPO practices, and the factors that influence the choice of the IPO mechanism from the set of mechanisms consisting of various types of auctions, fixed price public offering, and book building[5]. In Section 2 we offer evidence on overall usage patterns – first listing the many countries that have tried and abandoned the auction method, and then examining IPO auction outcomes in more detail. We find that, when standard auctions have had to compete with another method – either with fixed price public offers or with book building – auctions have lost out. Of the 50 countries that we examine, more than half have used the auction method at some point, yet IPO auctions are still in use only in the US, where usage has been sporadic and relatively rare, and in Vietnam, India and Israel, where there are (or until recently have been) restrictions preventing the use of book building.

We present empirical evidence in Section 3 that suggests that the lack of popularity of auctions cannot be explained either by lack of familiarity or by differences in underwriting fees: auctions have initially been quite popular in many countries, and the fees for fixed price public offers in most of them have been the same as those for auctions, leaving investment banks with no incentive to favor one method over the other based on fees. In spite of that, when issuers have been allowed to choose between fixed price public offers and auctions, the former method eventually prevailed[6]. The fixed price public offering method in turn lost market share when it faced competition from book building. Our findings refute the popular view that, but for the investment banks' market power, standard auctions would have replaced the book building method for bringing new equity issues to the market[7].

Our explanation for the popularity of the book building method relies on the observation that book building can be thought of as a "direct" ("truth-telling") mechanism, that requires little sophistication on the part of participants. In contrast, bidding in IPO auctions requires a high degree of sophistication on the part of all the bidders. In addition to valuing the shares being issued, each bidder must assess how many other bidders there will be, how much information they have, and what bidding strategies they will use, while at the same time accounting for the mistakes those other

[1] See Benveniste and Spindt (1989) and Benveniste and Wilhelm (1990) on structuring offers to induce the reporting of information, and Sherman and Titman (2002) on inducing information production. Ritter and Welch (2002), Ljungqvist (2007), Wilhelm (2005) offer reviews of the academic IPO literature.

[2] See Loughran and Ritter (2004) for discussion of the scandals and overall trends in IPO underwriting.

[3] Lowry et al. (2010) bring in a different perspective: They argue that, "underwriters' difficulty in valuing companies characterized by high uncertainty, raise serious questions about the efficacy of the traditional firm-commitment IPO process," and conjecture that, "alternate mechanisms, such as auctions, could be beneficial for firms that value price discovery over the auxiliary services provided by underwriters."

[4] The Salomon Treasury bond scandal of 1991 suggests that auctions may not be immune to manipulation

[5] We describe each method, and the primary differences between them, in more detail below in Appendix A

[6] The only exception that we know of is France, which used a unique auction method that discouraged free riders.

[7] Examples include "IPO Market Comes Back to Life", by Rachel Emma Silverman. Wall Street Journal, New York, N.Y.:Nov 11, 2003. pg. D.1. "Dutch auction IPO scheme grabs insider interest", The Red Herring (www.redherring.com), October 30, 2003. "BofI Holding Has Textbook Auction IPO", 15 March 2005, Dow Jones News Service. In fact, some have even argued that U.S. issuers should be forced to use auctions (see for example, "The Value of Trust," Economist Staff, The Economist, June 07, 2002.) The U.S. Securities and Exchange Commission asked for public comments on whether issuers should be forced to use auctions, since few have so far been willing to use them voluntarily. Forced action usage has been tried in, for example, Japan, Israel, and Vietnam.

bidders may be potentially making – and all that makes bidding in an IPO auction a demanding task[8].

As is well known, bidders in a common value setting face the "winner's curse", and need to adjust for this by shaving their bids. This adjustment depends, among other things, on the number and behavior of other investors who enter the auction. If bidders do not know how many will participate, how much they know, and how they will bid, unpleasant surprises are inevitable. Auctions that, by chance, happen to have an unexpectedly large number of entrants will on average be grossly oversubscribed and overpriced, while those that have an unexpectedly low number of participants may be left undersubscribed. These factors are difficult to predict and control, and such variation is an example of what we call "structural risk": that is, the risk that arises due to uncertainty about the bidding environment, rather than about the actual value of shares.

As we illustrate in Section 4, when bidders adjust their bids to account for such risk they underprice the issue much further, which is costly for the issuer. The fact that each IPO is for an entirely different stock with possibly unique characteristics increases the complexity of the bidding environment, thereby making bidding mistakes even more likely. We illustrate the high potential for mistakes in such cases with an example in Section 4.4. As we show, bidders who make unanticipated mistakes, in addition to suffering potentially large losses, can in addition impose costs on other bidders[9]. Further, there may also be naive bidders, whose mistakes may drive up the price of shares above their fair value[10]. Thus, we argue that book building is popular primarily because it is less vulnerable to mistakes on the part of participants, so long as the underwriter is trusted by the investors. Similarly, the fixed price method too requires much less sophistication from bidders when compared to auctions, since it eliminates the risk that the issue price may be unexpectedly high or low due to bidders' mistakes[11]. Further, fixed price public offerings are more transparent and less reliant on the underwriter's reputation when compared to book building, and hence may have an advantage in countries where it may be difficult for underwriters to establish sufficient reputation.

In Section 5 we show how these issues played a role in the failure of some IPO auctions. We provide additional anecdotal evidence for the lack of popularity of IPO auctions, and investigate in greater detail IPO auctions in Singapore. We also discuss the differences between IPO auctions and auctions for Treasury bonds and why the latter have been successful. We believe that the evidence we present makes the lack of popularity of IPO auctions less of a puzzle. We conclude in Section 6.

2. Global Patterns and the Surprising Rarity of IPO Auctions

When Margaret Thatcher, Prime Minister of the UK, began privatizing British companies, she set off major changes around the world in government, in industries and in IPO methods. Before then, the IPO method in most countries outside the US was fixed price public offers (a.k.a. open offers, universal offers or often simply called "the IPO method"). The trend towards floating extremely large public companies forced countries to try new methods and to coordinate IPOs across borders, since many privatizations were too big to be absorbed entirely by the local market. The wave of privatizations led to experimentation first with auctions and then with the US book building method.

Before we proceed with our investigation of international IPO experience, we will first describe the existing methods and their defining features.

2.1. IPO Mechanisms: Fixed Price Public Offers, Book Building, and Auctions

In *fixed price public offers*, the price and allocation rules are set before information on demand is received, and shares are allocated according to the rules announced earlier.

With *book building*, the underwriter typically arranges for investors to attend a road show and then collects indications of interest, which are used to build the order book. The offering price is set only after the order book is full,

[8] Nonequilibrium bidding, and its effects such as persistent winner's curse, has received high-profile attention in recent auctions research, e.g. Eyster and Rabin (2005) and Crawford and Iriberri (2007)

[9] The following quote of Munger from Poor Charlie's Almanack (2006, page 18) suggests that even sophisticated investors may find it difficult to figure out how to bid: "The problem with closed bid auctions is that they are frequently won by people making a technical mistake, as in the case with Shell paying double for Belridge Oil." See also Dyer et al. (1989).

[10] Chiang, Qian and Sherman (2009a) find evidence of return-chasing and other suboptimal bidding behavior by individual investors in IPO auctions.

[11] There is still some *winner's curse* in fixed price public offerings since the allocation depends on how many others bid.

giving the underwriter some idea of demand. The underwriter has substantial discretion over allocations, with those customers who helped in pricing the issue and those with long term relationships with the underwriter getting more favorable treatment.

Auctions for IPOs have taken several forms. Uniform price auctions, often mistakenly called Dutch or Vickrey auctions, are multi-unit sealed bid auctions in which all winning bidders pay the same price. The price paid may be the market-clearing price (the highest price that allows all shares to be sold), or it may be below the clearing price, leading to increased rationing. A "dirty" IPO auction is a uniform price auction where they "leave something on the table" by pricing below market-clearing. In a discriminatory or pay-what-you-bid auction, each winning bidder pays his or her own bid. While some auctions restrict entry, historically most IPO auctions have been of an open public nature. The auction price is based on investor bids, but unlike book building, auction allocations are usually determined by rules that are set, and publicly announced, prior to bidding, thus eliminating underwriter discretion with respect to allocations.

With either fixed price public offers or sealed bid auctions, underwriters may, and sometimes do, hold road shows before the offer price is set. As in book building, they are allowed to ask for feedback that may influence the offering price in the case of the fixed price offer and the reservation price in the case of auctions. However, without control over allocations, underwriters may not be able to offer enough of an incentive for investors to produce and share information.

Many countries have used hybrids – combinations of any two of the three methods. There have been hybrid auction/public offer and auction/book building IPOs, but the most common combination is book building/public offer. For most hybrids, book building (or sometimes an auction) is used to set the price and to allocate shares to institutional and foreign investors, while a fixed price public offer tranche is reserved for local retail investors that do not participate in the price-setting process. Hybrid book building/auctions on the exchange are used in Chile because of regulations, but the offer price is set through book building[12].

There are two types of hybrids: simultaneous and sequential. With sequential hybrids, the price-setting tranche (usually book building but possibly an auction) is completed first, so that the price from that tranche can be used for the subsequent fixed price public offer. See Chowdhry and Sherman (1996a) for a model of the effects of setting IPO prices too far in advance. Simultaneous hybrids are often called 'open pricing', since investors have to place orders while the offer price is still 'open' (before the final price is set). This allows both tranches to run at the same time, thus allowing the offer price to be set as late as possible. A key reason why the upper end of the price range is so frequently binding outside the US is that pricing above the upper end would require returning all orders in the retail tranche and restarting the subscription period with the new range. This problem does not occur in the US because it is practically the only country that uses pure rather than hybrid book building.

From the point of view of the mechanism-design literature, commonly used uniform-price and discriminatory auctions are examples of *indirect* mechanisms, in which truth-telling (i.e. correctly reporting own estimates of the value of shares) is generally not optimal. In contrast, *direct* mechanisms have bidders report their valuations to the auctioneer (underwriter), and provide them with incentives so that it is optimal to do so truthfully. In practice such a mechanism can look very much like book building, with bidders privately communicating their valuations to the underwriter, and the underwriter setting prices and allocations in a way that provides them with sufficient incentives to report.

It is well known that for a large set of mechanisms, the Revelation Principle (Myerson, 1981) states that for any indirect mechanism, there exists a direct one that generates identical outcomes in model economies. Interestingly, there is evidence showing that the outcomes of theoretically equivalent direct and indirect mechanisms differ in laboratory experiments[13]. Whether this is an important enough issue in the case of IPOs can only be discerned based on the historical experience of countries that have experimented with several different mechanisms for IPOs.

[12] Pension funds may only purchase shares through an exchange in Chile, so some IPO shares are sold on the floor of the exchange, after the offering price has been set and the rest of the shares have been allocated through book building. Such auctions may occur only minutes before general trading on the same floor. In its 2003 IPO, La Polar canceled the auction completely and distributed its shares through a book build and through brokerages.

[13] See e.g. Masatlioglu and Uler (2005)

2.2. International Historical Evidence

We conduct an extensive study of IPO placement practices in 50 countries. Unfortunately there is no standard reliable source of international data on IPO placement methods[14]. Table 1 summarizes the IPO methods used in each country, with more detailed information given in Table C.1. As one can see in these tables, most countries allow the use of many methods. We do not know of any country that had formerly allowed auctions and then changed their regulations to prohibit or limit them, or of any country that has forced issuers to use book building – the general trend in the last two decades has been to allow greater choice among issuers.

There are two notable patterns. First, the book building method was once rare outside the US but is now common. Second, auctions have been tried in more than 25 countries but are rare today.

Table 1 shows that the traditional method (in other words, the first and for many years the only method) in most countries is fixed price public offer. It also shows that nearly all countries except the United States are still using fixed price public offer in some form, either alone or as part of a book building hybrid. As a rough generalization, Table 1 shows that experimentation with auctions began in the 1980s or earlier in Europe, and in the 1990s or later in Asia and the Americas, but the auction method generally was dropped within a few years. Experimentation with book building exploded in the mid-1990s, and the method seems to have 'stuck' in most countries, again as a hybrid with fixed price public offer. Auctions usually were abandoned before book building was introduced, so that there have only been a few countries in which both methods were in use at the same time.

Although auctions have been used in more than half of the 50 countries listed in Table 1, the method seems to have been entirely abandoned in all but four of them. As can be seen in Table C.1, auctions are used sporadically in the US, at a rate of about 2 per year (22 from 1999-2009). They are used frequently in Vietnam and India, but both countries prohibit book building. They have been frequently used in the past in Israel, where auctions were the only allowed method for a decade. Book building has been allowed in Israel since mid-2007, but the market has not been active since that regulatory change, so it is too early to tell how the choice of issue methods will evolve there.

In India, book building was first allowed in the 1990s but was not popular for many years. Eventually, after regulatory changes, book building became more popular there, but in 2005 the Indian regulator[15] began mandating pro-rata allocation among bidders. Although India still labels its method book building, the method is now a uniform price auction, with no allocation discretion. Book building is effectively banned, but fixed price public offers are still allowed and auctions have so far remained the favored method.

Auctions are also being used regularly in Vietnam, but issuers there are allowed no choice of methods. Vietnam is still developing its markets in its transition away from central planning, and most IPOs are privatizations.

In France, auctions were popular in the first half of the 1990s. On the regulated exchanges, they gradually lost market share to sequential hybrid book building over several years, then dried up quickly in 1999 when simultaneous hybrid book building was allowed. Auctions continued to be used on the unregulated over-the-counter market (the Marche Libre or Free Market) for several more years, although they eventually seem to have dried up there, also. There were, however, two IPO auctions in France in early 2005[16], which came after there had been no auctions on regulated French exchanges for half a decade.

Auctions were the only method allowed in Israel for a decade. The law requiring their use expired in December, 2003, after which issuers were allowed to effectively choose a fixed price offering by setting a maximum price for the auction. Many of the IPOs between 2004 and mid-2007 chose to set a relatively low maximum price for their offerings, thus effectively choosing fixed price over auction[17]. In July 2007, a long-debated change went into effect,

[14] SDC Platinum offers the currently most extensive international IPO database. It includes indicators of placement and pricing techniques, but unfortunately these are missing for a large part of the dataset, and worse, are rather unreliable in terms of describing the actual process: e.g. auctions in Taiwan, Singapore and France are inconsistently classified as either fixed price or book building; on the other hand, many book built issues in US and UK are classified as fixed price, etc.

[15] see SEBI Circular #SEBI/CFD/DIL/DIP/16/2005/19/9

[16] The two 2005 auctions were for Cafom, on the Second Marche in January and for MG International, on Alternext in June. There have been no further auctions in France as of the end of July, 2007.

[17] The law for one decade had forbidden the use of a maximum price. Technically, Israel was using auctions even before this, but it had become standard to set the maximum price so low that it was virtually sure to be hit, thus effectively making the method a fixed price method. In 2007, Itamar Medical, Maayan Ventures, Clal Finance and Brainsway all set maximum prices for their IPOs, and all ended up being priced at those maximums, but we have not yet been able to verify what proportion of all TASE IPOs set maximum prices.

Table 1: Summary of IPO Methods Used in Various Countries.

A blank in any column means that, to the best of our knowledge, the method was not used. The "first introduced" years are the earliest years that we were able to find but may be later than the actual year of first use. On whether the book building method is now dominant or gaining in popularity, the answer is in the judgment of the main source listed in Table C1, or our best estimate if no other source was available. News article sources for any country are available upon request.

		Auctions		**Book Building**		
	Traditional method(s)	First introduced	Apparently abandoned	First introduced	Now dominant or gaining?	Hybrid with Fixed Price
Europe						
Czech Republic	Fixed price			2004	**yes**	yes
Finland	Fixed price			1993	**yes**	yes
France	Auctions, fixed price	1964	1999*	1993	**yes**	yes
Germany	Fixed price	1999		1995	**yes**	yes
Greece	Fixed price			1994	**yes**	yes
Hungary	Fixed price			1995	**yes**	yes
Ireland	Fixed price			1992	**yes**	yes
Italy	Fixed price	1980s	1986	1992	**yes**	yes
Netherlands	Fixed price	1980s	1989	1994	**yes**	yes
Norway	Fixed price			1995	**yes**	yes
Poland	Fixed price	1994	1995	1995	**yes**	yes
Portugal	Fixed price	1987	1992*	1995	**yes**	yes
Spain	Fixed price	1988		1993	**yes**	yes
Sweden	Fixed price	1980s	1980s	1994	**yes**	yes
Switzerland	Fixed price	Mid-1980s	1987	1995	**yes**	yes
United Kingdom	Fixed price	1960	1986	1992	**yes**	yes
N. & S. America						
Argentina	Fixed price	1991	1992	1993	**yes**	yes
Barbados	Fixed price			Never		
Brazil	Fixed price	Late 1980s	1994	1992	**yes**	yes
Canada	Book building			Early	**yes**	yes
Mexico	Fixed price			None yet		yes
Paraguay	Fixed price			Never		
Peru	Fixed price			1996	**yes**	yes
United States	Book building	1999	Still using	Early	**yes**	no
Asia/Pacific						
Australia	Fixed price	1999	1999	1993	**yes**	yes
Bangladesh	Fixed price	Allowed, 2009		Never		
China	Fixed price	1999	2002	2005*	**yes**	yes
Hong Kong	Fixed price			1994	**yes**	yes
India	Fixed price	2005*	Still using	1999	Banned, 2005	yes
Indonesia	Fixed price			2000	**yes**	yes
Japan	Fixed price	1989	1997	1997	**yes**	yes
Korea	Fixed price	1993		1997	**yes**	yes
Malaysia	Fixed price	1992	1994	2002	**yes**	yes
New Zealand	Fixed price			1997	**yes**	yes
Philippines	Fixed price	1994	1994	1998	**yes**	yes
Singapore	Fixed price	1991	1994	1999	**yes**	yes
Sri Lanka	Fixed price			Never		
Taiwan	Fixed price	1995	2003	2004	**yes**	yes
Thailand	Fixed price			1994	**yes**	yes
Vietnam	Auctions	2005	Still using	Never		
Africa/Middle East						
Egypt	Fixed price			2000		yes
Kenya	Fixed price			2008		yes
Israel	Auctions, fixed price	By 1980	?*	2008		
Jordan	Fixed price			Never		
Pakistan	Fixed price			Never		
South Africa	Fixed price			1994		yes
Turkey	Fixed price	1994	1995*	1997		yes

*Some unusual features or exceptions. See Table C.1 for more detail.

allowing book building for the first time. It is too soon at this point to tell how auctions will compete with book building in the Israeli market.

In Latin America, auctions have been used in Argentina, Brazil and Peru in the past. Latin American markets were quiet for many years, with delistings outnumbering listings in Brazil, Argentina and Chile[18]. Thus it was hard to predict if auctions were gone completely. However, Brazilian, Chilean and later Argentinean IPO markets began picking up in 2004-2005, with even stronger activity in 2006, and book building has been the dominant method, with no auctions that we know of.

Since 1995, Taiwan has allowed both auctions and book building, in addition to the traditional fixed price public offers. Taiwan's auctions are similar to those that were once required, and are still allowed, in Japan – sequential hybrids in which discriminatory (pay-what-you-bid) auctions are followed by fixed price public offers. Auctions were initially popular but lost market share over time, with more and more issuers returning to pure fixed price public offers. Book building was originally allowed only in certain restrictive circumstances but has gained popularity in the last few years.

In the US, the investment bank WR Hambrecht has been encouraging issuers to use auctions since mid-1999. The method got much publicity when Google, a popular search engine company, chose to use the auction method for its August, 2004 IPO, but still the auction method is not popular in the US. As of 2009, there have been 22 US IPO auctions, 19 of them lead-underwritten by WR Hambrecht through its OpenIPO method. Of the other 3 US IPO auctions, the lead underwriters were: Credit Suisse and Morgan Stanley for Google in 2004; Credit Suisse for Netsuite in 2007; and Credit Suisse, Goldman Sachs and Merrill Lynch for Rackspace in 2008. US auctions have had some unusual features (see the "United States" column of Table C.1, p.54).

Several types of IPO auctions have been used. Brazil, Japan, Malaysia, the Philippines, Singapore, Taiwan and the UK have used discriminatory auctions, while Argentina, Australia, Brazil, Finland, France, India, Israel, Malaysia, the Netherlands, New Zealand, Norway, Peru, Portugal, Singapore, Turkey, the UK, the US and Vietnam have used uniform price auctions. Dirty (priced below market clearing) auctions have been used in Australia, Belgium, Finland, France, Hungary, India, Malaysia, New Zealand, Singapore, Turkey, the UK, and the US.

Thus out of 50 countries, auctions have been tried in more than half, and yet all except India, Israel, Vietnam and the US seem to have abandoned them entirely, and auctions are rare or mandatory even in these last four countries. Book building is gaining in popularity or is already the dominant method in more than 40 of the countries. Fixed price public offer is still used in smaller countries and for smaller offerings, and is used for the retail tranche of hybrids, which are standard.

Naturally, one question that needs investigating is what drives the choice of the placement mechanism: as we explore in much greater detail in Appendix A and Section 4, we expect methods that rely upon investors' and underwriters' mutual reputation and relative sophistication to be more popular in more established markets with more sophisticated investors. Using the World Competitiveness Report (2009) Business Sophistication and Financial Sophistication indices as proxies for the market development, we estimated two simple logistic choice models.

Table 2 presents a logistic model of choice of whether to experiment with bookbuilding in a particular country. We can see that higher business sophistication is associated with a higher likelihood that at least some issuers will experiment with bookbuilding. Also, this likelihood is higher in larger, more financially sophisticated markets.

Table 3 shows results from a simple logistic model predicting the most common IPO placement method, that confirms this hypothesis – bookbuilding is much more popular in larger countries with established financial markets and relatively sophisticated participants, while fixed price issues are strongly associated with less sophisticated markets. Auctions and hybrids (here including bookbuilt/fixed price hybrids) are not strongly associated with either measure.

If bookbuilding is a version of a "direct" mechanism such results are to be expected, since, as we shall see below, implementing such a mechanism requires an established, trusted and sophisticated underwriter, communicating with investors who have sufficient capacity to collect and process information. Lacking these conditions, the potential benefits of bookbuilding disappear and simple fixed price issues become more attractive due to their simplicity and lesser reliance on the reputation of the underwriter. Hybrids can be fine-tuned to specific market conditions and are therefore observed in a wide range of markets.

[18] For example, Chile had no IPOs at all from 1998 to 2001 and only one each in the years 2002 and 2003.

Table 2: Business Sophistication and Experience with IPO Methods

Dependent variable = 1 if bookbuilding has ever been used in a country; zero otherwise. Logistic regression coefficients reported; z-statistics in parentheses. Financial sophistication and total market sophistication (defined as the average of financial and business sophistication) score as per Global Competitiveness Report (2009).

	(1)	(2)	(3)	(4)	(5)
Business soph.	3.229**	3.135*			
	(2.58)	(2.28)			
Financial soph.			1.727*	3.592	
			(2.18)	(1.94)	
Total soph.					3.505*
					(2.12)
Market size		1.522		2.230*	1.828*
		(1.80)		(2.43)	(2.11)
Constant	-12.09*	-17.93*	-6.134	-23.97*	-21.36*
	(-2.33)	(-2.52)	(-1.74)	(-2.24)	(-2.41)
N	46	46	46	46	46
pseudo R^2	0.409	0.554	0.180	0.543	0.563

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Market Sophistication and Prevalence of Bookbuilding

Dependent variable = 1 if the corresponding method is currently the most commonly used; zero otherwise. Logistic regression coefficients reported; z-statistics in parentheses. Financial sophistication and total market sophistication (defined as the average of financial and business sophistication) score as per World Competitiveness Report (2009).

	Fixed	Fixed	Bookbuild	Bookbuild	Hybrid	Auction
Financial soph.	-1.317*		2.735*			
	(-2.51)		(2.36)			
Total soph.		-1.726**		5.285*	-0.245	0.692
		(-2.82)		(2.15)	(-0.28)	(1.44)
Market size	-0.662	-0.434	2.178*	2.064*	0.371	-0.235
	(-1.66)	(-1.11)	(2.51)	(2.15)	(0.58)	(-0.72)
Observations	46	46	46	46	46	46
Pseudo R^2	0.170	0.214	0.434	0.532	0.017	0.038

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3. Problems with Popular Explanations

In what follows we discuss several commonly offered explanations for the lack of popularity of IPO auctions, and argue that they are not fully consistent with observed global evidence.

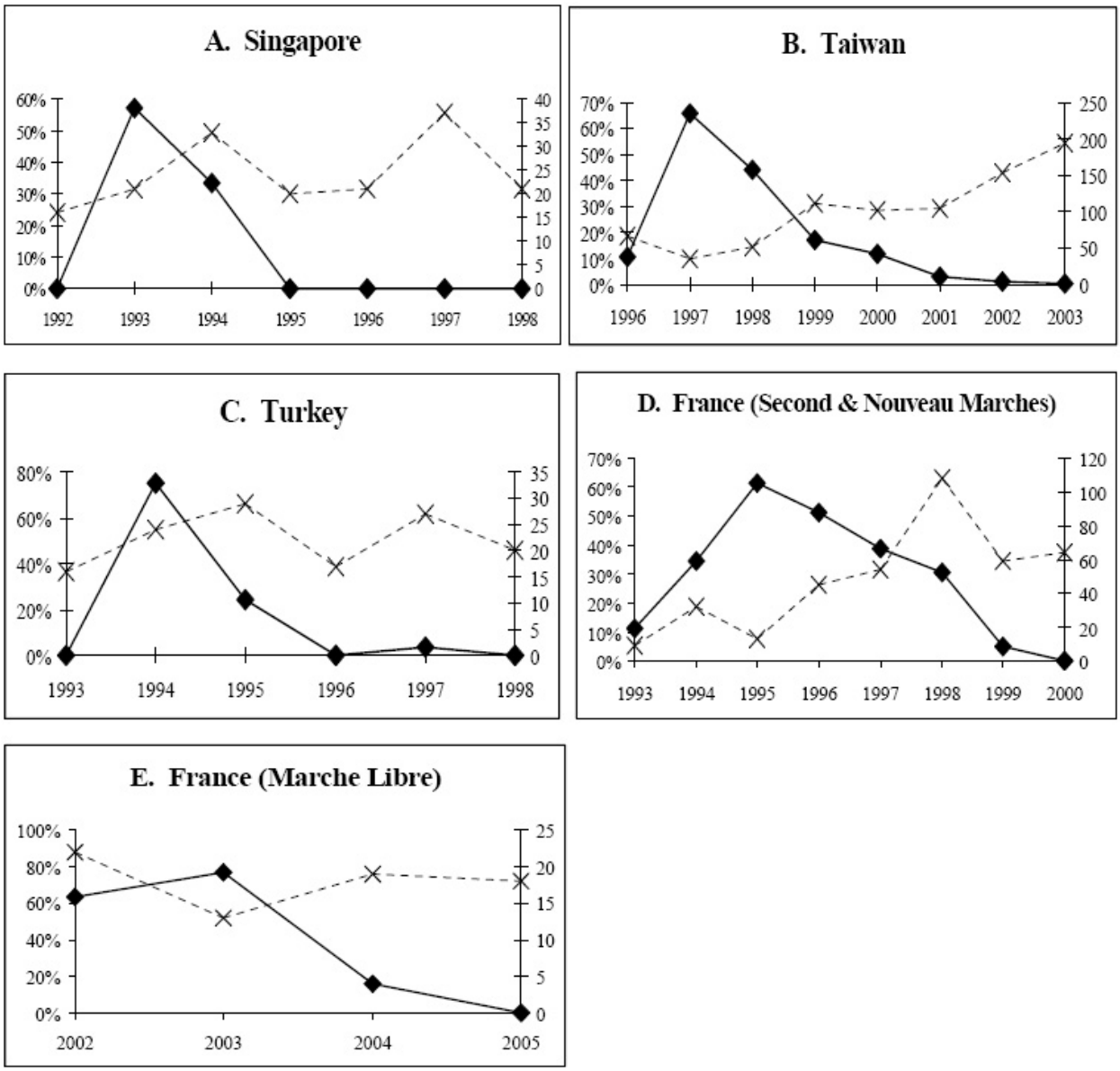
3.1. Were Issuers Unwilling to Try a New Method?

One possible explanation for the low numbers of IPO auctions in the US is that the auction method is simply too new and experimental, and that issuers are afraid to try an unproven method. This is plausible, since an IPO is a very expensive, very public step for a company, so issuers may not be anxious to experiment. However, this 'lack of familiarity' argument cannot explain the overall rejection of the auction method around the world. First, the mere fact that IPO auctions have been used in nearly half the countries for which we have information implies that quite a few issuers have been willing to experiment. More importantly, if we look at relative usage patterns over time, issuers have been most enthusiastic about IPO auctions when the method was new, and they generally became less willing to use it after they had become more familiar with the method.

Figure 1 shows the relative auction usage patterns over time in four countries. For Singapore, Taiwan and Turkey, the main alternative method was fixed price public offers, which had been the traditional method in those countries.

Figure 1: How Auctions Evolved over Time in Four Countries

In each graph, the X's (right axis; connected by dashed lines) give the number of total IPOs per year in that country, while the diamonds (left axis; connected by solid lines) are the percentages of IPO auctions out of all IPOs.
Sources: A: E-mail from the Stock Exchange of Singapore, October, 1999. B: The data was given to us by K.C. John Wei. See Liu et al. (2001) and, for 2002-2003 data, Hsu and Hung (2005). C: E-mail from the Istanbul Stock Exchange, March, 1999. D: Derrien and Womack (2003) and Chahine (2001). E: Euronext website (www.Euronext.com, in IPO Archives).



Auctions were first allowed in 1993 in Singapore[19] and Turkey, and in 1995 in Taiwan. In France, both auctions and fixed price public offers had been used for decades, but sequential hybrid book building was first introduced in the 1990s, while standard book building was only allowed beginning in 1999.

As can be seen from Figure 1 for the three countries in which the IPO auction method was newly introduced, auctions captured their greatest market share early on, with two-thirds or more of issuers choosing to use auctions when they were relatively new. As issuers became more familiar with the method over time, a lower proportion of them chose to use the auction method. Hence, it is hard to argue that, in these countries, the disappearance of IPO auctions was due to lack of familiarity or to an unwillingness of issuers to try a new method.

Of the four countries whose usage patterns are shown in Figure 1, France differs from the others in several ways. First, the auction method had been allowed for several decades in France. Second, a form of book building was in use during the period shown, in addition to auctions and fixed price. Last, the disappearance of auctions from the regulated exchanges seems to have been driven by a regulatory shift that allowed greater choice.

Derrien and Womack (2003) found that sequential hybrid book building was less efficient than auctions in France due to the requirement that the price be set too far in advance. Before 1999, the only form of hybrid book building that was allowed in France was a sequential hybrid, where the price must be set in advance to allow time for the public to place their orders. As the modeling in Chowdhry and Sherman (1996a) demonstrates, setting prices too early adds risk, leading to higher levels of underpricing. Once the more modern, simultaneous hybrid book building method was allowed in France in 1999, auctions quickly vanished from the regulated exchanges[20]. The 1999 regulatory change seems to explain the timing of auctions drying up on the French regulated exchanges, although it does not explain why they were still used for several more years on the unregulated over-the-counter Free Market (Marche Libré). Eventually, as shown in Figure 1 (Panel E), auctions also dried up on the Free Market.

One obvious question is whether issuers in these countries were truly allowed to choose freely between IPO methods. Although there were no regulatory restrictions that prevented issuers from using auctions, strong differences between the groups of issuers using different methods might imply some other sort of barrier, such as underwriter reluctance to underwrite auctions for some issuers. Therefore, in unreported analysis (available on request), we compare fixed price public offers and auctions in Singapore, Turkey and on the French Free Market based on both industry and amount of funds raised[21]. We did not find substantial differences in the size or industry patterns of auction and non-auction issues.

Thus it is clear, in all four of the countries shown in Figure 1, that the disappearance of auctions was not due to issuers' lack of familiarity with the auction method. Similarly in Japan, issuers were forced to use auctions from 1989 to 1997. In spite of the long period during which IPOs in Japan were accomplished exclusively through auctions, the method was abandoned as soon as issuers were given the option of instead using book building.

There is not enough evidence to conclusively reject the 'lack of familiarity' argument for all countries. It may explain why auctions have not caught on in countries with limited usage, such as Germany, Australia or the US, or in countries that have never tried auctions at all. It may also explain why open public auctions for corporate debt and seasoned equity never caught on[22], even though there was a race between three investment banks to introduce online corporate bond auction platforms in 2000[23], and WR Hambrecht offers an online seasoned equity auction method known as OpenFollowOn[24]. But the overall IPO evidence is that issuers in many countries have been willing

[19]The graph shows only uniform price auctions for Singapore. Singapore also had one discriminatory auction in 1991 and one in 1992. Uniform price auctions were first allowed in 1993.

[20]With the exception of the two IPO auctions in 2005 that were mentioned in Section I.

[21]Comparisons of French Second and Nouveau offerings can be found in Derrien and Womack (2003) and Degeorge, Derrien and Womack (2007). Hsu and Hung (2005) compare Taiwan IPOs by method.

[22]Bortolotti et al. (2006) show that auctions, in the form of block trades, have increased dramatically in the last decade and have become quite common around the world for seasoned equity offerings. The success of these SEO auctions fits well with our findings for IPOs, since the block trade auctions are single-unit auctions among a small group of sophisticated buyers – investment banks. The investment bank that wins the auction buys all of the shares at the winning bid price and then resells them on the market. With only one buyer, there is no room for free riders. Because the shares are relatively easy to value (since they are already trading) and the number of potential bidders is relatively small, these auctions are closer to Treasury bill auctions than to the types of auctions that have been used for IPOs.

[23]On August 10 2000, Deutsche Bank and Bear Stearns each auctioned off their own debt on their newly-developed platforms, while WR Hambrecht held its first OpenBook debt auction, for Dow, on August 15, 2000. WR Hambrecht handled a second OpenBook auction, for Ford Motor Credit, in March, 2001. It reportedly also attempted an auction for Dayton Hudson, but the bid-taking system crashed during the auction.

[24]Overstock, a company that also went public through an OpenIPO, used the OpenFollowon method in May of 2004 but chose a traditional marketed offering for its next follow-on in November, 2004.

to experiment with both auctions and book building, and that issuers became less likely to choose auctions as they gained familiarity with the method.

3.2. Underwriter Pressure for Using the Bookbuilding Method

Another explanation suggested by Ausubel (2002) for the failure of issuers to use IPO auctions is that investment banks have pressured issuers to use book building rather than auctions because the fees, and hence profits, are higher for book building. This argument is somewhat inconsistent – it assumes that underwriters have sufficient market power to keep book building fees artificially high, and sufficient power to force issuers to use the book building method in spite of the high fees, but that they do not have sufficient power to demand artificially high fees for auctions[25].

Regardless, this argument cannot explain the disappearance of auctions in most countries, because auctions have usually been replaced by fixed price public offers, and public offer fees are typically as low as, or even lower than, the fees for auctions. Ljungqvist et al. (2003) show that average fees tend to be quite low for fixed price public offers across most countries, substantially below those for book building[26].

A third explanation to consider is that underwriters might be pressuring issuers to use methods that lead to higher initial returns, so that the underwriters can allocate the underpriced shares to their favored clients. This cannot explain the choice between auctions and fixed price public offers, since neither method allows the underwriter to control allocations[27].

3.3. Do Issuers Prefer the Method that Minimizes Expected Underpricing?

The magnitude of underpricing is often mentioned as a disadvantage of the book building method[28]. However, underpricing in fixed price offers tends to be larger than underpricing under either auctions or book building[29]. In spite of that, we find that the fixed price public offer method has been favored over auctions, when both were allowed.

In addition, there are several reasons to believe that issuers care about other aspects of the process beyond just the magnitude of underpricing as evidenced by initial returns. For example, one reason to go public is to give current stockholders such as the founders, venture capitalists and angel investors a chance to diversify by liquidating at least part of their holdings. Such investors usually cannot sell until the end of the lock up period and thus care about the eventual stock price as well as the offer price and first day's trading price. If a deep, liquid market is not established, those investors may be unable to sell their shares at a reasonable price, even after the time and expense of an IPO. Companies that go public but do not attract a following may end up being ignored and stuck in the so-called Orphanage[30]. If they do not attract an institutional investor following, they will generally not be covered by analysts and will not be monitored closely enough to be accurately priced. This means that they will be unable to do follow-on equity offerings and will tend to trade at a substantial discount, due to their illiquidity and added risk. In order to minimize this possibility, firms may be willing to pay, through underpricing, to attract the attention of serious investors in the IPO[31]. This may explain the importance of analyst coverage found in Loughran and Ritter (2004), Cliff

[25] A related argument is given by Degeorge et al. (2007), who show a correlation in France between greater publicity/analyst attention for IPOs and the use of book building rather than an auction (they do not analyze the fixed price public offers in their sample). They argue that underwriters induced issuers to use book building by convincing them of the value of other services (more analyst attention) but do not explain why such services would be bundled only with book building, rather than with all three methods in use at the time.

[26] Similarly, Chahine (2001), examining French data from 1996 to 2000, found that the mean, median and standard deviation of gross spreads were slightly lower for fixed price than for auctions. In most countries, when auctions were first used, the fees were the same for auctions as for fixed price public offers.

[27] Many countries allow orders in fixed price public offers to be favored on the basis of order size, but this usually involves favoring small over large orders. Chowdhry and Sherman (1996b) show that favoring small orders may reduce the Rock (1986) winner's curse. Parlour and Rajan (2005) also examine rationing in IPOs.

[28] Although, as we show in Section 5.1, the evidence on whether auctions lead to less underpricing relative to book building is mixed and inconclusive.

[29] See Ljungqvist et al. (2003).

[30] Orphan stocks are also known as wallflowers. See Barron's Dictionary of Finance and Investment Terms.

[31] Underpricing as a way of inducing costly evaluation has been modeled in Sherman (1992), Chemmanur (1993), Booth and Chua (1996), Sherman (2000), Sherman and Titman (2002) and Busaba and Chang (2003). Yung (2005) models costly evaluation by both investors and the underwriter. Cornelli and Goldreich (2001), Jenkinson and Jones (2004)) and Cornelli and Goldreich (2003) offer evidence on whether or not book building performs this role in practice. See Sherman and Titman (2002) for a list of additional reasons why issuers may prefer more accurate pricing.

and Denis (2004) and Mola et al. (2010). In the words of Martin Manley, Chairman and CEO of Alibris[32], "Taking a company public is like getting a heart transplant: you only do it once and you need it to be done very, very well. It is not a decision driven by price."

This brings up the question of what objective function issuers are maximizing when choosing an IPO method. Loughran and Ritter (2004); Sherman and Titman (2002); Sherman (2005), and Chemmanur and Liu (2003) offer alternative objective functions that consider more than just maximizing proceeds. The appropriate objective function for IPO issuers is a subject in itself, and one worthy of future research. In this paper, we simply note that the evidence indicates that issuers care about more than just maximizing the expected proceeds from the IPO[33]

4. Why Do Issuers Avoid Auctions?

While popular explanations for the the success of the book building method are not convincing, for reasons we discussed in Section 3, not all academics have been convinced by the arguments made in favor of book building in the theoretical finance literature either. This is presumably based on the view that it is possible to design a uniform price hybrid auction that can to a large extent match what book building can achieve when it comes to rewarding price discovery through underpricing the IPO, and promoting wider distribution of the IPO shares. The scepticism of some of the academics is reflected in the following observation by Ausubel (2002): "Imagine attempting to explain to a visitor, from another era or another planet, the economic rationale behind various institutions in the American economy at the start of the twenty-first century. Few practices seem more difficult to justify to the outsider than the current procedure for the issuance of equity securities."

We therefore examine the basis for this scepticism in Appendix A by comparing two specific mechanisms for bringing out new equity issues. We model both book building and a hybrid auction, where, the hybrid auction is a standard uniform price auction with a non-competitive tranche. We find that in the example economy of Appendix A, the level of underpricing as well as price discovery (amount of information revealed) depends only on the number of informed participants in the hybrid uniform price auction. In contrast, in book building, for a given number of participants, a range of underpricing can be supported. That is because, unlike in the hybrid auction, the allocations can also be varied based on the informed bids. Hence, in general, the book building process can support a lower level of underpricing for the same number of informed investors who participate in the issue when compared to the hybrid auction.

However, this advantage becomes less important when information gathering costs are sufficiently high. For example, suppose information gathering costs are such that only N informed bidders enter the hybrid auction, i.e., the auction underpricing is such that there is no incentive for the N+1st investor to incur the costs necessary to become informed. Suppose the lower bound on allocations to the uninformed is binding. In that case the auction outcome can not be improved upon by book building in the example economy we consider, i.e., it will in general not be possible to have better price discovery while at the same time keeping the underpricing lower. That suggests that at least under certain conditions auctions may have an advantage over book building because of their transparency. Hence, it would be difficult to explain the extent to which book building has come to be the dominant IPO mechanism in practice based only on the reasons that have been advanced in the theoretical finance literature.

In this section, we therefore argue in favor of a different reason for the apparent lack of popularity of IPO auctions. Unlike book building which is a direct mechanism where truth telling may be optimal, auctions are indirect mechanisms, and participants in auctions require both knowledge of the environment and sophistication on the part of all the participants. Because of that there are difficulties in making auctions work in practice. As Vohra (2001) notes, "A direct mechanism places a huge computational burden upon the auctioneer", and the rules are hard to specify explicitly – especially when all possible uncertainty about the environment is taken into account. On the other hand, in an indirect mechanism *the computational burden is shifted to every participant*, and every one of the participants has to be as sophisticated as the auctioneer of the equivalent direct mechanism, which is difficult to achieve in practice.

[32] Alibris held an IPO auction through WR Hambrecht in May, 2004, but canceled it after observing the bids. See Mr. Manley's blog, Jam Side Down, at http://www.martinmanley.com/ipo_diaries/.

[33] When the firm's employees have a large number of options that are exercisable at the public offering price, the incentive may well be to underprice the issue as much as possible subject to various constraints.

As we noted earlier, auctions expose both the bidders and the issuer to risk from the variation in the number and composition of bidders[34]. The problem is made worse by the complexity of the IPO environment, where it is easy for participants to make mistakes that can impose large costs on all other participants as well, making other IPO mechanisms more attractive. In what follows we illustrate these issues with suitably calibrated numerical examples.

4.1. Potential Problems with Auctions: Baseline Model

Consider a simple uniform-price auction: There are K lots of IPO shares offered for sale. Each lot consists of n shares, where all shares have the same random, ex ante unknown value of V to everyone, with a common knowledge prior $G(V)$, with $\mathrm{E}V < \infty$, which is assumed to have a positive density everywhere on a compact support $\Omega_V \subseteq \mathbb{R}^+$. There are N identical bidders who compete for the allocations. Utility of a bidder who receives an allocation of x shares at a price p is given by $u(c_0 + (V - p)x)$, where u is a strictly increasing, concave function, and c_0 is his initial capital. Without loss of generality, we normalize $u(c_0) = 0$. The expected value of shares and expected utility are both assumed to be finite: $\mathrm{E}V < \infty$, $\mathrm{E}u(c_0 + (V - p)x) < \infty \; \forall p \in \Omega_V, 0 \leq x \leq 1$.

For expositional convenience we consider a unit-demand auction, where all $K = 15$ winning bidders receive identical allocations of one lot of shares each, and all $N - K$ losing bidders receive an allocation of 0.

We first consider the case with zero information and transaction costs. Every bidder i, $i = 1...N$ receives conditionally independent, identically distributed signals s_i about the true value V:

$$s_i \sim F(s_i|V) \tag{1}$$

where $F(s_i|V)$ is assumed to have a finite expectation and a strictly positive density over a compact support Ω. Without loss of generality, we impose a normalization $\mathrm{E}s_i = V$.

After observing their signals s_i, the agents submit their bids b_i for one lot each. The agents' strategy (or *bidding function*) $B(s)$ is the correspondence between their signals and bids: $b_i = B_i(s_i)$.

The auctioneer collects bids $b = \{b_1...b_N\}$, determines the clearing price and allocates one (and only one) lot of shares to every bidder whose bid is above the clearing price. An allocation without preferences and rationing implies that the auction clearing price $p \in [b^{(K+1)}, b^{(K)}]$ – i.e. p lies between the bids of K'th and $(K + 1)$'st agents[35]. For the sake of argument, let $p = b^{(K+1)}$. Ties are broken at random (note that when the unconditional signal distribution has no mass points and all bidders' strategies are strictly increasing in their signals, a tie is a probability zero event).

An equilibrium allocation is such that for each bidder i his strategy B_i is the optimal response to the collection of other bidders' strategies.

This model, under assumptions of symmetry[36], full rationality, identical priors and common knowledge of the information structure, is analyzed in Milgrom (1981). It is useful to repeat some of the results from there, and to demonstrate their quantitative implications.

Theorem 1. *The above model has a unique symmetric equilibrium, where every bidder i has the same, strictly increasing bidding function $B(s)$, that solves the equation*

$$E\left\{u(V - B(s))\,\middle|\, S_i = s, s_{-i}^{(K)} = s\right\} \equiv 0 \tag{2}$$

and in the risk-neutral case $u(x) = x$ take a simple form of

$$B(s) = E\left\{V\,\middle|\, s_i = s, s_{-i}^{(K)} = s\right\} \tag{3}$$

where $s_{-i}^{(K)}$ is the K'th highest signal of all agents other than i.

Proof. See Milgrom (1981).

[34] Endogenous entry into IPO auctions is modeled in Sherman (2005)

[35] Here and below, we use notation $z^{(K)}$ to denote K'th highest component of a vector z, and z_{-i} to denote a vector with i'th component dropped: $z_{-i} = \{z_1, z_2, ..., z_{i-1}, z_{i+1}, ..., z_N\}$

[36] Here meaning that the bidding functions of different participants are the same: $B_i(\cdot) \equiv B(\cdot) \; \forall i$

In other words, agents can't do better than bid under the assumption that they have received the *lowest* of the winning signals. Note also that monotonicity of B also implies that B is strictly positive everywhere in the interior of Ω: in other words all N bidders submit bids in equilibrium.

As the number of bidders increases, the auction price asymptotically approaches the true value V, in other words, the auction discount approaches zero (see Pesendorfer and Swinkels (1997) for a detailed analysis and a discussion of the relevant assumptions).

In the numerical examples we examine, unless otherwise mentioned, we consider a hypothetical IPO with an ex ante expected value of \$15 million, split into K = 15 blocks of 100,000 shares each, where the share value V has a lognormal distribution with $E(V) = \$10$, and standard deviation of $\log(V) = 0.30$ (i.e. corresponding to a standard deviation of 30% for the continuously compounded rate of return to an uninformed investor in the stock). The private signal s_i is centered at the actual share value, conditional on which it is also lognormal with a standard deviation of 30%. The bidder pool consists of N potentially informed bidders[37]. In addition to the risk-neutral case, in order to investigate the effects of bidders' risk aversion, we will also consider constant relative risk aversion bidder utility $u(c) = \frac{c^{1-A}}{1-A}$, with initial capital of c_0 calibrated to \$30 million for each bidder.

4.1.1. Winner's Curse and Bid Shaving

Figure 2 shows equilibrium bidding functions, depending on the number of participants in an auction. When $N = 2K$ so that number of winners is equal to the number of losers, bids are very close to the signals. However, as the number of participants grows, so does the strength of the negative signal associated with winning the auction: it now implies that the original bidders' signal likely was in the right tail of the distribution and was overstating the underlying share value (the so called *"Winner's Curse"*). Consequently, bidders shave their bids. On the other hand, when $N < 2K$ so that there are more winners than losers, *losing* the auction is an indication of the signal biased downwards (*"Loser's Curse"*), and bidders adjust their bids upwards instead. The equilibrium of the uniform price auction has the following characteristics:

4.1.2. Low Equilibrium Discount

Even with zero information, transaction and opportunity costs, an open auction does not completely eliminate underpricing, which occurs due to the finite number of participants, and becomes larger when bidders are risk-averse. The auction discount, depending on the number of participants and their degree of risk aversion, is shown in Figure 3. Note that, in this example, even when the number of participants is relatively small, the auction discount is low when bidders are risk neutral (between 1% and 2% in the twice-subscribed case of $N = 30$).The discount can go up substantially when bidders are sufficiently risk averse and ill diversified.

Aggregate uncertainty, which enters this model due to imperfect revelation of the true underlying value through a limited number of noisy signals, increases the expected discounts, as one can see from Figure 4. For example, when the standard deviation of the signal doubles, the underpricing in the twice-oversubscribed auction also doubles. As the number of participants grows, price discovery improves, and both mean expected discount and their variance are reduced (Figure 5).

4.2. Structural Risk in IPO Auctions

From the above results it may seem that wider auction participation must necessarily be in the interest of the issuer, improving price discovery, increasing revenue and decreasing risk. However, in practice imprecise valuation is not the only source of aggregate risk in auctions. Much of it comes from the features of the bidding environment itself, such as the variation in the number and strategies of other bidders. This variation has historically been very high.

For example, when Japan auctioned off parts of its railway system, the 1993 auction of Japan Railway (JR) East drew 18,670 bidders, while the 1996 auction of JR West drew only 3,395 bidders, a decrease of more than 80%. 335,000 JR West shares (20%) were left unsold. When Argentina auctioned off its first telecommunications company, Telefonica, in December, 1991, it hoped for at least 80,000 bids from local investors but received more than 100,000.

[37] In Appendix A we consider a hybrid uniform price auction with a noncompetitive tranche – with $N = 2$ informed bidders and $\theta = 50$ uninformed bidders, since the focus there is to compare the hybrid auction with book building. In contrast, in this section we focus on illustrating the structural risk in auctions.

Simulated Uniform-Price Auctions.

Allocations and discounts in simulated uniform-price unit-demand auctions. Unless otherwise specified, the log of the value of a share and the log of each signal about the value of the share are jointly normally distributed with $\sigma_V = \sigma_S = 0.3$ and $EV = ES = 10$. There are N participants, each bidding for at most one lot of 100,000 shares, with the total of $K = 15$ lots offered. Except in Figure 3, all bidders are risk-neutral.

Figure 2: Bidding Functions

Equilibrium bid
as a function of signal for different numbers of risk-neutral participants N.

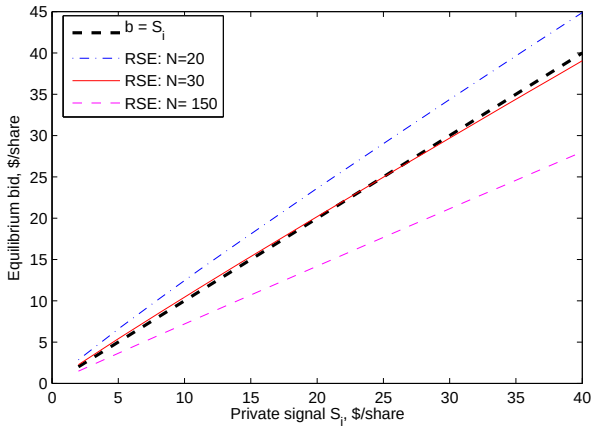


Figure 3: Discount and Risk Aversion

Expected auction discount for different numbers of bidders N and different risk aversion.

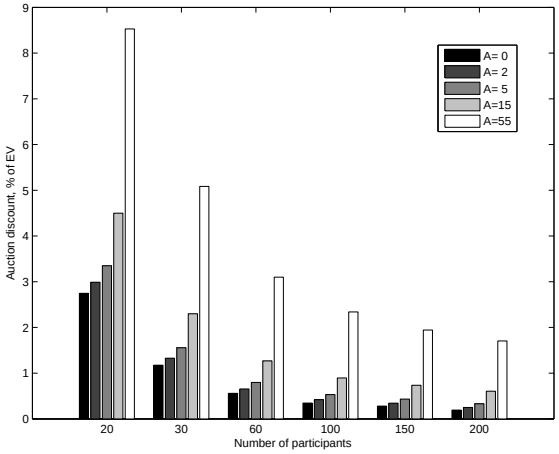


Figure 4: Signal Quality and Discount

Equilibrium expected discount for different values of noise σ_S and number of risk-neutral bidders N.

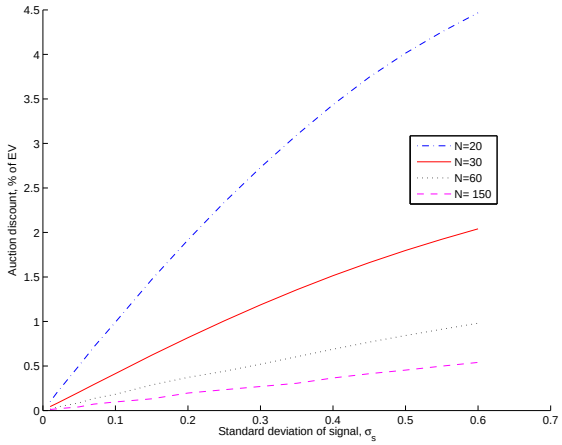
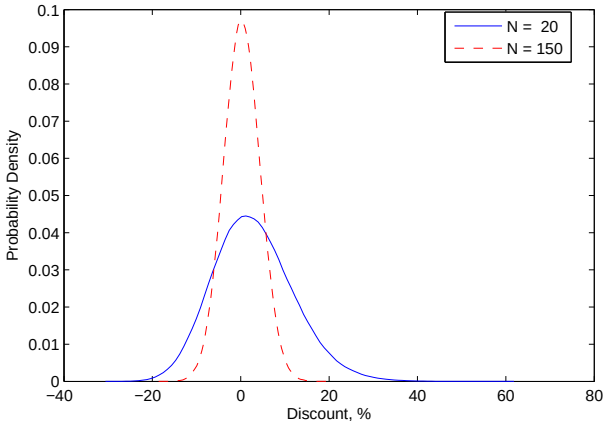


Figure 5: Discount, % of EV

Probability distribution of auction discount for $N = 20$ and $N = 150$.



When it auctioned off its other telecommunications company, Telecom, just a few months later, the auction drew more than 270,000 applications from local investors.

Amihud et al. (2003) found large fluctuations in the number of bidders for IPO auctions in Israel. Similarly, Kandel et al. (1999) looked at 28 auctions over 3 years in Israel and found that orders ranged from 1,388 to 13,518[38]. Lin et al. (2003) and Hsu and Shiu (2004) report wide fluctuations in bidder numbers for Taiwan's IPO auctions. There is also evidence of variation in the demand for Singapore auctions[39]. Subscription levels ranged from the Vickers Ballas auction, which was 1,300% oversubscribed (at the minimum bid), to Sunright, which was 82% undersubscribed. The number of bids ranged from 1,128 for Eng Wah to 162,492 for Singapore Telecom. In the same month that Singapore Telecom's auction was heavily oversubscribed,the auction of another well-respected Asian telecommunications company, Korea Telecom, was 90% undersubscribed (i.e. received orders for only 10% of the available shares). While some of these variations in participation levels would have been anticipated, there would have been some surprises.

We illustrate the effect of structural risk by considering an environment similar to the baseline model, but with added uncertainty about the number of bidders. For simplicity assume that all bidders are identical and there are L potential bidders, out of whom either N_1 or N_2 get to participate, with ex ante probabilities p and $1-p$.

Figure 6: Discount and $\Pr\{N_2 = 150\}$

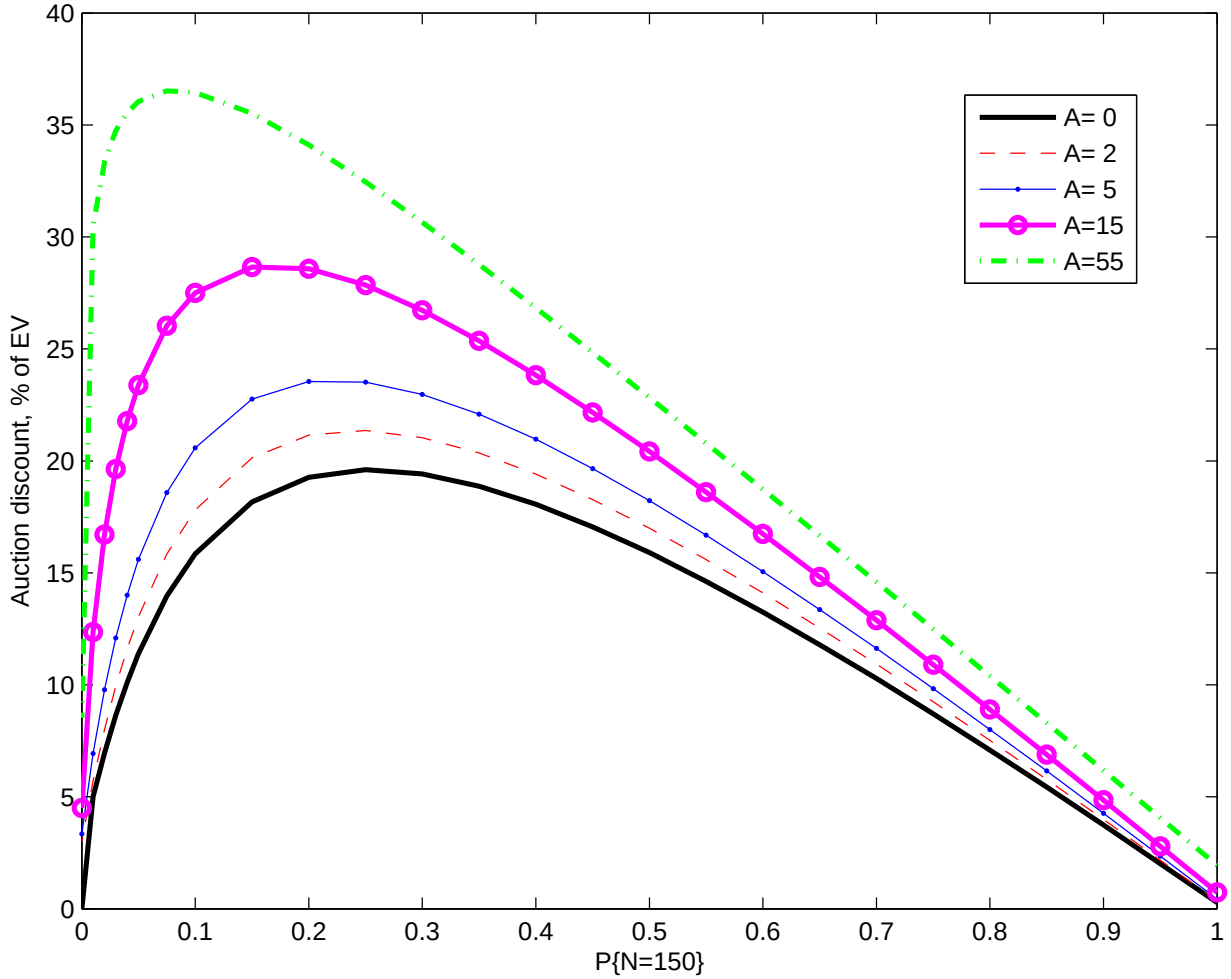


Figure 6 gives the expected discount when the probability of $N_1 = 150$ varies from 0 to 1 for different values of risk

[38]Multiple orders were allowed, so the number of orders might overestimate the number of bidders.
[39]Data available on request

aversion of bidders. The expected discount is small when there is no uncertainty about the number of bidders. However when the bidders face additional risk from underestimating the competition (i.e., there is a positive probability of $N = 150$,) the expected discount increases. It is highest when the uncertainty about the number of bidders is high, and the risk aversion of the bidders is also high. Restricting the number of participants to 20 bidders in this case would result in an outcome clearly superior for the issuer – even though it means abandoning openness, which is lauded as one of benefits of auctions.

It is necessary to note that there are ways of designing auctions in order to control this risk: for example, requiring bidders to indicate their intention to bid before starting an auction, with a subsequent revelation of the number of participants prior to bidding, would reduce both the risk the bidders would face and the return they would demand. However, such practices so far have not been common in auctions of IPOs[40].

Auctions are not the only IPO method for which there have been fluctuations in the number of participants, of course. However, the timing of sealed bid auctions and their method for determining the offer price make unanticipated variations in subscription levels more problematic than for the other two main IPO methods. With fixed price public offers, the subscription level affects a person's chance of getting shares but not her return, conditional on getting shares, since the subscription level does not affect the offer price. With book building, the underwriter observes the subscription level as well as the 'bids' and can then set the price, taking the subscription level into account.

Thus we have shown that uncertainty over the number of bidders leads to more underpricing, more risk and less accurate pricing. Uncertainty over the precision of bidders' information leads to similar results (available upon request).

4.3. Undesirable Equilibria

It is recognized in the literature that auctions have multiple equilibria, some of them undesirable from the standpoint of the issuer. For example, Biais and Faugeron-Crouzet (2002) discuss how "tacit collusion" can have a detrimental effect on the issuer revenue in an IPO auction.

Milgrom (1981) considers a modified setup where information is costly, and after receiving their signals, but before bidding, agents learn exactly how many of them paid for their information[41]. He notes that there is a unique pure strategy symmetric equilibrium, where N bidders choose to participate, with N such that their expected profit just covers the signal cost – so that participating in an auction with $N + 1$ participants would yield an expected loss. In this setting no other investor would want to join the auction, and no participating investor would want to deviate from their strategy.

For example, consider our baseline model of a small IPO with an ex ante expected value of \$15MM, with bidders competing for 15 equal round lots of $100,000$ shares each. Additionally, suppose that a participating institution would have to incur a cost of $\$9,600$ to acquire the private signal, or about 1% of the average lot value[42]. The bold solid line in Figure 7 shows ex ante expected profit to a participant in this auction, net of information costs, depending on number of bidders. As we can see, this auction is profitable as long as the number of participants does not exceed 25, which would be the number of bidders in the symmetric equilibrium of Milgrom (1981), and with 25 bidders the issue is priced on average with an approximately 1% discount that serves to compensate bidders for the information collection costs. Naturally, the lower information costs are, the more bidders participate and the better is price discovery (i.e., variance of the return to buying in the auction.)

Now let us again consider a departure from this model – however this time, instead of looking at the effects of uncertainty about the number of bidders, consider what happens when there is uncertainty about their strategies.

Let us see what happens if, starting from this equilibrium, 5 of the 25 bidders unexpectedly participate with non-competitive (i.e. arbitrarily large) bids. The thin solid line in Figure 7 shows the large decline in profit of other bidders, which is now negative for most of the range of N. Such a deviation is, of course, not profitable by itself. The presence of such bidders may seem beneficial to the issuer: as shown by the bottom (dashed) line in Figure 9, they drive up

[40] The Google, Netsuite, and Rackspace IPO auctions in the U.S. required bidders to acquire unique bidder IDs before the auction began, but the total number of unique IDs awarded was not announced.

[41] Sherman (2005) presents a more general model in which information is costly, there are many potential bidders, and each bidder decides independently whether to evaluate and whether to bid without knowing the choices of others. She shows that endogenous entry adds risk for all even when all bidders are acting optimally. We show that deviations from the optimal strategy add even more risk.

[42] This corresponds, for example, to two weeks of labor of a $\$250,000$ a year analyst

the price for everyone. However this is of course not an equilibrium situation: when other bidders anticipate this happening, they shave their bids accordingly[43]: as we can see from Figure 8, they can actually guarantee themselves profits similar to those of the "no-deviation" case; and the extra revenue the deviating bidder gets comes from the issuer's pocket. In Figure 10 this extra discount is given by the distance between the the two lines, and we can see that it does not decline as the number of "informed" bidders increases, since it comes from rewarding the free-riders.

Note that with unanticipated free riders the auction price can be substantially higher than fair value, i.e., the auction discount can be a large negative value (see Figure 9.) In contrast, when bidders rationally anticipate that a certain number of bidders will free ride, the auction price is at a discount to fair value – but the discount is not that much higher than what would prevail when there is free riding (with 5 free riders), as can be seen from Figure 10.

4.4. Bidding in Auctions can be Difficult

Computing optimal bidding strategies in auctions is not easy, especially when there is added uncertainty about the bidding environment itself. We illustrate this with an example somewhat resembling a popular TV game "Let's Make a Deal"[44]:

Consider an auction where all the bidders follow the strategy such that the winning bidder will gain \$0.5 when $N = 20$, and lose \$1 when $N = 150$. Suppose further that the number of participants, N will be 20 or 150 with equal probability. Hence the expected gain to participating in the auction is $0.5 \times \frac{15}{20} = 0.375$ when 20 bidders participate. The expected loss is $1 \times \frac{15}{150} = 0.1$ when 150 bidders participate. If each bidder considers the two possible outcomes equally likely, the ex-ante expected gain to participation in the scheme is:

$$\frac{1}{2} \times \frac{15}{20} \times \$0.5 - \frac{1}{2} \times \frac{15}{150} \times \$1 = \$0.1375$$

On the other hand, the collective gain to all bidders is:

$$\frac{1}{2} \times \frac{15}{20} \times \$0.5 \times 20 - \frac{1}{2} \times \frac{15}{150} \times \$1 \times 150 = \$ - 3.75$$

In other words, while each bidder expects to gain by participating in the auction, collectively they all lose on average. Obviously something is wrong with the calculations given above. The mistake is that the bidders did not correctly take into account the fact that whenever he wins it is more likely that there were only 20 bidders and whenever he loses it is more likely that there were 150 bidders.

In order to correctly calculate the conditional probabilities, it is convenient to assume (without loss of generality) that N bidders are chosen at random from a larger population N_0. Then, from the perspective of a bidder who is chosen,

$$\Pr\{N = 20\} = \frac{\frac{20}{N_0} \times \frac{1}{2}}{\frac{20}{N_0} \times \frac{1}{2} + \frac{150}{N_0} \times \frac{1}{2}} = \frac{20}{170} \approx 12\%$$

and

$\Pr\{N = 150\} = \frac{150}{170} \approx 88\%$.

The correctly computed ex-ante gain to a participating bidder is:

$\frac{20}{170} \times \frac{15}{20} \times \$0.5 - \frac{150}{170} \times \frac{15}{150} \times \$1 \approx -\$0.044$, which when multiplied by the ex-ante expected number of participants of $\frac{20+150}{2} = 85$ gives the total loss as \$3.75, the same as the total loss we computed earlier.

This example demonstrates how challenging it can be to correctly calculate the expected returns to participating in an auction, and thus how individuals may make costly errors that may eventually discourage them from participating in IPO auctions.

Nonequilibrium models that allow for bidding mistakes have been receiving increasing attention in the literature, motivated by the need to explain some consistent features of both field data and laboratory studies on auctions, such

[43] Effectively we are looking at an asymmetric equilibrium, where one bidder acts as a price taker and $N - 1$ bidders compete among themselves for $K - 1$ lots. This leads to a larger profit per winning bidder due to reduced competition. However, these larger profits now have to be shared among all N participants (including the "free-rider").

[44] http://en.wikipedia.org/wiki/Let's_Make_a_Deal

Impact of Free-Riding

All environment as before, information gathering cost is at 0.96% of ex-ante expected share lot value, so that 25 investors participate in equilibrium under free entry (point A). Figure 7 plots bidder profit, net of information acquisition costs, expressed in % of ex-ante expected share lot value, in the symmetric equilibrium, and in case 5 bidders, unexpectedly to others, forego information acquisition, and make a very large bid instead. In this case, at the previous break-even point of $N = 25$, the expected auction discount becomes negative at -5.4% (point B1), which is equal to the expected loss of each deviating bidder. The other 20 bidders also incur a loss of -3.7% each (point B2), consisting of the information gathering cost of 0.96%, and the loss of each winner of -5.4%, multiplied by the probability of winning the auction of $(15-5)/(25-5) = 0.5$. Figure 8 plots the *gross* bidder profit. The bold line corresponds to the symmetric equilibrium with no deviation, and the point A denotes the break-even case of $N = 25$. The thin solid line shows the gross profit of non-deviating (i.e. information-gathering) bidders in the asymmetric equilibrium where 5 investors deviate and forego information gathering. In this case, the non-deviating bidders no longer break even when $N = 25$, and the new break-even point is at $N = 23$, where the non-deviating bidders have a gross profit of 1.1% (point C2) and the deviating ones have a profit of 2.0% (point C1). Figure 9 shows the auction discount under the symmetric equilibrium, and in case of an unexpected deviation (b). The discount at the break-even point (a) equals to $0.98\% \times 25/15 = 1.6\%$, exactly compensating the 25 participating bidders for the cost of information. The negative discount of -5.4% at point (b) corresponds to an expected loss of -5.4% by each deviating and -3.7% by each non-deviating bidder (B1 and B2 in Figure 7 correspondingly). Figure 10 shows the auction discount under the symmetric equilibrium. At the respective break-even points of $N = 25$ and $N = 23$, the discount is equal 1.6% (a), and 2.0% (b). It is equal to the profit of a deviating bidder (C1 in Figure 8), or to $(23-5)/(15-5) = 1.8$ times the gross profit of a non-deviating bidder (C2 in Figure 8).

Figure 7: Net Bidder Profit and Unanticipated Free-Riding

Off-equilibrium case: 5 bidders "free-ride", and the others don't expect it.

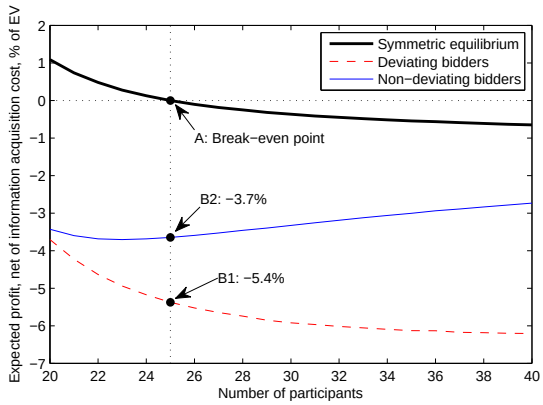


Figure 8: Expected Bidder Profit

Comparison of bidder profits in the asymmetric ("free-riding") equilibrium.

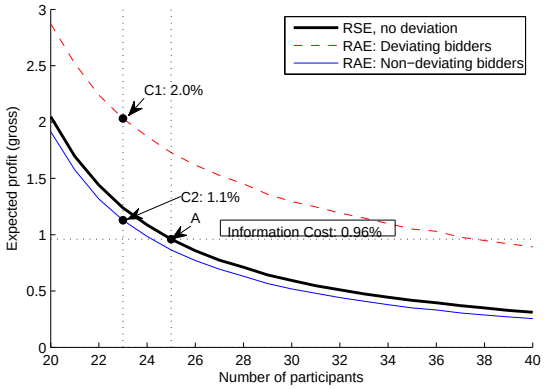


Figure 9: Expected Discount

Auction discount in symmetric equilibrium and unexpected free-riding (off-equilibrium case.)

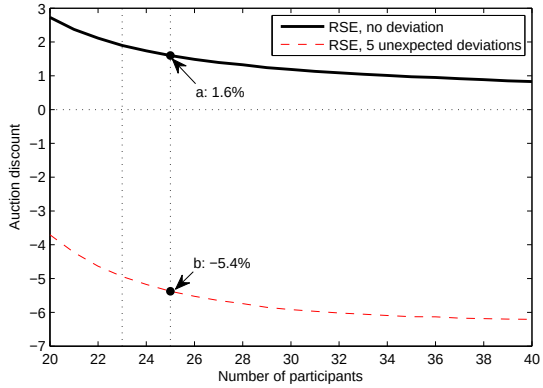
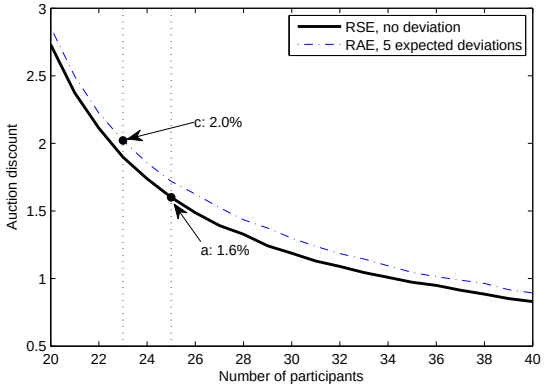


Figure 10: Free-Riding Equilibrium

Asymmetric equilibrium: the bidders expect a given fraction of bidders to "free-ride"



as persistent winner's curse in second price auctions and overbidding in first price auctions. Crawford and Iriberri (2007) investigate such issues in the context of a nonequilibrium model of strategic thinking, where different groups of bidders maintain different beliefs about their environment and the sophistication of their rivals, and show that their model indeed explains the practically observed phenomena that are difficult to reconcile with rational bidding.

4.5. Summary

In this section, we first modeled auctions in a frictionless environment in which all eligible bidders are endowed with valuable private signals and bid in every auction. In this case auctions are underpriced on average, but not by much when bidders are risk neutral and there are sufficiently large numbers of bidders. Risk aversion on the part of bidders increases the average underpricing, but auction discounts are still relatively low. This is the oft-cited auction solution in which more bidders leads to a more efficient result, with underpricing largely vanishing once sufficient numbers of investors bid. Hence, in a frictionless world with no information generation costs, auctions lead to highly efficient pricing as long as they are open to large numbers of informed, sophisticated bidders.

We next examined some more realistic settings, beginning with one in which there is uncertainty over the number of bidders. Bidding becomes difficult when there is uncertainty about the number of bidders, how much they know and what strategies they will follow, leading to more risk, more underpricing and less efficient price discovery. We show that free riders (those who chose to bid very high to be first in line, without investing in information collection) add risk for other bidders and for the issuer, with the issuer ultimately having to underprice more because of the presence of potential free riders. That suggests a role for monitoring bidders and limiting their access to reduce the free riding problem.

Last, we showed that it is not easy to bid in auctions, and even sophisticated bidders can make mistakes. When investors make bidding errors, or when they follow suboptimal strategies such as return-chasing, costs are imposed not only on those bidders themselves but on all auction participants and ultimately on issuers. The bidding errors and problems that we have shown in this section appear to match the problems that have occurred in practice in many auctions around the world, as we will explore in more detail in the next section.

5. Empirical Evidence

In this section we first provide some anecdotal evidence supporting the arguments in the earlier section. We then examine the evidence from Singapore in greater detail. Finally we discuss the US experience with auctions for Treasury securities.

5.1. Anecdotal Evidence on Initial Returns

It is necessary to note that auctions often lead to very large first day gains or losses, which casts doubt upon the popular idea that auctions should necessarily act as a good aggregator of market sentiment and result in accurate pricing (assuming that the first day market price is a good estimate of the "true" value itself). Appendix C.1 lists examples of IPO auctions that have led to large first day gains, while Appendix C.2 gives examples of negative first day returns. One example is the 1993 auction of Japan Railway East, which was in such strong demand that it was heavily oversubscribed and yet traded as high as 70% above the auction clearing price on its first day. In contrast, the later auction of Japan Railway West attracted only about one-fifth as many bidders and was 20% undersubscribed. When El Al, the Israeli Airline, was auctioned off in 2003, demand was so unexpectedly low that orders barely covered the minimum number of shares. Within days, the stock was trading for more than double the auction price (a 112% increase) on the Tel Aviv Stock Exchange. Thus, there are many examples of extreme initial returns resulting from IPO auctions. These do not prove that auctions are inferior to other issue methods, since other methods have also led to large positive or negative initial returns. Nevertheless, these examples show that the pricing accuracy of the sealed bid IPO auction method should not be taken for granted. Regarding the question of whether auctions lead to less underpricing, relative to bookbuilding, the overall evidence is surprisingly weak, since there is little data that allows a direct comparison. The relevant comparisons that have been made to date are the following:

- France: Auctions co-existed with a restricted, sub-optimal form of book building (a sequential hybrid, rather than 'open pricing' which is a simultaneous hybrid) until 1999, when more standard bookbuilding was allowed

and auctions were quickly abandoned. Derrien and Womack (2003) found that the differences in underpricing between auctions and bookbuilding were "small and statistically insignificant when examined unconditionally" (page 47), but that auctions were better than the sequential hybrid bookbuilds in their "ability to incorporate more information from recent market conditions into the IPO price" (abstract), thus confirming that the differences were due to the regulatory restrictions on bookbuilding that were later eliminated.

- Japan: Auctions were required for many years but vanished quickly in 1997, once bookbuilding was allowed. Thus, the two methods did not overlap but were used in close succession. Kutsuna and Smith (2004) found a small but statistically significant increase in initial returns under book building, and also found that a wider range of companies, including younger start-ups, were able to go public under book building.

- India: Regulations were changed in 2005 to prohibit bookbuilding, replacing it with auctions. Bubna and Prabhala (2009) find that auctions led to more underpricing, relative to bookbuildng.

The evidence is inconclusive, since auctions have led to less underpricing in Japan, more underpricing in India and to no statistically significant difference in France, relative to bookbuilding.

5.2. IPO Auctions in Singapore

The available data on auctions is sparse and not easily amenable to rigorous quantitative analysis using statistical methods, since most countries that have tried IPO auctions gave up on them after a few years, leading to small samples. For example, the influential Kandel, Sarig and Wohl (1999) paper is based on only 28 IPO auctions in Israel, while Degeorge, Derrien and Womack (2007) examine only 19 auctions in the U.S. Moreover, data on participation levels are often unavailable.

Singapore's IPO auctions during 1993-1994 present an interesting natural experiment and an illustration of some of the potential issues that we believe is of general relevance. We have data on the full sample of all 20 uniform price IPO auctions in Singapore, and will attempt a quantitative characterization of that data in this section.

The lessons from the Singapore experience are relevant for several reasons. First, Singapore is a sophisticated financial center whose banking and security markets are well regulated. One example of its technological sophistication is the fact that IPO auction bidders beginning in 1993 could place their bids through automated teller machines (ATMs), thus making those auctions as widely accessible as online internet auctions are today. The Singapore stock market in 1993 was fairly well developed and active, with two active exchanges, 241 public companies traded, and 280MM S$ of average daily dollar transaction volume[45].

Singapore's uniform price auctions were hybrids and thus were well suited to reduce the impact of free riders, since uninformed investors could also participate, without specifying a price, through the simultaneous fixed price tranche. Therefore, if there is evidence of free riders including return chasers becoming an issue in hybrid uniform price auctions, they are likely to be even more of an issue in 'pure' uniform price auctions.

5.2.1. The Data

We use data on all 20 Singapore IPO issues that were held during 1993-1994, which include 20 uniform price hybrid auctions (tenders) and 31 pure fixed price issues[46] . The available statistics include size of individual tranches (fixed price, tender, employee, and private placement), number of shares outstanding and offered, IPO clearing price, interval data on bids collected (number of bids and number of shares bid in a given price range), obtained from the Stock Exchange of Singapore.

In addition we use market performance data from Bloomberg Finance L.P., and an archive of Singapore English-language financial press available through Lexis-Nexis Academic.

The main shortcoming of our data is its fairly low duration – there were only 20 IPO's conducted in Singapore during those two years, and the method has never been tried there again.

For each of auctions $t = 1..T$ we know:

- J_t bid intervals $[\underline{b}_{jt}, \overline{b}_{jt}]$, $\overline{b}_{J_t t} = +\infty$

[45] Daily average exchange rate in 1993 US$1 = S$1.57

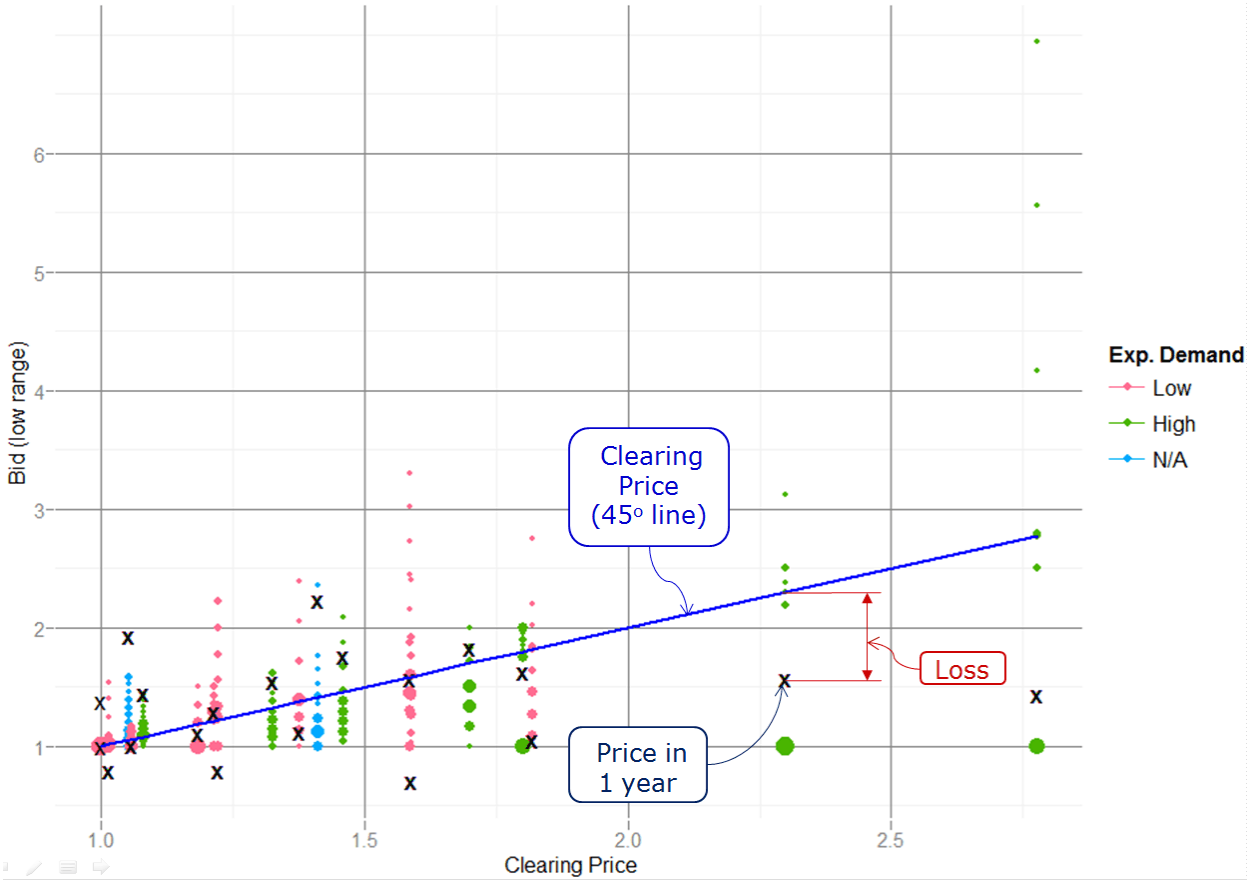
[46] A list of these is available upon request, along with a detailed description of the regulations.

- q_{jt}: the total number of shares applied for in $[\underline{b}_{jt}, \overline{b}_{jt}]$
- n_{jt}: the total number of applications in $[\underline{b}_{jt}, \overline{b}_{jt}]$
- m_t: Clearing price

Figure 11 illustrates the bid distribution in the 20 auctions. Each circle represents the low point $\underline{b}_{jt}$ of a range for a group of bids in a particular auction; circle size is proportional to the relative size of that group within the auction. Fixed price is normalized to 1 for all auctions. "x" denotes the price after 1 year. Auction clearing price m is on the horizontal axis. Blue solid line is a "45-degree" line $\underline{b}_{j,t} = m_t$ and denotes locations of the marginal winning bids.

Figure 11: Bidding in Singapore IPO's

Each circle represents the low point of a range for a group of bids in a particular auction; circle size is proportional to the relative size of that group within the auction. Fixed price is normalized to 1 for all auctions. "x" denotes the price after 1 year. Auction clearing price on the horizontal axis. A "45-degree line" denoting locations of the marginal winning bids in blue. "High" and "Low" expected demand auctions are ranked according with demand forecasted using the specification in (6).



5.2.2. Singapore IPO's: a Short History

The hybrid auction scheme was first introduced as an option for Singapore on July 29, 1991, when companies were allowed to offer part of the issue in a "Dutch" (discriminatory) auction. It, however, has not gained much popularity, with only one Dutch tender IPO (Singapore Computer Systems) in 1991, and one more (Keppel Integrated Engineering) in 1992[47]. No other IPO auctions took place in Singapore until February 1993, when an alternative uniform price ("French") auction system was introduced.

[47] See Hameed and Lim (1998)

Figure 12: Singapore IPO Issues: Size, Time, and Annual Returns

Top panel: 1-year market adjusted return vs. subscription closing date. Color: subscription rate (ratio of shares applied to shares offered). Colored circle proportional to value of the tender tranche. Gray area proportional to fixed price tranche. Thin solid circle proportional to market value (all evaluated at the fixed tranche price). Thin dotted line shows aftermarket movement from first day close.
Bottom panel: Thick green line: 90-day cumulative return on the STI index. Thin red line: 90-day cumulative return on a buy-and-hold portfolio of last 4 tender IPO shares, purchased at tender price (equally weighted)
Sources: Stock Exchange of Singapore and Bloomberg Finance L.P.

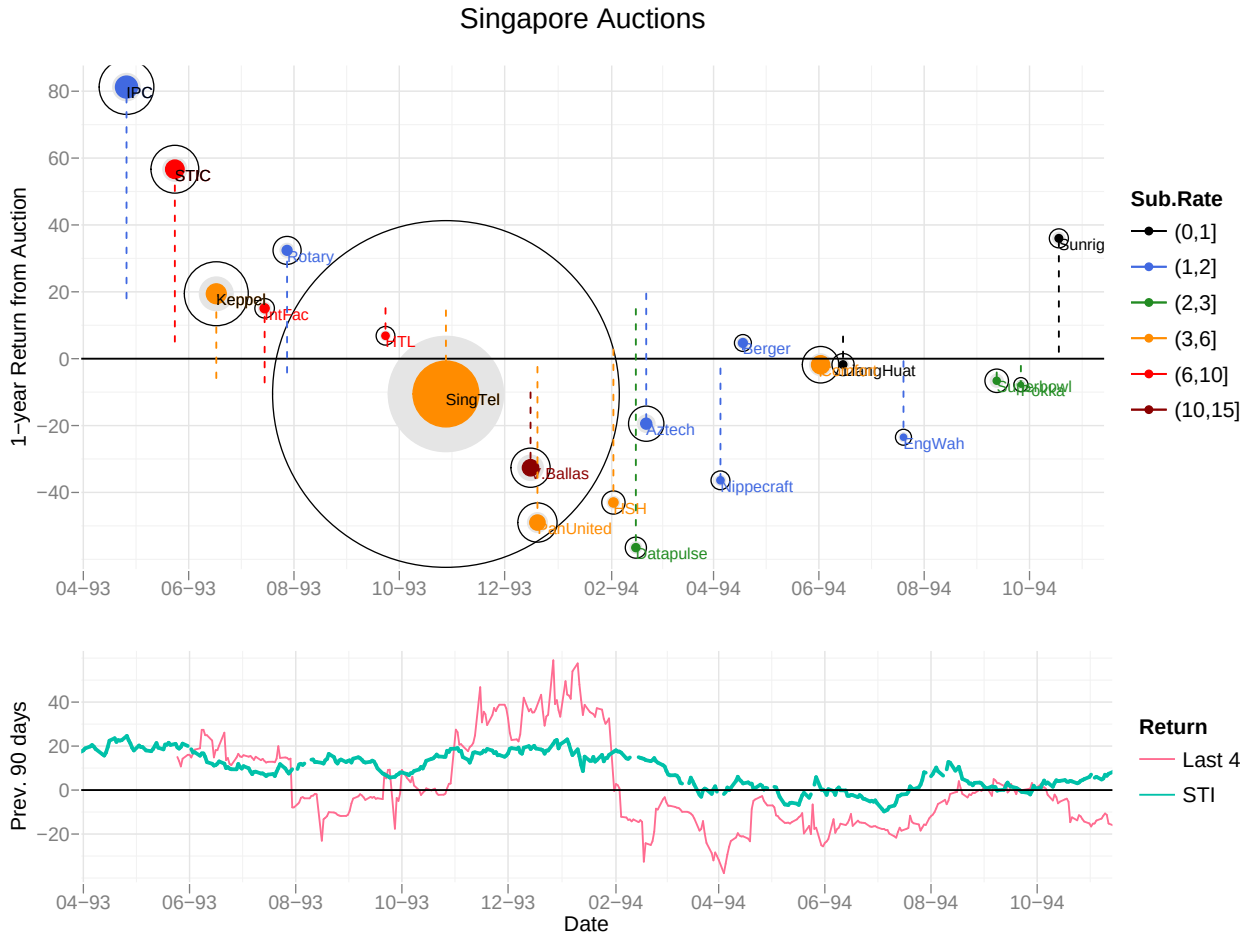
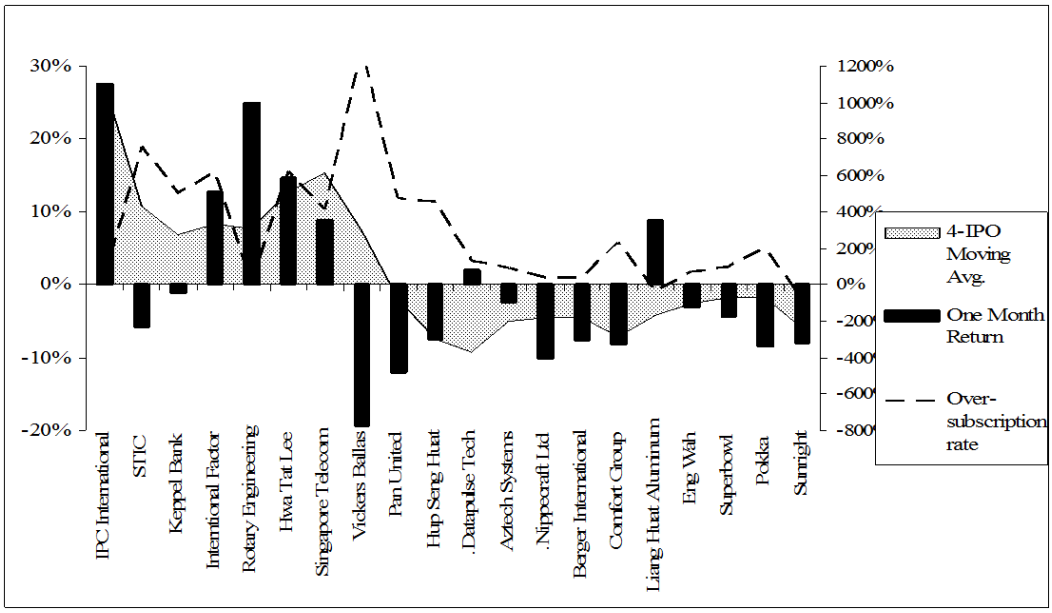


Figure 13: One month buy-and-hold returns and subscription levels in Singapore

All 1993-1994 auctions are ordered by date. One month raw returns are the returns to winning bidders that held their shares for 30 days in the aftermarket. The 4-IPO moving average is the average return on the last 4 offers (or all previous, if less than 4). The oversubscription rate is in percent – an offering that was 60% oversubscribed received orders for 1.6 times the shares available.



A timeline showing Singapore IPO auctions' size, 1-year returns and subscription levels in 1993-1994 is shown in Figure 12 and Table 4.

Figure 13 provides visual evidence of how Singapore's auctions evolved over time by plotting one month returns and subscription levels for all of Singapore's auctions, ordered chronologically. Although there were variations, the returns and participation levels for IPO auctions fell over time. Investors would have made money on five of the first seven uniform price auctions (known as tenders) in Singapore, if they had bought at the auction strike price and sold after the shares had traded for one month. The average raw return on the first seven offerings was 11.7%, for this holding period, and the average oversubscription ratio was 4.2 (420% oversubscribed). However, the returns were negative for seven of the last eight auctions done in Singapore, with an average one-month return of -5.1% for these auctions (tenders)[48]. People noticed the poor performance, complaining that auctioned IPO shares were falling below their auction strike price on the aftermarket and joking that they must be catching a new disease called "tenderitis"[49].

While the oversubscription level for the last eight auctions was 0.7, which means that offerings were still on average 70% oversubscribed, this was substantially lower than the average of 420% oversubscription for the first 7 auctions. Two of the last five auctions were undersubscribed, including the last auction, for Sunright, which received bids for only 18% of the shares available. The average number of bidders per auction was 48,095 for the first seven auctions[50] and 6,494 for the last eight. The decrease in returns is similar if we calculate the one month returns relative to the Straits Times Index (blue chips) or Sesdaq Index (smaller, younger companies), or if we use two month

[48] A similar pattern occurred for the 19 U.S. IPO auctions that have been lead-managed by WR Hambrecht from 1999-2007 analyzed in Degeorge et al. (Forthcoming). For the first 9 IPOs, from 1999-2003, the mean initial return is 29.1% with a standard deviation of 84.3%. Excluding Andover.net, which is arguably an outlier, the mean and standard deviation are 1.3% and 11.5%. For the next 10 IPO auctions from 2004-2007, the mean initial return is -0.1% with a standard deviation of 5.3%. This less attractive performance, from the standpoint of investors, in the second half of the sample may at least partially explain why there have been no OpenIPOs since May, 2007. However, there have since been two other U.S. IPO auctions lead-managed by other investment banks - Netsuite in December, 2007 with an initial return of 36.5% and Rackspace in August, 2008 with an initial return of -19.9%.

[49] "New strategies needed for future IPOs", Ven Sreenivasan, Singapore Straits Times, p. 13, February 3, 1995.

[50] The average is 23,196 for the first six auctions, excluding the unusually large Singapore Telecom offering.

Table 4: Singapore Tender IPO Issues: Subscription and Returns

Subscription rate is defined as a ratio of the number of shares applied for in a tender issue to the number of shares available as of the closing date of the subscription period. The raw returns are total returns to a bidder who purchased a share at the auction clearing price and sold at the close of the corresponding period. Adjusted returns are defined as the difference between raw and market returns (as measured by the Straits Times Index) in the corresponding period. All market returns are adjusted for dividends.

Company	Date	Subscription Rate		Return							
		Fixed Price	Tender	1 day		1 week		1 month		1 year	
				Raw	Adj.	Raw	Adj.	Raw	Adj.	Raw	Adj.
IPC Corporation	04/26/93	3.9	1.2	22.5%	18.0%	18.1%	12.5%	27.5%	24.2%	81.3%	51.2%
Spore Tech Industrial Corp.	05/24/93	3.9	8.6	4.2%	5.1%	-2.5%	-0.2%	-5.8%	-2.2%	56.7%	36.1%
Keppel Bank	06/17/93	16.1	6.0	-5.7%	-5.8%	-8.6%	-6.9%	-1.1%	-4.8%	19.4%	0.4%
International Factors	07/15/93	29.2	7.2	-4.8%	-7.1%	-2.4%	-8.7%	12.7%	-0.9%	15.1%	-11.6%
Rotary Engineering	07/28/93	8.1	1.2	2.8%	-4.2%	2.8%	-6.4%	25.0%	11.4%	32.4%	6.0%
Hwa Tat Lee Holdings	09/23/93	41.0	7.2	19.6%	15.1%	12.7%	6.5%	14.7%	9.9%	6.9%	-5.6%
Singapore Telecom	10/28/93	3.0	5.1	15.0%	14.5%	6.1%	10.8%	8.9%	9.6%	-10.6%	-14.0%
Vickers Ballas	12/16/93	30.9	14.0	-6.0%	-10.1%	-8.7%	-14.4%	-19.3%	-20.3%	-32.6%	-21.6%
Pan United Corporation	12/20/93	16.5	5.8	4.0%	-2.4%	-5.0%	-11.1%	-12.0%	-14.2%	-49.0%	-37.6%
Hup Seng Huat	02/02/94	32.7	5.6	1.0%	2.8%	0.0%	-1.7%	-7.5%	-0.1%	-43.0%	-27.0%
Datapulse Technology	02/15/94	34.0	2.3	15.0%	14.9%	10.0%	12.5%	2.0%	14.6%	-56.5%	-41.6%
Aztech Systems	02/21/94	13.6	1.9	17.4%	19.5%	15.7%	20.5%	-2.5%	10.4%	-19.4%	-3.7%
Nippecraft	04/05/94	11.2	1.4	2.7%	-2.9%	-2.7%	-9.5%	-10.0%	-17.2%	-36.4%	-29.2%
Berger International	04/18/94	19.6	1.4	4.7%	2.8%	-5.3%	-4.4%	-7.6%	-8.7%	4.7%	16.0%
Comfort Group	06/02/94	24.4	3.3	-4.5%	-5.1%	-5.4%	-4.6%	-8.1%	-6.4%	-1.8%	5.2%
Liang Huat Aluminium	06/15/94	8.5	0.6	4.4%	6.6%	3.5%	6.3%	8.8%	8.7%	-1.8%	6.4%
Eng Wah Organization	07/20/94	4.4	1.8	0.8%	-0.7%	-5.3%	-7.1%	-3.0%	-6.9%	-23.5%	-16.9%
Superbowl	09/12/94	2.3	2.0	-3.3%	-4.1%	-6.6%	-7.4%	-4.4%	-7.2%	-6.6%	2.6%
Pokka	09/26/94	8.1	3.0	-0.7%	-2.1%	-8.5%	-9.5%	-8.5%	-8.5%	-7.7%	1.0%
Sunright	10/18/94	1.2	0.2	2.0%	2.0%	-3.3%	-3.4%	-8.0%	-1.7%	36.0%	48.3%
Total											
Average		15.6	4.0	4.6%	2.8%	0.2%	-1.3%	0.1%	-0.5%	-1.8%	-1.8%
Standard Deviation		12.4	3.4	8.7%	9.1%	8.3%	9.6%	12.4%	11.5%	35.4%	25.6%
% Negative		-	-	30.0%	50.0%	60.0%	70.0%	65.0%	65.0%	60.0%	50.0%
Min		1.2	0.2	-6.0%	-10.1%	-8.7%	-14.4%	-19.3%	-20.3%	-56.5%	-41.6%
Max		41.0	14.0	22.5%	19.5%	18.1%	20.5%	27.5%	24.2%	81.3%	51.2%

returns. It would appear that for investors who were learning and updating their priors over time, auctions became less attractive.

We argued in Section 4.2 that a large number of unanticipated bids will result in the auction clearing price being too high, whereas a surprisingly low subscription rate will lead to large underpricing. We further observed that unanticipated free riders, including return-chasers, may make auctions less attractive for sophisticated investors. We examine the data in three steps to see whether there is support for these conjectures.

5.2.3. Evidence of Return-Chasing Behavior

Here we investigate what factors affect popularity of a particular IPO auction and whether there is evidence of return-chasing behavior.

First, we check whether high returns to participating in the preceding auction leads to a higher participation rate in the current auction, using the following regression (Equation 4):

$$S_{Ai} = \alpha_0 + \alpha_1 S_{Fi} + \alpha_2 r_{i,lag30d} + u_i \tag{4}$$

where:

- S_{Ai} is the subscription rate in the i^{th} auction;
- S_{Fi} is the subscription rate in the fixed price tranche, included here to control for unobserved issue-specific factors affecting the demand for shares;
- $r_{i,lag30d}$ is the return that would have been obtained by buying in the $(i-2)^{nd}$ auction and selling one month after trading begins.

Since in Singapore the auction and fixed price tranches occurred simultaneously (as opposed to countries like Taiwan where tranches took place sequentially,) fixed price tranche demand is a good proxy of overall demand at the time of the auction.

For the return from a previous auction, $r_{i,lag30d}$, we use the return from 2 auctions ago because the one month return on the $(i-1)^{st}$ auction is in general not available by the time the i^{th} auction is open for bidding[51]. We also consider the following variation (Equation 5) of equation (4) above:

$$N_{Ai} = \alpha_0 + \alpha_1 N_{Fi} + \alpha_2 r_{i,lag30d} + u_i \tag{5}$$

where:

- N_{Ai} is the number of persons bidding in the ith auction divided by the dollar value of shares offered in the auction tranche, at the reservation price;
- N_{Fi} is the number of persons bidding in the ith auction's fixed price tranche divided by the dollar value of shares offered in the fixed price tranche.

The results are shown in Table 5, and seem to indicate the presence of "return-chasers". The coefficients for both variables have the predicted sign and are significant at the 1% level. The auction subscription rate and number of bidders are significantly positively related to our proxy for overall demand, as expected. And, after controlling for demand, the subscription rate or number of bidders is significantly positively related to the return on the second-to-last auction, which is a sign of return-chasing. The R^2 is 60% for Equation 4 and 39% for Equation 5.

Thus, both higher underlying demand and a higher return to participating in a recent auction lead to higher participation in the current auction.

It is also of interest how much of the variation in demand could be explained by the factors that were observable by the participants in real time, i.e. before the subscription date. Therefore in the following specification we replace

[51] In two cases we had to use the 30 day return on the $(i-3)$'rd auction since the return on the $(i-2)$'nd auction was not available when the i'th auction opened.

Table 5: Determinants of Auction Subscription in Singapore

The dependent variable is the auction subscription rate (ratio of the total number of shares requested in all bids to the number of shares offered) for Equation 4 and the number of bidders in the auction for Equations 5 and 6. The subscription rate or number of bidders in the fixed price tranche are used to control for overall demand for the shares. Other controls: 90-day cumulative return on a buy-and-hold portfolio of last 4 tender IPO shares, purchased at tender price (equally weighted), and an increased news coverage dummy (see Section 5.2.3 for details).

	Eq. 4	Eq. 5	Eq. 6
Subscr. rate in fixed tranche	0.18***		
	(4.27)		
Number bidding in fixed tranche		0.03***	
		(3.29)	
1 month ret. on next-to-last auction	14.18***	-.001***	
	(3.5)	(2.26)	
90-day ret. of 4-auc. portfolio			11.05***
			(4.14)
Increased news coverage			2.72**
			(2.28)
Constant	0.74	-0.00	3.18***
	(0.85)	(0.77)	(5.06)
R^2	0.60	0.39	0.56
Obs.	18	18	18

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

the unobservable (to auction participants) characteristics of the simultaneous fixed price tranche with a news coverage variable[52] (Equation 6):

$$N_{Ai} = \alpha_0 + \alpha_1 \Delta NEWS_i + \alpha_2 r^p_{i,lag90d} + u_i \tag{6}$$

where:

- $\Delta NEWS_i$ is a dummy variable equal to 1 if the current IPO receives more news coverage[53] than the median of all the past auctions, and 0 otherwise
- $r^p_{i,lag90d}$ is the cumulative 90-day return on an equally weighted buy-and-hold portfolio of shares offered in the past 4 auctions, purchased at the tender price[54], on the last business day prior to the day of subscription

It is easy to see that these real-time variables explain somewhat over half of the variation in participation (R^2 = 56%), again suggesting that return-chasing was taking place. Again, the coefficient on recent auction return is positive and significant at the 1% level.

While a higher participation rate in the auction is positively related to a higher auction clearing price, the higher price may be "rational", reflecting a higher intrinsic value of the issue over and above that reflected in the fixed price (and over and above the higher value reflected in fixed price tranche demand) – for example, Sherman (2005) models sealed bid auctions in which informed bidders are following the optimal entry and bid-shaving strategy. This model predicts that when the intrinsic value of the offering is higher, both the auction clearing price and the initial return to winning bidders will be higher. It is therefore important to further investigate whether noise bidders adversely affected the environment.

5.2.4. Bid Distribution and Future Returns

One reason for a high clearing price is naturally a high realization of the share value. Another possible reason for such results may be the presence of free-riders: bidders who do not engage in price discovery but instead name a very

[52] See Liu, Sherman and Zhang (2009) for analysis of the role of media coverage in IPOs.
[53] Measured by the number of articles that mention the IPO in Singapore business press in the 4 weeks before the subscription date
[54] Green line in Figure 12

high price in order to obtain an allocation. In an asymmetric equilibrium with such free-riders (whether anticipated or unanticipated) the distribution of bids will be mixed: the free-riders would bid high regardless of the underlying value, and the other bidders would bid according to their signals.

Cornelli et al. (2006) note that "in the case of IPOs, Ritter and Welch (2002) conjecture that overenthusiasm among retail investors may explain high first-day returns and low long-run returns. However, the extent to which the presence of irrational investors (motivated by "investor sentiment") can account for these phenomena is controversial, not least because of the difficulty in empirically identifying the demand curves of different investor groups". This difficulty presents a problem for us as well, since due to the multiple censoring of our dataset it is not possible for us to directly observe individual bids. However in what follows we present several quantitative results that seem to confirm irrational investors' presence.

The number of bid ranges in our bid data and their breakpoints are auction-specific and do not allow for direct comparison between auctions. However, in presence of free-riders there should be aggregate effects: namely, their presence should increase the variance of the bid distribution and create positive skewness.

On the other hand, a high mean bid can be a signal of either high underlying value, or free-rider presence, or both. Therefore, controlling for the mean, we would expect free-riders to drive up auction prices relative to the underlying value, and potentially cause future negative returns. In line with prior reasoning, we would also expect free-riders to be more prevalent among smaller individual bidders[55].

We use a two-step estimation procedure: first, we approximate the bid distribution in each auction by a separate lognormal distribution. This distribution choice allows us to capture changes both in the mean (potentially attributed to higher underlying value and overall, rational or irrational, level of excitement about the issue) and in the skewness and variance (which both positively depend on the same parameter σ). In addition, these parameters, unlike range statistics, can be compared across auctions.

We use maximum likelihood to estimate the bid distribution parameters:

$$(\hat{\mu}_t, \hat{\sigma}_t) = \underset{\mu,\sigma}{\operatorname{argmax}} \prod_{j=1}^{J_t} \left(F(\bar{b}_{jt}|\mu,\sigma) - F(\underline{b}_{jt}|\mu,\sigma) \right)^{n_{jt}}$$

where the observed values J_t, b_{jt}, n_{jt} are as described in Section 5.2.1.

Figure 14 shows the estimated μ and σ for the applications distribution in the 18 auctions for which we have sufficient data[56]. As one can see, most losses characterize auctions with either a high μ, or a high σ, or both, which is a picture that one would observe in presence of a large number of bidders who do not engage in price discovery.

Table 6, Panel A illustrates the relationship between the parameters of the applications distribution and future returns. Given the small sample size, a robust version of the estimation is presented in Table 6, Panel B, showing similar results. We can see from these tables that either a high μ, or a high σ, or both, are significantly negatively related to one year returns on the offerings, as one would expect if the auction price and initial demand are influenced by a large number of bidders who do not engage in price discovery.

One last piece of evidence of the presence of free riders in our data is the analysis of the very highest bids. If a bid is so high that it seems implausible as a genuine result of careful analysis, the more likely explanation is free riding, and thus we look for excessively high bids in our data. In four of our twenty auctions, the highest bids were more than 1,000% of the reservation price. The highest bid was 1,153% (817%) of the reservation price (clearing price) for STIC, 1,200% (1,182%) for Eng Wah, 1,700% (1,000%) for Hwa Tat Lee Holdings and 5,000% (2,778%) for Singapore Telecom. In the case of Singapore Telecom, the reservation price of $2.00 translated to a prospective price-earnings (PE) multiple of 27 times. The highest bid was 50 times this, implying a PE of 1,350 times for a mature company in an established industry. This is clear evidence of the presence of at least some free riders, while our earlier analysis indicates that there were sufficient numbers of such investors to affect the auction price.

[55] For IPO auctions in Taiwan, Chiang et al. (2009a) find that institutional investors are informed and bidding optimally, but that retail investors are return-chasing and following suboptimal bidding strategies. Chiang et al. (2009b) find further evidence that retail (but not institutional) investors in Taiwan's IPO auctions suffer from nave reinforcement learning, while Degeorge et al. (Forthcoming) find evidence of free riding and possible return-chasing by retail investors in U.S. IPO auctions.

[56] Since two auctions were undersubscribed, we are not able to estimate the bid distribution shape there. However we note that both of these auctions produced positive returns (48.3% in case of Sunright and 6.4% for LiangHuat Aluminum), and their undersubscription implies either a low μ, or low σ, or both, so we consider our results to be conservative

Figure 14: Applications Distribution and IPO Returns

Returns are market-adjusted (using STIC index); 1 year from tender. Circle area proportional to absolute return; red filled circles represent losses; blue crossed circles represent gains.

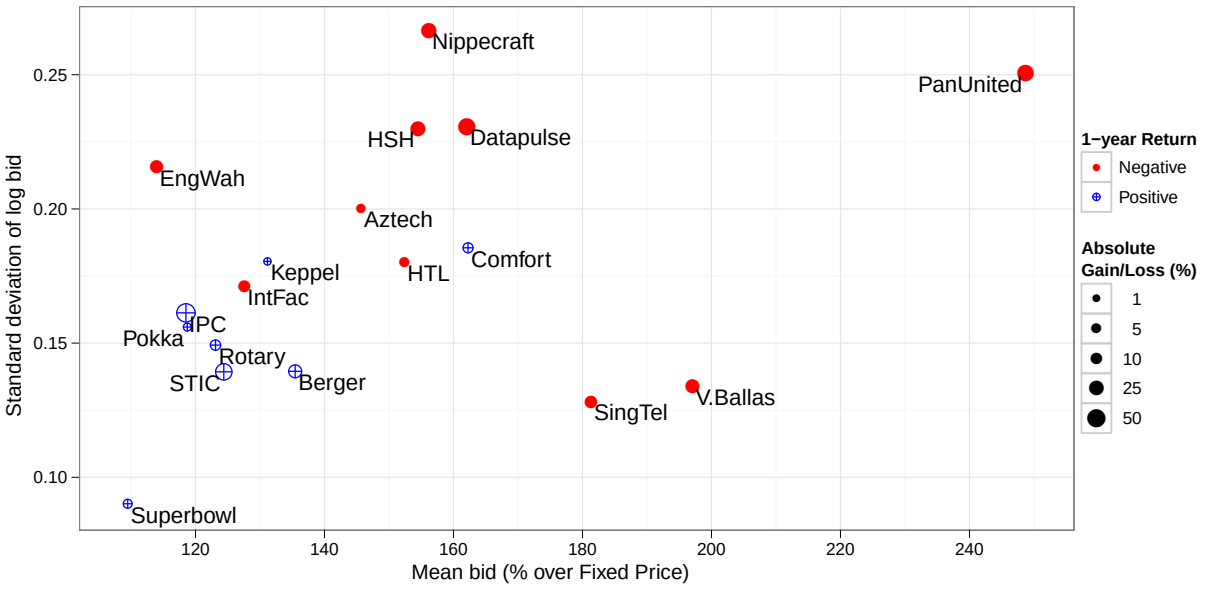


Table 6: Applications Distribution and IPO Returns

Regressions of gross returns to investors who get in and out of a position at different points in time on estimated parameters of the distribution of bids in the IPO auction. Returns are between the points listed, which are (FIX: fixed price tranche, AUC: auction clearing price, 1D: first trading day close, 1Y: last close in the first year of trading), market-adjusted where relevant: e.g. (FIX, AUC) is the auction premium, and (1D,1Y) is the market-adjusted return from the first day to the first year close. σ and μ are the estimated parameters of the fitted lognormal distribution. Panel A shows results from a regular least squares regression (robust variance estimates are used). Panel B reports coefficients from robust regressions that reduce the impact of outliers (see Hamilton (1992) for a detailed description).

	(FIX, AUC)	(FIX, 1D)	(FIX, 1Y)	(AUC,1D)	(AUC,1Y)	(1D,1Y)
Panel A: Least Squares Estimates						
$\hat{\sigma}_N$	-0.536	-0.270	-3.289**	0.171	-2.179**	-2.285**
	(-0.76)	(-0.25)	(-2.60)	(0.32)	(-2.62)	(-2.86)
$\hat{\mu}_N$	1.269***	1.237***	0.385*	-0.0129	-0.486**	-0.451**
	(14.85)	(7.93)	(1.77)	(-0.10)	(-2.48)	(-2.65)
Constant	0.0145	0.0136	0.715**	0.000676	0.509**	0.495***
	(0.13)	(0.08)	(2.67)	(0.01)	(2.80)	(3.27)
R^2	0.866	0.721	0.298	0.006	0.502	0.571
Obs.	18	18	18	18	18	18
Panel B: Robust Estimates						
$\hat{\sigma}_N$	-0.478	-0.129	-3.077*	0.123	-2.088**	-2.244**
	(-0.72)	(-0.12)	(-2.08)	(0.16)	(-2.19)	(-2.32)
$\hat{\mu}_N$	1.271***	1.226***	0.435	-0.00493	-0.385*	-0.438*
	(8.51)	(5.17)	(1.31)	(-0.03)	(-1.80)	(-2.03)
Constant	0.00306	-0.00910	0.639**	-0.00856	0.433**	0.480**
	(0.03)	(-0.05)	(2.51)	(-0.07)	(2.65)	(2.90)
R^2	0.841	0.670	0.237	0.002	0.458	0.501
Obs.	18	18	18	18	18	18

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5.3. *Lessons from Treasury Auctions*

The auction method is old and well established, and has been particularly successful for the largest security issue markets – those for government debt, particularly US Treasury securities. Auctions have been frequently used for new preferred stock issues in the United Kingdom, particularly for government-owned utilities[57]. Key differences between government debt and IPOs make auctions theoretically more likely to work for these high grade debt auctions. First, Treasury auctions are held frequently at regular time intervals, with a core of regular participants. Fleming (2007) shows that, for 903 US Treasury security auctions between July 30, 2001 and December 28, 2005, 75.4% of the securities were purchased by dealers and brokers. Although there are more than 800 financial institutions set up to bid directly in Treasury auctions, they accounted for only 0.5% of the allocations, with individuals accounting for another 0.5%. Thus, Treasury auctions have a stable set of regular bidders – the 22 primary dealers that are expected to participate regularly. Moreover, close substitutes to the extremely high grade debt securities being issued are already trading actively in the market (on the when issued market, through the off the run securities, etc.), making valuation relatively easy and precise.

In spite of these advantages it took several decades for auctions to replace the fixed price method for selling Treasury bonds, even after auctions had been adopted for US Treasury bills. Garbade (2004) provides a detailed analysis of this process, noting in particular how back in 1959 the Secretary of the Treasury Robert Anderson in his testimony before the Joint Economic Committee defended the fixed price method, stating that "many of the small banks, corporations, and individuals... did not have the professional capacity to bid in an auction. Lacking professional expertise, they were liable to either bid too high and pay too much or bid too low and be shut out, and therefore were likely to avoid note and bond auctions altogether". Garbade (2004) further demonstrates that these worries were quite well-founded, given that the US Treasury failed in its first two attempts, in 1935 and 1963, to establish auctions for long term bond sales. The third attempt, in the early 1970s, succeeded due to the Treasury's combined "familiarity, gradualism, and willingness to improvise".

Fleming and Garbade (2002, Table 2) show that even now, of the four main securities lending facilities in the US and UK, two of the four use fixed price offerings rather than auctions. One reason for this can be that bidding is difficult even for today's sophisticated institutional investors. For example, Fleming and Garbade (2007) offer evidence that dealers frequently fail to shave their bids sufficiently in certain types of US Treasury auctions, passing up "true arbitrage opportunities" in these auctions. Fleming et al. (2005) show that they also fail to exploit certain simple mechanical profit opportunities[58]. On the other hand, Goldreich (2007) shows that both discriminatory and uniform price Treasury auctions lead to underpricing. Thus, even in cases when some of the easiest-to-value securities are sold to a regular set of sophisticated investors, there is evidence that the auction method has not always been preferred over fixed price methods, and that these regular bidders sometimes lack the sophistication to place optimal bids. In contrast, IPOs occur less frequently, at sporadic intervals, and their value is much more difficult to determine. Each issue is different and may attract a different set of participants, many of whom have little relevant experience. Thus, the apparent relative success of contemporary auctions for government debt does not guarantee that the auction method will also be preferred for IPOs.

As we can see, even in Treasury auctions, it took a while to make things work. The key feature is the stable number of sophisticated bidders, coupled with a noncompetitive tranche to accomodate unsophisticated bidders.

6. Conclusion

In this paper, we first established a surprising empirical regularity - that IPO auctions have been tried in at least 25 countries, and have generally been rejected in favor of other methods for bringing new equity issues to the market. IPO auctions have been used for issues of all sizes, from very small to very large. The auction methods used have varied, yet the outcomes have been surprisingly consistent: When issuers have been given a choice, they have generally chosen not to use auctions once they became familiar with the method. In this sense, IPO auctions have consistently failed the market test.

[57] In the six month period from Oct. 1, 1974 to March 31, 1975, all seven preferred stock issues in the UK used "Offers for Sale by Tender", i.e. auctions. The issuers were all local waterworks or water companies.

[58] Due to the specific price rounding scheme used in Treasury bill auctions, some bids offer strictly inferior expected profits; however many participants still bid at those suboptimal levels

We did not find support for the common explanations offered for the unpopularity of IPO auctions in the US - that issuers were reluctant to use a new, experimental method, or that underwriters pressured issuers to use a method for which they charged higher fees or were able to allocate underpriced shares. We did not find that issuers consistently preferred the method that led to the lowest initial returns. Moreover, there is little support for the popular view that auctions lead to highly accurate pricing and hence to a low mean and variance of initial returns.

In order to explain these regularities, we examine the issue of complexity. While indirect mechanisms, such as auctions, may have simple rules, this does not imply that the investors' task is in any way simple: for example, bidders must place their bids before knowing how many others will enter the auction, and those who invest time and money evaluating an offering risk being squeezed out by others who do not adequately understand the optimal bidding strategies and perhaps have no information on the value of the shares.

The optimal bid for any one participant depends on the number of other bidders, their information sets and their bidding strategies, but none of this is known at the time that bids are placed in a sealed bid auction – presenting a structural risk, which can easily exceed the uncertainty about valuation of the company itself. In other words, optimal auction bidding strategies are complicated, requiring sophistication and discipline, and mistakes by some impose costs on all bidders. Without some way to screen out "free riders" and ensure the participation of sophisticated, long term investors, IPO auctions are highly risky for both issuers and bidders.

Bookbuilding, on the other hand, is closer to a "direct" mechanism and therefore requires less bidder sophistication. With book building the underwriter can act as a gatekeeper, coordinating the number and type of entrants, and setting the price and allocations only after observing all orders. In a realistic example, we solve for an optimal direct mechanism with multiple investors, and show that it is in fact characterized by many features that are associated with bookbuilding in real life.

At the same time, bookbuilding gives enormous discretion to the mechanism administrator (i.e. underwriter), whereas auctions are transparent with little discretion. Bookbuilding is thus vulnerable to abuse by underwriters, at the expense of issuers. Jagannathan and Sherman (2005) propose ways to make bookbuilding more transparent and thus, effectively, closer to auctions in that sense. The optimal placement method is likely to be different from both traditional book builds, with their lack of transparency and resulting opportunities for potential abuse, and standard sealed bid auctions, with their high risk for both investors and issuers.

Standard sealed bid auctions have rigid, automatic pricing and allocation rules that do not appear to satisfy the many goals that issuers have for IPOs, based on the market test. However this does not mean that optimal auctions – or more generally, transparent placement methods – cannot be designed. Thus, we proposed a direct-revelation ex post incentive compatible optimal uniform price mechanism, demonstrating roles for both informed and uninformed investors to play, and then we compared its properties to those that have been observed in actual issues. We also demonstrated how such a mechanism can be used to ensure sufficient information collection in case of costly signals, comparing revenues and other properties with those of a hybrid auction.

Although the outcomes in various countries have been surprisingly consistent in terms of which issue methods have been chosen by issuers, it is important to offer a menu of alternatives to issuers, since the best method may depend on conditions and may change over time. For example, uniform price auctions may be a better method in exuberant times, when accurate evaluation is difficult and thus not the main driver of pricing, such as with dot.coms during the internet bubble. At the time, no one knew how to value the stocks. The use of uniform price auctions would have allowed the offer prices to be driven up until the shares were overpriced by most estimations, leading to aftermarket price drops that would have popped the bubble earlier. Since each issue method has advantages and neither clearly dominates, only the market can tell whether there is a place for both or only one of them. We should have competing mechanisms available to issuers.

In summary, there have been many experiments with IPO auctions across different countries, cultures and market conditions over the last several decades. The auction method has failed the market test, in the sense that issuers have eventually rejected the method in virtually all countries in which issuers were allowed to choose among alternatives. We offered an explanation for this, based on the complexity of optimal bidding strategies and the vulnerability of each bidder to mistakes by others. We modeled this explanation and proposed an alternative direct mechanism for IPOs, comparing its properties with those of a hybrid auction.

Appendix A. Auctions vs. Bookbuilding

In this Appendix we show that uniform price auctions can do what book building can do in terms of price discovery and underpricing when the cost of gathering information is sufficiently large, and there is a binding minimum amount that must be allotted to uninformed investors. For this purpose, we examine two uniform price[59] IPO placement mechanisms in a stylized economy. One is an optimal direct allocation mechanism, somewhat resembling book building in its' setup and the resulting outcomes (hereafter referred to as book building for convenience), and the other is a hybrid auction. Both methods provide for allocation of shares to competing sophisticated informed investors as well as uninformed and possibly unsophisticated investors. Participation by uninformed investors may be desirable for a variety of reasons, including the need for wide spread holding of the issue.

One major difference between the two mechanisms is that the former, being direct, employs a relatively complex allocation rule on the part of the underwriter, but it is optimal for all investors to truthfully report own valuations. In contrast, the auction offers a relatively simple allocation rule for the underwrite to follow with no discretion, by moving the complex computational burden to all sophisticated informed investors participating in the auction.

Design of optimal IPO mechanisms has received wide attention in the literature. For example, Maksimovic and Pichler (2006) examine the problem of allocating an IPO between informed and uninformed investors under a discrete information structure. Spatt and Srivastava (1991) find that the optimal mechanism for IPOs incorporates both pre-play communication and participation restrictions. Malakhov (2007) presents an optimal uniform price mechanism for the case where all informed agents act in perfect collusion (in effect there is only one informed bidder). In that case, an analytical closed form solution exists and is characterized by substantial underpricing that results from the monopoly power of the informed investors, while the presence of rational uninformed investors helps reduce the bargaining power of the informed. The problem with multiple bidders is substantially more complex[60]. Here we investigate a direct-revelation ex-post incentive compatible optimal uniform price mechanism, as well as a hybrid auction mechanism, in a setting resembling that of Malakhov (2007), but allowing for competition among multiple informed investors.

We find that the book building method results in less underpricing on average when compared to the hybrid auction method for a given number of informed investors participating in the IPO. However, in the example we consider, when there are no rents to being informed under the book building method, and the minimum allocation to the uninformed is binding, the allocations and the underpricing under the book building method are about the same as those under the auction method. That suggests that under certain conditions the auction method can achieve what book building can. Hence the inability of the auction method to compete with book building and fixed price methods may in part be due to the fact that auctions are *indirect* methods requiring high degree of sophistication on the part of *all* participants, which may be difficult to satisfy in practice.

Appendix A.1. Economic Environment and Calibration

Consider an underwriter who has to issue Q shares. The underwriter has access to N informed institutional investors each of whom receive a private signal about the true value of the issue by incurring a fixed cost of C, and a pool of θ uninformed retail investors. Let us denote the joint probability density function of the signals as $g(s)$. Let $f_{s_i|V}$ denote the probability density of signal s_i received by investor i conditional on the true value of the stocks being V. Suppose the signals, conditional on the realization of the value V, are i.i.d. In that case $g(s)$ is given by:

$$g(s) = \int_{\Omega_V} \prod_{i=1}^{N} f_{s_i|V}(s_i|V) dG_V(V) \tag{A.1}$$

where V is the true value that is distributed according to G_V on $\Omega_V \subseteq \mathbb{R}$, and $s = (s_1, s_2, ..., s_N) \in \Omega \subseteq \mathbb{R}^N$ is the vector of signals.

[59] We focus on uniform price auctions for two reasons. First, regulations in many countries (e.g. Rules of Fair Practice of the National Association of Securities Dealers in the US) prohibit price discrimination. Second, if uniform price auctions can achieve what book building can achieve under some conditions, more complex auctions may be able to as well as book building under more general conditions.

[60] Bennouri and Falconieri (2004) investigate a case with multiple informed agents, but under a special simplified information structure that makes it difficult to draw parallels with auction models

$\hat{V}(s)$ is the expected value of V conditional on the entire vector of signals:

$$\hat{V}(s) = \mathrm{E}\{V|s\} = \frac{\int_{\Omega_V} V \prod_{i=1}^{N} f_{s_i|V}(s_i|V) dG_V(V)}{g(s)} \tag{A.2}$$

We assume that all distribution functions and their parameters are public knowledge, and all parties have correct priors. Let $u_i(s)$ denote the ex post realized utility of agent i conditional on the vector of signals being s, when prices and allocations are given by $p_i(s), x_i(s), i = 1, 2...N$. For risk-neutral investors, $u_i(s) = (\hat{V}(s) - p_i(s))x_i(s)$. Since most countries impose the restriction that that all those who receive an allocation in an IPO issue should pay the same price , we will focus on the uniform-price case where $p_i(s) \equiv p(s)\ \forall i$.

We assume that in any type of issue, at least 50% of the shares have to be allocated to a pool of θ uninformed bidders for exogenous reasons.

In what follows we consider a hypothetical IPO of $1,500,000$ shares. The value of each share is lognormally distributed with an expected value of $V = \$10$ (i.e., total value of $\$15 million$), and standard deviation of $\log(V) = 0.30$. Each private signal $s_i, i = 1, 2, ...N$ is lognormally distributed with an expected value that equals the realized value of the share, and a standard deviation of $\log(s_i) = 0.30$. We will consider the case where the bidder pool consists of $N = 2$ investors each of whom can become informed by spending the fixed cost C and $\theta = 50$ uninformed bidders. In the examples, unless otherwise stated, we will assume that the information gathering cost is $225,000 per informed investor – i.e., 3% of the expected value of the 750,000 shares that are not reserved for uninformed investors.

We will now consider two methods for issuing the Q = 1,500,000 shares. In the first method – which we will call book building for convenience – the two informed investors collect the signals by paying C, and truthfully reveal them to the underwriter. The underwriter keeps aside 50% (i.e., 750,000 shares) as the minimum amount to be allocated to the uninformed investors. The underwriter then decides on the price $p(s)$ and nonnegative allocations $x_i(s), i = 1, 2$, subject to the condition that $(x_1(s) + x_2(s) < 750,000)$. The uninformed are allocated a total of $750,000 + (750,000 - (x_1(s) + x_2(s))$ at the same price $p(s)$. Let Q_I and Q_U denote the expected number of shares allocated to the informed and the uninformed investors, with $Q_I + Q_U = 1,500,000$.

In the second method, the underwriter first offers a single block of Q_I shares to the two informed investors using a uniform price auction. Each of the two informed investors pay the information cost C and collect their signals. After observing their own signals they submit their bids $b_i(s_i), i = 1, 2$. The entire block of Q_I shares are then allocated to the highest bidder at the price, $p(s)$ that equals the second highest bid. The uninformed investors are allocated $Q_U = 1,500,000 - Q_I$ shares at the same price $p(s)$.

Appendix A.2. An Optimal Direct Mechanism (Book building)

The underwriter's objective is to choose the price and allocations so as to minimize the expected discount, $(\hat{V}(s) - p_i(s)) \equiv \frac{u_i(s)}{x_i(s)}$, i.e.

$$\min_{x(\cdot)} \int_{\Omega} \frac{u_i(s)}{x_i(s)} g(s) ds \tag{A.3}$$

for any $i, i = 1, ..N$ (it is the same for all i), subject to the following implementability constraints (in the derivations below we assume that there are N informed investors, even though we set N = 2 in our computations.) Here, we shall consider only mechanisms that treat the agents in a symmetric way, i.e. allocations x_i and promised utilities u_i do not explicitly depend on i, and any change in order of elements of the vector argument s would only result in an equivalent change in order of elements of x and u (note that due to conditional independence functions g and $\hat{V}$ are always symmetric in this way).

'Uniform Price' Constraint: All informed bidders pay the same price (or equivalently, receive the same discount), i.e.,

$$\frac{u_i(s)}{x_i(s)} = \frac{u_j(s)}{x_j(s)}, \forall i \neq j \tag{A.4}$$

$$\tag{A.5}$$

'Ex-post Incentive Compatibility' Constraint: We want each informed bidder i to have the incentive to reveal her signal truthfully conditional on the realization of the entire vector of signals $s = (s_1, s_2, ..., s_N)$ – i.e. she would not want to report a different signal even after learning what signals were reported by the other bidders.

Lemma 2. *Ex-post incentive compatibility is satisfied if the following holds:*

$$\frac{\partial u_i}{\partial s_i}(s) = \frac{\partial \hat{V}}{\partial s_i}(s) x_i(s) \quad \forall i \in 1, 2, ..., N \tag{A.6}$$

Proof. Let us suppose that the investors $1, 2, ..., i-1, i+1, ..., N$ receive a vector of signals $s_{-i} = (s_1, s_2, ..., s_{i-1}, s_{i+1}, ..., s_N$. Suppose the investor i receives signal s_i and reports s_i' to the underwriter. His utility is then given by $u_i(s_{-i}, s_i, s_i') = (\hat{V}(s_{-i}, s_i) - p(s_{-i}, s_i'))x_i(s_i')$. Suppressing the first argument s_{-i} for clarity, truth-telling requires that $\forall s_i, s_i'$,

$$u_i(s_i, s_i) \geq u_i(s_i, s_i') = \hat{V}(s_i)x(s_i') - p(s_i')x(s_i')$$

implying that $p(s_i')x(s_i') \geq \hat{V}(s_i)x(s_i') - u_i(s_i, s_i)$. Therefore,

$$\begin{aligned} u_i(s_i', s_i') &= \hat{V}(s_i')x(s_i') - p(s_i')x(s_i') \leq \\ &\leq \hat{V}(s_i')x(s_i') - \hat{V}(s_i)x(s_i') + u_i(s_i, s_i) \end{aligned}$$

and consequently,

$$u_i(s_i', s_i') - u_i(s_i, s_i) \leq (\hat{V}(s_i') - \hat{V}(s_i))x(s_i')$$

On the other hand, truth-telling also implies that $u_i(s_i', s_i') \geq u_i(s_i', s_i)$, similarly implying that

$$u_i(s_i', s_i') - u_i(s_i, s_i) \geq (\hat{V}(s_i') - \hat{V}(s_i))x(s_i)$$

and therefore we have

$$(\hat{V}(s_i') - \hat{V}(s_i))x(s_i) \leq u_i(s_i', s_i') - u_i(s_i, s_i) \leq (\hat{V}(s_i') - \hat{V}(s_i))x(s_i')$$

Dividing by $s_i' - s_i$ and taking the limit $s_i' \to s_i$, we obtain (A.6).

Ex-post incentive compatible mechanisms have many desirable properties, in particular they are less sensitive to the investors' opinions about beliefs of other investors[61]. This formulation is similar to that of the modified Vickrey auctions of Dasgupta and Maskin (2000) where each bidder can submit a schedule of bids contingent on the realizations of the bids of others. "Open-book" issues where buyers can see others' orders and modify theirs accordingly can be described as having some of these properties, although there is a timing issue in practice, since most bids are usually placed near the end of the auction period. The road show process can also lead to some information about the bids being revealed over time. In this situation, agents find it optimal to follow their equilibrium strategies regardless of the exact distribution of others' types (Chung and Ely, 2007).

'The allocation to an individual uninformed bidder does not exceed that of the informed' Constraint: We want the informed bidders to be at least as well off as the uninformed, after all the signals are made public.

$$\frac{Q - \sum_j x_j(s)}{\theta} \leq x_i(s) \tag{A.7}$$

'Incentive to gather information' constrant: The informed bidders do not have an incentive to forego information gathering and instead participate in the issue as uninformed (implying that their ex-ante expected gain from

[61] A mechanism that is very sensitive to such hard-to-measure parameters as bidders' opinions about opinions of others is much more prone to be undermined by their mistakes and disagreements: as Wilson (1987) noted, "Game theory has a great advantage in explicitly analyzing the consequences of trading rules that presumably are really common knowledge; it is deficient to the extent it assumes other features to be common knowledge, such as one player's probability assessment about another's preferences or information".

participating in the issue exceeds that of the uninformed by at least C):

$$\int_{\Omega} [u_i(s) - u_u(s)]\, g(s) ds \quad \geq \quad C \tag{A.8}$$

where the utility of the uninformed is given by

$$u_u(s) \quad \equiv \quad \frac{u_i(s)}{x_i(s)} \frac{Q - \sum_{i=1}^{N} x_i(s)}{\theta}$$

***'Total allocation to the informed does not exceed $Q/2$' Constraint**:*

$$\sum_i x_i(s) \quad \leq \quad Q/2 \tag{A.9}$$

Appendix A.2.1. Solution Properties

As we will see, the book building mechanism in this model economy has properties that match several empirical regularities documented in the literature. Figure A.1 shows the fraction of the 750,000 shares offered through book building (with the other 0.75 million allocated to the uninformed at the price set through the book building process) that is given to the uninformed investors who participate in the book building process as a function of the signals received by the two informed participants. They receive a relatively larger fraction of shares when the informed bidders agree with each other, but this share falls as the reported signals and the implied expected value of V increases. Figure A.2 shows the expected auction discount given values of the signals received by the two informed participants – it is highest when there is little disagreement about the issue price and the allocation to the uninformed bidders is low.

These properties are consistent with the empirical regularity that large investors with an established relationship with an underwriter (informed investors in the model) tend to receive more shares when they are more valuable, and when the issue is more heavily underpriced (see, for example, Jenkinson and Jones (2004, 2008) and Cornelli and Goldreich (2001, 2003); Cornelli et al. (2006).)

Figure A.3 gives the percentage of the shares offered through book building that is allocated to the first informed participant as a function of her signal when the signal received by the second informed participant is fixed (at $s_2 = 14.5$.) As can be seen, when the cost of gathering information is low, the second participant gets some allocation even when the first participant gets a higher signal. However, as the cost of information gathering increases (and consequently the required compensation for information gathering increases,) the fraction allocated to the participant with the lower signal value declines. In the limit, as the information gathering cost reaches the maximum information gathering cost that can be supported (rewarded) through book building, almost all the shares are given to the informed participant receiving the higher signal, and the allocation scheme approaches that of the uniform price auction (i.e. a step function centered at the other bidder's reported signal). This suggests that when the auction outcome is such that there are no rents to gathering information, the minimum number of shares to be given to the uninformed becomes binding, and book building can not improve much on the outcome of the auction – the auction clearing price and the auction allocations will be close to the solution under the book building mechanism.

Figure A.4 illustrates the ex post incentive compatibility property of the book building mechanism: regardless of the realization of bidder 2's signal S_2, bidder 1 never has an incentive to misreport his own signal S_1.

Figures A.5 and A.6 plot the equilibrium proportion of the shares offered through the book building mechanism that is allocated to the informed participants as a group, as a function of the auction discount and the cost of gathering information respectively. As can be seen, the fraction allocated to the informed participants increases with the auction discount and with the cost of gathering information. Note that IPOs that have a higher information gathering costs are the ones that will on average be associated with higher discounts. Those are the issues that also have a larger fraction of the allocations going to the informed participants, consistent with the observation in the literature that "hot issues" are typically allocated more to institutional investors (who are more likely to be informed.)

Figure A.7 illustrates the relationship between disagreement between the signals of the informed bidders (measured by Bray-Curtis distance $\frac{|s_1 - s_2|}{s_1 + s_2}$) and the auction discount when the cost of gathering information is fixed at 3% of the expected value of the 750,000 shares offered through book building (i.e., \$225,000), one point in the graph corresponding to one particular realization of signals. As we can see, the discount is higher for the issues where

disagreement is higher. When both informed investors report the same signal (a group of red points in the lower left corner), the discount is relatively low. It is still, however, increasing in the issue price, as figure A.8 illustrates.

Appendix A.3. A Hybrid Auction

Our hybrid auction consists of a fixed price tranche, open to all investors, and an auction tranche, that is only open to the two informed investors. As discussed earlier, hybrid offering methods are used in most countries. Such hybrids have the feature that individual investors are allowed to self-select, so that those that do not have relevant pricing information can participate in the fixed price public offer tranche.

The issue price is determined in the auction tranche, with the highest bidder receiving the entire informed allocation at the price equal to the second highest bid. The size of each tranche in the hybrid auction is pre-announced. Thus, the primary difference between the "stylized bookbuilding" and the "hybrid auction" methods is that the former allows the underwriter extra flexibility to change how much to give each bidder depending on the signals that are communicated.

Biais and Faugeron-Crouzet (2002) examine an economy where some agents are endowed with information about the value of the IPO issue. They show that the optimal mechanism resembles book building, but that an auction like mechanism can come close to book building. Sherman (2005) considers an economy where anyone can choose to become informed by incurring a cost, and shows that a book building like mechanism will in general dominate the uniform price auction for IPOs. Here, we consider an environment with a richer signal space, nesting both the endowed and costly information cases, and show that a hybrid auction may lead to the same solution as the book building like mechanism when information gathering costs are sufficiently high.

Again, suppose the issuer is selling Q shares, with an uncertain value V each. He has access to a pool of 2 institutional and θ individual bidders, and selects their respective total allocations, Q_I and Q_U, prior to the auction (such that $Q_I + Q_U = Q$). He then collects bids from the informed bidders, allocates Q_I shares to the highest informed bidder at the price equal to the second highest bid, and splits the remaining Q_U shares between the uninformed bidders at the same price.

Each participating informed bidder $i \in \{1, 2\}$ can obtain a signal s_i at a cost of C each, where we again assume that s_i are independent and identically distributed, conditional on the realization of V. All bidders and the issuer understand the information structure and have correct priors about all the distributions.

As before, the underwriter is able to distinguish those who gathered information from those who didn't, and prevent the uninformed bidders from pretending to be informed. However, as the "fixed price" tranche is open to everyone, he is not able to prevent potentially informed bidders from participating in the issue as uninformed (or from not participating at all), and needs to provide sufficient incentives for them to accept his invitations, implying the participation constraint

$$\mathrm{E}\left\{(V-p)Q_I\right\} \quad \geq \quad \frac{1}{\theta}\mathrm{E}\left\{(V-p)Q_u\right\} + C \tag{A.10}$$

In the comparison that follows, we will compare book building outcomes to matching auction outcomes that have the same fraction of shares allocated to the informed investors Q_I.

Appendix A.4. Book building vs. Hybrid Auctions: a Comparison

Each line of Table A.1 presents a comparison of a book building mechanism that guarantees the informed investors a particular level of compensation for information gathering with a hybrid auction that provides the same total allocation to the informed, and gives the rest of the issue to the uninformed.

The left panel of Table A.1 shows the effect of an increase in the information gathering cost C for book building: when it is low, it has no effect on prices and allocations since the lowest attainable discount of 5.71% provides enough revenue to cover up to \$130,000 in information gathering costs; however as information gathering costs rise above \$130,000, the underwriter is forced to discount shares more deeply. At the same time, he is also allocating progressively fewer shares to the uninformed. It is not possible in this setting to provide a discount higher than 10.46%, or, equivalently, to compensate a cost of gathering information higher than \$370,000. Note that when information cost

Allocations and discounts in Book building (Optimal Direct Mechanism) of Section Appendix A.1. The value V per share is distributed lognormally with E(V) equal to 10 and standard deviation of 0.30 for log(V) – corresponding to a standard deviation of 30% for the continuously compounded rate of return to an uninformed investor in the stock. The private signal S is centered at the actual share value, conditional on which it is also lognormal with a standard deviation of 30%. The bidder pool consists of 2 potentially informed and 50 uninformed bidders. The cost of information for each bidder in Figures A.1 and A.2 is fixed at 3% of expected issue value.
Figure A.3 illustrages how the optimal incentive-compatible allocation scheme approaches that of an auction as the required compensation for information gathering increases: each line shows the allocation to Informed Bidder 1 as a function of his reported signal, given that the signal reported by Bidder 2 is equal to 14.5. Note that the allocation in an auction is a step function, with Bidder 1 getting 100% of the informed allocation when $S_1 > S_2$, 0% when $S_1 < S_2$, and 0.5 when $S_1 - S_2$. Figure A.4 illustrates ex-post incentive compatibility: each line shows expected profit of bidder 1 who received a signal $S_1 = 0.49$ as a function of his report S_1', for three different levels of S_2.

Figure A.1: Signals and x_u

Allocation to Uninformed as a function of signals.

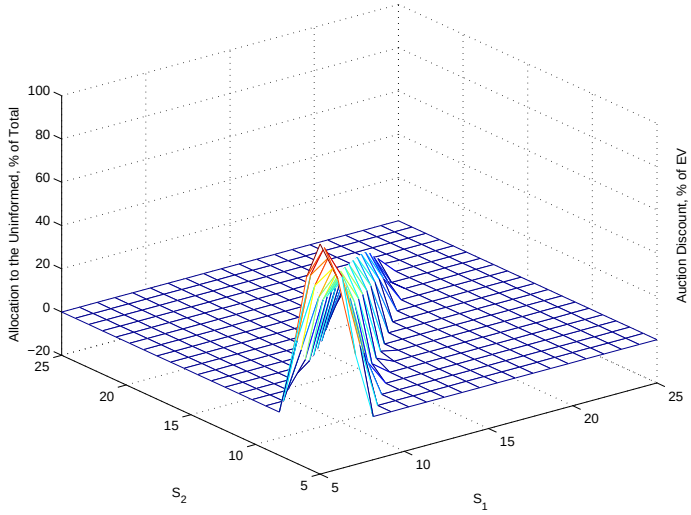


Figure A.2: Signals and Discount

Auction Discount as a function of signals.

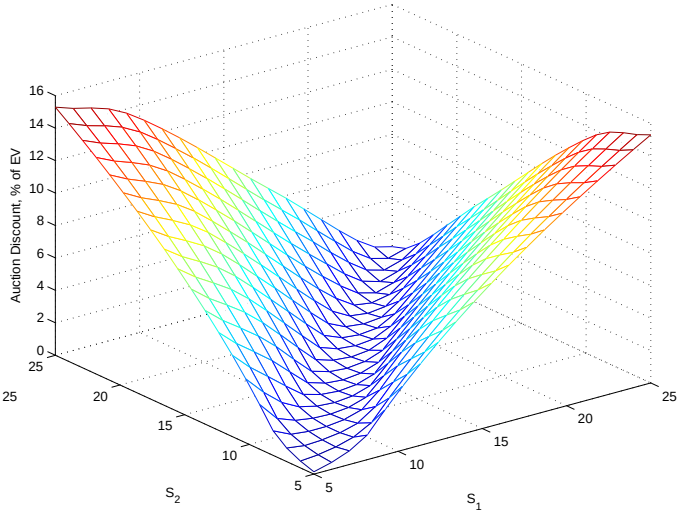


Figure A.3: Informed Allocation

Percentage of Informed Allocation to Bidder 1 when Bidder 2ś Signal = $14.5.

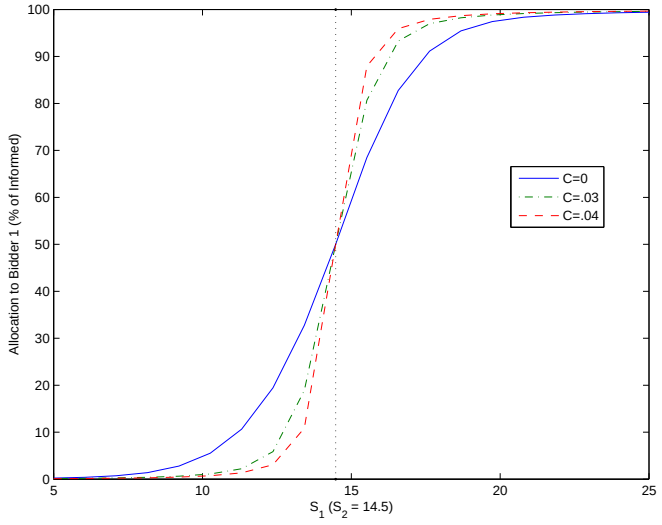
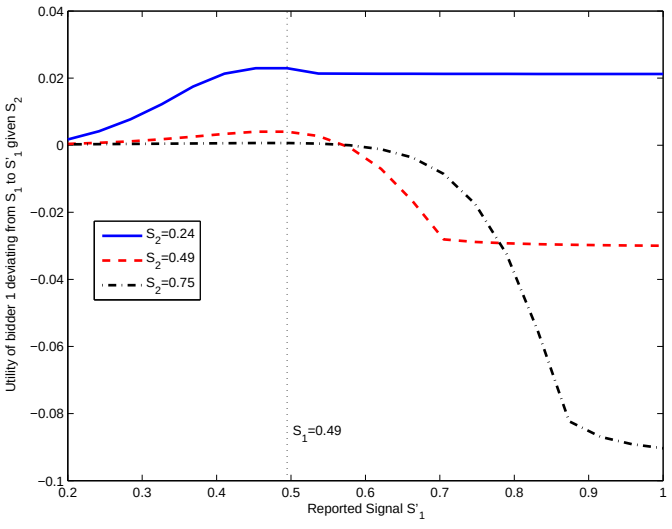


Figure A.4: Ex-Post IC Constraint

Cost of deviation from truth-telling by Bidder 1.



Allocations and discounts in Book building (Optimal Direct Mechanism) of Section Appendix A.1. The value V per share is distributed lognormally with E(V) equal to 10 and standard deviation of 0.30 for log(V) – corresponding to a standard deviation of 30% for the continuously compounded rate of return to an uninformed investor in the stock. The private signal S is centered at the actual share value, conditional on which it is also lognormal with a standard deviation of 30%. The bidder pool consists of 2 potentially informed and 50 uninformed bidders.

Figure A.5: Discount and Informed Allocation

Equilibrium combined share of the informed bidders in the optimal mechanism vs. the auction discount

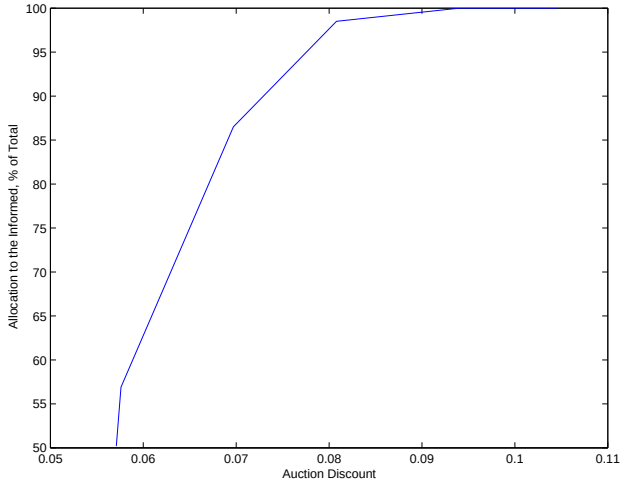


Figure A.6: Cost of Information and Discount

Equilibrium share of the informed bidders in the optimal mechanism as a function of information gathering cost C

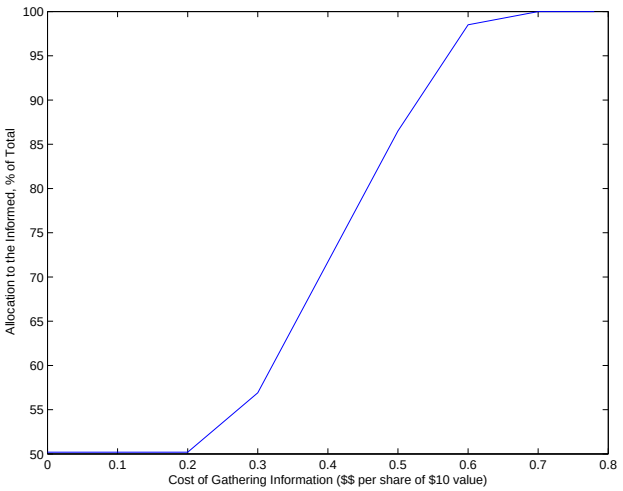


Figure A.7: Disagreement and Discount (C=0.03)

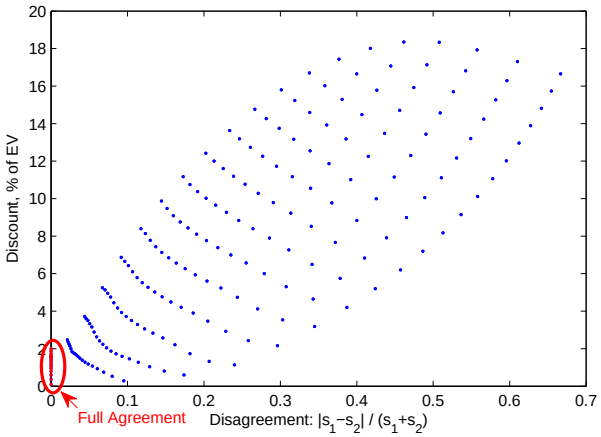


Figure A.8: Discount under Full Agreement (C=0.03)

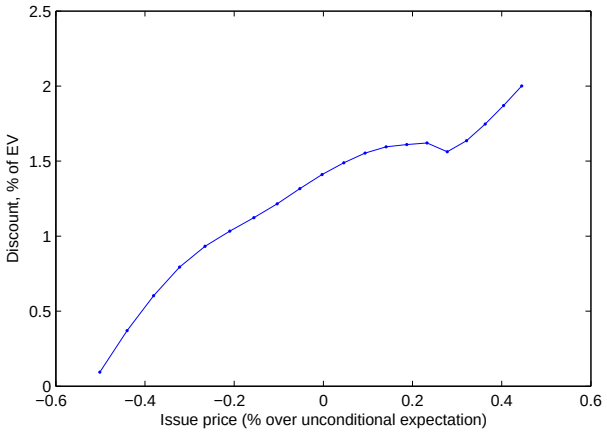


Table A.1: Auction vs. Bookbuilding

A comparison of a hypothetical hybrid bookbuilding process and a hybrid auction in terms of investor profit and discount. Both schemes are uniform price, and incorporate a fixed price tranche. In all computations, the standard deviation of the log signal σ_S and the log share price σ_V are set equal to .3. The issue consists of 1,500,000 shares, each with expected value of $10, for the total expected value of $15 million. There are two informed and 50 uninformed investors. The hybrid bookbuilding scheme consists of a fixed price tranche and a bookbuilding tranche for 750,000 shares each. Uninformed investors can apply for allocations in either tranche, and purchase shares at the price that is determined by bookbuilding. Each uninformed investor gets $1/50$ of the total uninformed allocation (i.e. 750,000 shares of the fixed price tranche plus the uninformed share of the bookbuilding tranche). Informed investors participate in the bookbuilding process, collect information, communicate it to the underwriter, and receive shares depending on that information, subject to the incentive compatibility and truth-telling constraints. Amount allocated in the bookbuilding tranche to each informed investor and the group of uninformed investors, as well as the issue price, is determined by the underwriter based on the information communicated by the informed investors. The hybrid auction consists of a fixed price tranche, open to all investors, and an auction tranche, that is only open to the two informed investors. The issue price is determined in the auction tranche, with the highest bidder receiving the entire informed allocation at the price equal to the second highest bid. The size of each tranche in the hybrid auction is pre-announced and does not depend on the bids.

"Informed Allocation" is the ex ante expected percentage of total (i.e. 1,500,000) shares that goes to the informed. All numbers are ex ante expected values. Discount is in % of the ex ante expected value. Difference between informed and uninformed investors' profit represents the highest supportable information gathering cost per informed investor, in $ million.

Cost of Information	Allocation to Informed	Bookbuilding (Optimal Direct Mechanism)						Hybrid Auction					
		R^2	Discount		Profit per Investor, $Mil			R^2	Discount		Profit per Investor, $Mil		
$Mil	Investors		% of E(V)	$Mil	Informed	Uninformed	Difference		% of E(V)	$Mil	Informed	Uninformed	Difference
< 0.13	25.1%	54.4%	**5.71%**	0.856	0.139	0.012	0.13	48.5%	**10.38%**	1.556	0.195	0.023	0.17
0.15	28.4%	51.3%	**5.76%**	0.863	0.158	0.011	0.15	48.5%	**10.38%**	1.556	0.221	0.022	0.20
0.24	43.3%	48.3%	**6.97%**	1.045	0.254	0.011	0.24	48.5%	**10.38%**	1.556	0.337	0.018	0.32
0.29	49.3%	48.1%	**8.08%**	1.211	0.303	0.012	0.29	48.5%	**10.38%**	1.556	0.383	0.016	0.37
0.34	50.0%	48.1%	**9.40%**	1.410	0.352	0.014	0.34	48.5%	**10.38%**	1.556	0.389	0.016	0.37
0.38	50.0%	48.0%	**10.38%**	1.556	0.392	0.016	0.38	48.5%	**10.38%**	1.556	0.389	0.016	0.37

varies from one issue to another, that would generate a positive correlation between IPO underpricing and allocation given to the informed investors ("preferred" clients.)

Note that as the cost of information, and with it the need to compensate the informed investors for that cost, increase, both the expected discount and the allocation to the informed investors in the book building mechanism also increase.

On the other hand, the discount in the hybrid auction (right side panel of Table A.1) is determined by the level of competition between the informed bidders, and for a given number of informed bidders (2 in this example) it stays the same regardless of their actual allocation – provided that this allocation is actually sufficient to compensate them for information gathering. Thus, the hybrid auction is characterized by multiple revenue-maximizing allocations. The highest possible compensation for information gathering ($370,000) is attained when all of the 750,000 shares goes to the informed (note that we reserved 750,000 shares, i.e., half the 1,500,000 shares being issued to be offered to the uninformed.) In that case the expected discount in the hybrid auction is 10.37%, about the same as the discount that obtains under the book building method.

As we noted earlier, in the example we examined in this section, allocations and prices under the book building mechanism come close to that under the uniform price auction as the required compensation for information approaches the maximum that can be supported. However, there is one critical difference: in the auction (which is an indirect method), the computational burden lies with the investors, all of whom have to correctly evaluate the environment and each other's bidding strategies. In contrast, "book building" (which is a direct method), takes this burden from the investors and places it with the more experienced underwriter, thus eliminating the potentially disastrous consequences of mistakes.

These results suggest that book building may not help improve on the outcome of the hybrid auction method when the informed just cover their cost of gathering information.

Appendix B. Computation Details

Appendix B.1. Evaluating Auctions

To find equilibrium bidding functions in the calibration exercises, we numerically solved equation (2) in the symmetric case, and its suitably adjusted modifications in the other cases. The lognormal signal distribution was approximated with a truncated lognormal on a range $[\underline{S}, \overline{S}] = e^{\mu-10\sigma}, e^{\mu+10\sigma}]$. Monte-Carlo integration with $100,000$ draws of (V, s_{-i}) was used to compute the conditional expectations; in order to properly account for low tail probabilities and avoid underflow we used importance sampling[62]. In risk-neutral cases such as (3) the optimal bids were computed directly; in the general case, a two-step procedure was used: in the first step, a Monte-Carlo sample was generated; in the second, an iterative zero-finding algorithm[63] was used to find the optimal bidding function conditional on the sample. We found that the solution is very robust with respect to the Monte-Carlo sample selection.

In order to improve computational performance, integration was used to evaluate the bidding functions on a grid of values spanning $[\underline{S}, \overline{S}]$, with piecewise cubic Hermite polynomials[64] used to interpolate the functions between the grid points.

Given bidding functions computed as above, various outcomes such as expected profits were also computed using Monte-Carlo simulation with 1,000,000 iterations.

Appendix B.2. General Optimal Mechanism

Due to our assumption that the price and allocations are symmetric in that they do not explicitly depend on i, but only on signals reported, the dimensionality of the underwriter's problem can be reduced. Instead of optimizing over N allocations for each realization of N signals, we note that the the constrained optimization problem given by equations (A.3-A.9) can be equivalently specified in terms of minimizing the expected discount $\xi \equiv \hat{V}(s) - p(s) \equiv \frac{u_i(s)}{x_i(s)}$, which is itself symmetric in signals, i.e. $\xi(s_1, s_2) = \xi(s_2, s_1)$:

$$\min_{\xi(\cdot)} \int_{\Omega} \xi(s) g(s) ds \tag{B.1}$$

[62] See, for example, Judd (1998).

[63] See Forsythe et al. (1977)

[64] Selected to ensure monotonicity of the interpolating function, see Fritsch and Carlson (1980)

subject to

$$\frac{\partial u_i}{\partial s_i}(s) = \frac{\partial \hat{V}}{\partial s_i}(s)\frac{u_i(s)}{\xi(s)} \tag{B.2}$$

$$\theta \min_i u_i(s) + \sum_i u_i(s) \geq \xi(s) \tag{B.3}$$

$$\xi(s) \geq \sum_i u_i(s) \tag{B.4}$$

$$\int_\Omega (u_i(s) - u_u(s))\, g(s) ds \geq C \tag{B.5}$$

where $i \in \{1, 2\}$ and $u_u(s) \equiv \left(\xi(s) - \sum_{i=1}^{2} u_i(s)\right)/\theta$. The signal space was then discretized using a square grid of $T \times T$ ($T = 25$) points and the lognormal bivariate signal distribution was approximated with a truncated lognormal. The solution to (B.1-B.5) in terms of ξ and the boundary values $u_i|_{s_i=\underline{S}}$ was found using a multidimensional constrained SQP algorithm[65]. Due to the symmetry of ξ, only $\frac{T(T+1)}{2}$ elements of ξ and T elements of u_0 have to be determined.

Appendix C. Details on International IPO Experience

Appendix C.1. High first day gains

- Tenaga Nasional, Malaysia, May 1992, 34%: Malaysia's first auction was a hybrid discriminatory auction/public offer. Initial returns for winning bids ranged from 23% to 34%, even though the market-clearing price in the auction was almost 46% above the 4.50 ringgit reservation price. The initial return for the public offer was 94%.
- DDI (an affiliate of Kyocera), Japan, September 1993, 49%: Bids went as high as 6.02 million/share. The offer price was set at 3.7 million, because most successful bids were concentrated at that price. The first day's close was at 5.5 million.
- East Japan Railway, Japan, October 1993, 58%: JR East soared 70% above the market-clearing price the first day, only to drop back down to around the 370,000/share offer price within two days. Winning bids ranged from 352,000 to 623,000, so the highest bidders were still out of the money when the stock closed at 600,000 the first day.
- Petron, the Philippines, Sept. 1994, 63%: Hybrid discriminatory auction/public offer. The first day's closing price was 63% above the lowest winning bid, 23% above even the highest bid, 39% above the highest foreign bid and 136% above the reservation price. The fixed price tranche drew 459,133 subscribers.
- Andover.net, US, December, 1999, 252.1%: The offering was priced at $18 even though the clearing price was $24, reportedly to avoid any delay. The first day's closing price was 164% above even the auction clearing price.
- El Al, Israel, June 2003, 40%: Demand was low in the auction – they sold fewer shares than expected, all priced at the minimum bid. The shares began trading on the Tel Aviv Stock Exchange just two days later, closing up 40% the first day and up a total of 112% by the end of the second trading day.

Appendix C.2. High first day losses

- Japan Telecom, September 1994, down 14.5% from the weighted average bid price of 5.44 million/share on the first day, and down another 10% by the end of the week: The lowest successful bid was 5.22 million, but the public offer price (set after the auction) was 4.7 million, showing that the auction bids were considered unrealistic. The weighted average bid price gave the company a P/E of 219 times prospective earnings, in a mature telecom market.

[65] As implemented in the optimization package SNOPT, see Gill et al. (2002)

- Japan Tobacco, October 1994, down 23.5% the first day, and it kept falling from there: The auction had been unusually enthusiastic, with a weighted average winning bid of 1.438 million/share for shares that institutional investors valued at no more than 800,000. Successful bids ranged from 1.362 million to 2.11 million. It closed the first day at 1.10 million, and the second day at 1.06 million (down more than 26%). After 2 weeks of trading, it was at 956,000, down 33.5%. The highest bidders lost almost 48% the first day. 41% of the shares were never sold.
- Global Securities (Global Menkul Degerler A.S.), Turkey, May 1995, down 11% the first hour: The reservation price was set at TL6,000 per share, but bids went as high as TL100,000. The auction price was set at TL9,750, a 62.5% premium. The price fell by 56.1% (giving a market-adjusted return of -60.5%) over the first three months.

Table C.1. International Experience with IPO Methods

Country	Argentina	Australia	Austria	Bangladesh	Barbados
Main sources:	E-mail - COMISIÃN NACIONAL DE VALORES (ciprod@mecon.ar) 1/29/99; ^The Economist Intelligence Unit; ~"Black gold" by Katherine Conradt, LatinFinance 07/01/1993	Euroweek April 1998 Supplement, Australia: A Special Report; ^Letter - Australian Stock Exchange, 23 April 1996	Letter - Wiener Borse (Vienna Stock Exchange), 14 June 1996	Press Release, Chittagong Stock Exchange, Sept. 14, 2008	Letter - Securities Exchange of Barbados, 8/28/97
Does gov't restrict methods?	No	No	No	Yes	
Most commonly used method	^Hybrid Book Building	Hybrid Book Building	Hybrid Book Building	Public Offer (only method allowed until recently)	Public Offer
* Public offer (Fixed price)		Have virtually disappeared	Yes - Usually for small firms	Yes	Yes - only method used
Advance payment?		^Yes	No		Yes
* Book Building	Yes	Yes - "the norm"	Yes - Traditional for large IPOs, such as privatizations		
Is it gaining popularity?		Already dominant	Yes		
When was it first used?	~1993 for Yacimientos Petroliferos Fiscales	1992			
* Tender/Auction	~Tried in 1991-92, then abandoned	Tried briefly in 1999 (see below)	No	Allowed, beginning 2009	
Discriminatory/uniform					
Hybrid Methods?	Yes, at least for privatizations - Hybrid Book Building/Public Offer	Yes - "open priced book building approach" widespread	Yes - book building for larger issues includes an open pricing public offer tranche	Yes - auction with fixed price public offer	
General notes:	^According to the Economist Intelligence Unit, March 9, 2000, listings on the Buenos Aries Stock Exchange have been declining for years. ~In 1992, a Dutch auction was used for the Telecom privatization, but the overpricing led to a market crash. So, in 1993 for Yacimientos Petroliferos Fiscales, book building was used for the first time, with great success.	Two offerings by Ord Minnet's eCapital in 1999 were called bookbuilds but were online auctions, with updated weighted average bid prices posted twice a day and people allowed to change their bids any time during the auction. The open priced bookbuilding approach was pioneered in Australia by the then Potter Warburg in the 1992 Government Insurance Offices flotation. "Short form" retail prospectus first used in Nov. 1998. According to Asian Business, Sep. 2000, "Enter e-IPOs", scripless "e-IPO" methods already in use.	Public offer procedures are different from listing offer procedures & are governed by different EU directives. IPOs are possible without listing. Subscription periods vary widely - up to seven weeks for smaller IPOs; 2 - 3 days for internationally announced, well-publicized offerings, with a possibility of early closing; occasionally, privatizations close only after a few hours. It is possible that the foreign tranches of some large IPOs have included auction-type elements	In 2009, Bangladesh began allowing two stage sequential hybrid offerings where prices are set through the "true Dutch auction" method. Only institutional investors are allowed to bid in the auction. The subsequent fixed price public offer opens at least 25 days after the auction price is determined. This method is officially called "book building", but the offer price is automatically set at the market-clearing price and allocations are pro-rata.	There were 3 IPOs in 1994, none in 1995 and 2 in 1996. 1994: Barbados Farms Ltd., ST. James Beach Hotels Ltd. and CIBC W.I. Holdings Ltd.; 1996: Almond Beach Resorts Inc. and Life of Barbados Ltd.

Country	Brazil	Canada	China	Chile
Main sources:	E-mail, COMISSÃƒO DE VALORES MOBILIÃRIOS, <intl@cvm.gov.br>, 9/20/99; ^www.bndes.gov.br.; ~Letter - Bolsa Do Rio, 26 Aug. 1996; *Newspaper articles	E-mail, Commission des valeurs mobilières du Québec, 10/29/99	Gao (2010); *Newspaper articles	E-mail, Superintendencia de Valores y Seguros, Oct 7, 1999; ^ Santiago Stock Exchange, 11/14/99; *Celis and Maturana(1998).
Does gov't restrict methods?	No	Yes	Yes - Only one method allowed at a time; changed often	No (but pension funds can only buy thru an exchange)
Most commonly used method	Hybrid Book Building	Book Building	Public Offer	*Hybrid Book Building/Auction on Exchange
* Public offer (Fixed price)	Yes, ~but usually with IB discretion in allocation	Sometimes, only in combination with bb	Used in early 1990s	Allowed
Advance payment?	Yes; some term pmts	No	Yes	
* Book Building	Yes - first used in global offers; now also in domestic offers	Yes - primary method	Yes, but with very unusual features; market still developing	Yes
Is it gaining popularity?	Yes			Yes
When was it first used?	1992, for global offerings		2005 for local offerings (earlier for foreign portions of international offerings)	*1995
* Tender/Auction	Allowed; *sometimes used before 1994	No	Yes, from 1999-2002	Yes - on stock exchange
Discriminatory/uniform	~Both have been used		Uniform	
Hybrid Methods?	Yes - bb with public offer	Sometimes - bb with public offer, but no pay in advance (similar to US bb w/ some shares sold to retail)	Yes, hybrid bookbuilding/public offer, but with unusual features	Yes - bb to determine price & auction on exchange for pension fund investors
General notes:	As in many Latin American markets, there were few domestic IPOs in Brazil for many years, with delistings outnumbering new listings. According to the International Federation of Stock Exchanges Sept. 2000 Newsletter, there was only one IPO in 2000 and only 7 or 8 in the last four years. *In 2000, 41 companies were delisted by November 6, with another 27 expected by year-end. *The market picked up in 2006, with 26 IPOs that year and more than double that number in 2007.	Issuers can specify the price in the preliminary prospectus, making the method more like Public Offer, but they rarely do. Best efforts offerings are legal but also rare.	From 1990-2000, strict quotas limited which companies allowed an IPO. Fixed price public offers were used for most of the 1990s, with prices set by government formulas rather than by issuers. The price rule was based on book values from 1990-1995 and required a P/E of 15 from 1996-1999. Auctions were used from July 1, 1999 to 1st half of 2002, with pricing dominated by individual investors through on-line bidding. Offer prices pushed to high levels, with many stocks suffering large losses in later trading. From July 2002 to 2004, the regulator returned to a controlled P/E system, with offering price P/E ratios less than 20. A type of two-stage book-building system was adopted on January 1, 2005. IPO price set by institutional investor feedback, then institutional and individual investors placed orders. *This method was replaced by another form described as bookbuilding in summer, 2009. Bookbuilding methods tried so far in China are not comparable to methods used elsewhere. Regulatory reforms in 1999, 2005 and 2009 all promised to finally reduce the role of the government in price-setting.	^,*Regulations changed in 1995 to allow pension funds to buy IPO shares, but only through an exchange. Thus, road shows are used to set price and allocate some shares, while shares to pension funds must be sold thru either an auction or daily transactions on the exchange. Almost all IPOs are best efforts rather than underwritten. Major tax advantages to individuals buying primary shares guarantee them an approximately 10% return per year for 5 years if the stock price doesn't move.

Country	Czech Republic	Egypt	Finland	France	Germany
Main sources:	E-mail, the Czech Securities Commission, 10/26/99 ^Prague Stock Exchange Website, www.pse.cz	Newspaper articles in Financial Times, Euromoney, International Herald Tribune, Associated Press Worldstream	E-mail, Financial Supervision Authority of Finland, 11/29/99; ^Letter - Mandatum & Co., 30 May 1996; Also see web page www.rata.bof.fi	E-mail - Listing Division, Paris Bourse SBF SA, 7/28/2000, ^Derrien and Womack (1999)	E-mail - BAWe (Bundesaufsichtsamt fur den Wertpapierhandl) 2/2/2000, www.bawe.de; ^E-mail - DGBank, 11/18/99
Does gov't restrict methods?	Yes		No	Yes, but many options	No
Most commonly used method	^Hybrid Book Building/Public Offer	Fixed Price Public Offer	Hybrid Book Building/Public Offer	Hybrid Book Building/Public Offer	Book Building
* Public offer (Fixed price)	Yes - "must be used for first round" (for voucher privatizations)	Yes - primary method	Yes	Yes - Offre a Prix Ferme (OPF) or Open Price Offer (OPO; only for hybrids)	Yes - Offentliches Angebot ^now superseded by bb
Advance payment?	Yes - 30% (installment)	Yes	Usually, for retail investors	No, but need corresponding cash in account	No
* Book Building	^Yes, since 2004	Yes, at least for some large offers	Yes	Yes - Placement Garanti (PG), only as hybrid	Yes - ^"used for almost every IPO"
Is it gaining popularity?			Yes	Yes	Yes
When was it first used?				1993	1995
* Tender/Auction	possible for second round, if number of		Allowed	Rare - Offre a Prix Minimal (OPM)	No
Discriminatory/uniform	"single, but rules of auction can be different"		Uniform price	Uniform price	
Hybrid Methods?	Possible to have auction/public offer, but not common	Yes - bb with public offer	Yes - bb for institutional, public offer for retail at price set by bb - "most common over last 18 months" (to Nov., 1999)	Yes - All book building must be combined with either OPF or OPO	Yes - "lottery" methods often used for retail tranche allocations; IB discretion
General notes:	All Czechoslovakian companies nationalized in 1948 & owned by the state from 1948 - 1990. Two waves of voucher privatizations - in 1993 & 1994. ^ Private co. IPOs on Prague Stock Exchange began after Czech Republic entered European Union: Zentiva, 2004; ECM Real Estate & Pegas Nonwovens, 2006; AAA Auto, 2007; New World Resources (NWR), 2008, through a large joint listing in Prague, London and Warsaw. Prague SE less active than Warsaw & Budapest Exchanges. Retail allowed to participate.	The Cairo Stock Exchange was dominated by privatizations for much of the 1990s and saw the first truly private company IPO in 1997, with Cairo Precision Industries. Fixed price public offer with pay in advance was the only method until 2000. Orascom, June 2000, was the first hybrid bookbuild/public offer. After Orascom, there were no IPOs at all until the Dec. 2004 IPO of Lecico, which was also a hybrid bookbuild, as was Egypt Telecom in Dec. 2005.	IPOs governed by Securities Market Act 495/1989. Must set preliminary price range in prospectus. Usually, price for all shares set by bb, but w/ price ceiling for retail tranche (or else retail investors must have at least one day to cancel orders after price set). Investors in public offer sometimes get interest on subscription funds, depending on when subscription was paid. Price for employees usually 10% lower than for retail, for tax reasons. Issuer must at least estimate # of shares for each tranche in prospectus.	Open Price Offer (OPO) introduced in 1999 because sequential hybrid PG/OPF required setting price too far in advance. With hybrid PG/OPO, price is not set until day of listing, *as in hybrid bookbuilds in most countries. Derrien & Womack(2003) showed bookbuild problems due to time delay of PG/OPF. When simultaneous hybrid bookbuilding (PG/OPO) allowed, auctions dried up except for two in 2005: Cafom on Second Marche in January and MG International on Alternext in June. Auctions died out later on unregulated Marche Libre (Free Market).	"In recent time the book building technique has been used for nearly all IPOs, local offers and international offers." ^"Sometimes retail investors are preferred for privatizations or larger transactions. For example, the issuer offers discounts for orders given early within the subscription period." ^A joint statement was made by the larger issuing houses, stating they would not use the auction method.

Country	Hong Kong	Hungary	India	Indonesia	Ireland
Main sources:	General sources; ^Asian Business, Sep. 2000, "Enter e-IPOs"	E-mail, Hungarian Banking & Capital Market Supervision, 11/30/99	SEBI (Securities & Exchange Board of India) web page, www.sebi.gov.in; *Bombay Stock Exchange, 4/13/96; ^Assoc. of Merchant Bankers of India, 5/27/96.	Indonesian Capital Market Supervisory Agency (BAPEPAM) , 9/24/99; www.bapepam.go.id; ^"IBRA sets BCA share price at Rp 1,400", The Jakarta Post, Thurs. 05/11/2000.	E-mail, Irish Stock Exchange, 9/15/ 99; *Newspaper articles
Does gov't restrict methods?		No	Yes	Yes	No
Most commonly used method	Public Offer, but Hybrid Book Building/Public Offer increasing	Hybrid Book Building/Public Offer	Auction; was Public Offer		Hybrid Book Building
* Public offer (Fixed price)	Yes	Yes	Yes - *, ^ most common in 1990s	Yes - only method allowed before 2000	Used mainly for larger offerings
Advance payment?	Yes	Yes - minimum 10% installment	* Usually; installments common.	Yes	Yes
* Book Building	Yes	Yes	No - allowed in 1990s, banned in 2005	Introduced in 2000	Yes (traditionally called placing, but the methods are similar)
Is it gaining popularity?	Yes	Yes			
When was it first used?	1994	1994	1999		
* Tender/Auction	Allowed since 1993 but never used	Allowed, not used	Yes, since 2005	No	Very rare.
Discriminatory/uniform			Uniform price		
Hybrid Methods?	Yes - bb only with public offer; simultaneous	Yes - bb/public offer is the most common method	Yes - originally sequential hybrids, which led to timing problems; simultaneous hybrids later allowed	Yes - sequential hybrid, with fixed price public offer after bookbuild	Yes - bb/placing with public offer. Simultaneous.
General notes:	In hybrids, amount initially allocated to retail investors is typically only 10-15%, but clawbacks can raise the % to 30-50% if retail demand high. Often a third, private placement tranche for "strategic investors". Overallotment options common. Grey market trading begins during, or even prior to, the offer period. Substantial interest may be earned on subscription funds when demand is high. ^Hong Kong's Securities and Futures Commission has released detailed guidelines for electronic initial public offerings (e-IPOs).	Greenshoe options common. Current SHs may have right of priority. Otherwise, shares in public offer allocated under "the principle of card dealing, or subscription-proportionate allocation". BB used for the majority of institutional allocations (private placements). Public offer was main method in 1990-94. BB used 1st for large, international transactions. Public offer in hybrids has a fixed price range or maximum price, so final price can be set by bb. Note: Budapest Stock Exchange (as well as Warsaw) most active in region.	BB allowed but heavily restricted in1995. Rules relaxed July, 1999, & BB became more popular. Sept. 19, 2005, the regulator (SEBI) banned BB in favor of auctions through SEBI Circular # SEBI/CFD/DIL/DIP/16/2005/19/9 changing institutional investor allocations from "discretionary" to "proportionate". Since 2005, only hybrid auctions & pure public offers allowed, but upper limits for auctions make some effectively fixed price also. Auctions may be open book, with updated bidding totals posted online every 30 minutes during auction.	All IPOs fully underwritten; may list on Jakarta or Surabaya Stock Exchange, or both. Allocation method: Max. 40% to institutional (pro-rata); rest to retail, favoring small applications (pooling basis - everyone gets at least 500 shares and rest pro-rata; if 500 shares each is not feasible, use lottery). ^ Indonesia nationalized many banks that failed as part of the 1998 Asian flu. IBRA (Indonesian Bank Restructuring Agency) began hybrid bookbuilds to sell banks, beginning with Bank Central Asia (BCA) in 2001	Usual time period from day the offering price is set to the day the subscription period begins varies significantly - approx one month but could be less or more. *The number of IPOs on the Irish Stock Exchange has not been high, but generally the method used now is simultaneous hybrid bookbuilding/public offer.

Country	Israel	Italy	Japan	Jordan	Kenya
Main sources:	E-mails - Tel Aviv Stock Exchange, Feb., Sept. and Oct. 1999; *Newspaper articles	E-mail, Borsa Italiana S.p.A. 11/24/99; ^Italian Stock Exchange Commission (CONSOB) web page, www.consob.it	Pettway (1999); ^Institutional Investor, June 2000, "Opening Japan's Capital Markets"; *Newspaper articles	E-mail, Amman Stock Exchange, 24 June, 1997; ^Amman Stock Exchange web page (accessme.com/AFM).	Fax, Capital Markets Authority, 4/3/00; ^"Deals of the Year, 2009", The Banker, May 1, 2009
Does gov't restrict methods?	Not since mid-2007		Yes, but several options	Yes	
Most commonly used method	Auctions?	Hybrid Book Building/Public Offer	Hybrid Book Building	Public Offer - only method allowed	Public Offer
* Public offer (Fixed price)	Yes	Yes - only for retail	Yes, but w/ allocation discretion		Yes
Advance payment?	No	No		Yes	Yes
* Book Building	Allowed since mid-2007	Yes - only for institutional	Yes		^Used only once so far, for the foreign tranche of a large offering
Is it gaining popularity?	Too soon to tell	Already the only method used	Yes		
When was it first used?			1997/1998		^2008, for Safaricom
* Tender/Auction	Yes - required for a decade	Not used	Yes		
Discriminatory/uniform	Uniform price, but two stages		Discriminatory		
Hybrid Methods?		bb/public offer - only method in last few years	Yes - auction up to 50% of shares; rest sold at auction weighted average bid price. *Hybrids also for bookbuilding.		Yes - the one bookbuild still used fixed price public offer for local investors
General notes:	Two stage auctions - Institutional auction takes place 24-48 hours before publication of prospectus. Winning inst'l orders included in prospectus. Institutional investors may not withdraw their bids, can only offer HIGHER prices in public auction. Public auction 7 days after prospectus released. * From 1993-2003, fixed price public offers banned, only auctions allowed. Some auctions, some fixed price public offers occurred in 2004-2007. BB first allowed in mid-2007. Few IPOs in 2 years since BB allowed, due to market conditions.	Substantially more funds raised from sale of existing shares than from new shares for primary offers in general (this includes privatizations and seasoned issues); public offer tranche usually close to 40%, but the size of each tranche can be adjusted based on demand. Maximum price for public offer set at least 1 day before the open of the subscription period.	Auctions began 04/01/89 as hybrids: up to 50% sold through auction, rest distributed at weighted average winning bid price. Method for remaining shares similar to placing - price fixed in advance but underwriter can distribute to anyone (max. 5,000 shares). Book building only allowed since 1997 fiscal year. Auctions disappeared within one quarter. ^Commercial Code requires the par value of a share to be backed by a minimum of Y50,000 in assets, leading to very high per share prices that discourage retail investors.	^Offering price currently set by Issuing Committee at Ministry of Industry and Trade. This will soon change with the introduction of private sector underwriters to the market. The subscription period will be determined in the near future by the new regulations that regulate the new issues that will be issued in accordance with the Companies Law and the Securities Law that was passed on May 15,1997.	Public Offer method: Investors pay in advance, wait 3 weeks for refunds. Interest on float goes to compensation fund. Price set 10 days before subscription period opens. Those who apply for minimum number of shares usually get them. Allocation is at the issuer's discretion, but figures on intended allocation must be furnished to Capital Market Authority. ^BB tranche was considered for KenGen in 2006 but too controversial. Safaricom, 2008, is only Kenyan IPO with a bookbuilt tranche so far.

Country	Korea	Malaysia	Mexico	Netherlands	New Zealand
Main sources:	E-mail, Korea Securities Research Institute 10/26/99; ^Korea Stock Exchange fax, International Relations, April 13, 1996; *Newspaper articles	E-mail, Kuala Lumpur Stock Exchange (now named Bursa Malaysia), 1996; *Newspaper articles	E-mail, Bolsa Mexicana de Valores (the Mexican Stock Exchange), Sept.& Nov. 1999; www.bmv.com.mx; ^Newspaper articles	E-mail, Stichting Toezicht Effectenverkeer (SECURITIES BOARD OF THE NETHERLANDS), Oct. 1999; ^"KPN's Stock Won't Trade Until Completion of IPO", Wall Street Journal Europe, 05/20/1994	E-mail 10/15/99 - Securities and Exchange Commission of New Zealand; www.gplegislation.co.nz; ^Fax - Cavill White Securities Ltd., 21 May 1996
Does gov't restrict methods?	Yes			No	Yes
Most commonly used method	Hybrid Book Building	Hybrid Book Building	Public Offer	Hybrid Book Building	Hybrid Book Building
* Public offer (Fixed price)	Yes, in hybrids; Was only method until 1998	Yes - traditional method	Yes	becoming obsolete	Yes - but brokers have allocational discretion.
Advance payment?	^Yes	Yes		No	Yes; installments getting popular. Legal min. = 10%.
* Book Building	Yes - most common	*Yes - hybrid	^Yes, at least for international tranches	Yes	Yes
Is it gaining popularity?	Yes	*Yes - it has become the main method		Yes	Yes - last few years
When was it first used?	Required beg.1998 for KSE, 1999 for KOSDAQ			"In recent years"	1997
* Tender/Auction	Only if co. not listing on an exchange	Used for several large privatizations;		Allowed	"Not applicable in practice"
Discriminatory/uniform				Discriminatory	Uniform price
Hybrid Methods?	Yes, at least for privatizations	Yes - both hybrid auctions and hybrid bookbuilds; simultaneous	Yes - bb with public offer	Yes - bb with public offer	Yes - bb for institutional, public offer for retail at price set by bb
General notes:	There have been several dozen internet Direct Public Offerings (DPOs), some of which used auctions. Book building is required if the co. wants to list on KSE or KOSDAQ. *Korea until recently required Public Offer, and the gov't set the offer price until 1996. Recent Korea Gas Co. privatization used public offer for retail, max. order 4,000 shares, and bb for institutional, with price set by bb.	Some issuers must provide profit guarantee (through bank guarantee) of at least 90% of forecast earnings for first 2-3 years. Early 1990s: often long lines for subscription forms. Mid-1990s: began publishing forms in newspapers. 30% of IPO shares allocated to bumiputras (until 2009). Securities Commission still reserves right to review price setting. Before 1/1/1996, the SC set price fairly low, leading to high returns and low application success rates (i.e. heavy rationing) for IPOs. *Recent trend (2009) is to attract foreign, particularly Chinese, firms to list in on KLSE.	IPO "has to be opened to all investors" (except foreigners, who face industry-based limits). ^Stock exchange officials considered lowering listing requirements in 2000, to encourage listings. Regulations loosened in 2007, because listings on the BMV had fallen from 200 a decade earlier to only 133, with only 4 IPOs in 2007. Many IPOs were cancelled in 2008, and no companies had even begun the process in the first half of 2009. Given the overall inactivity of the IPO market, we cannot tell if bookbuilding is likely to become popular.	Book building is "almost standard practice nowadays". The involvement of retail investors in IPOs is high. AEX is currently studying rules concerning the distribution of shares. One of the proposed new rules is the duty to disclose the allotment of the offered securities. ^At least in 1994 and before, book building had to be completed and the final price set before the opening of the public offer subscription period. Almost all issuers allowed grey market ("when issued") trading prior to completion of their IPO.	Public Offer method required by Securities Act 1983, but many exceptions have been made. The Securities Commission is allowed to grant exemptions & has used this power on several occasions since 1997 to permit open pricing, including book building. Book building used mainly for institutional tranche of international offerings but also for strictly local offerings. For Public Offer, brokers have discretion in terms of allocation; "public pool" offerings are rare.

Country	Norway	Pakistan	Paraguay	Peru	Portugal
Main sources:	E-mail - Banking, Insurance and Securities Commission of Norway, Sep. 99; ^Letter - Oslo Bors (Oslo Stock Exchange), 14 June 1996	E-mail, Securities and Exchange Commission of Pakistan, 12/01/99; ^web page - Karachi Stock Exchange (Listing regulations), updated 30-05-1993; *Media search	E-mail - Comision Nacional de Valores, Oct 99; the Stock Exchange web page is www.pla.net.py/bvpasa	E-mail - Lima Stock Exchange, 10/20/99	E-mail, Comissão do Mercado de Valores Mobiliários (www.cmvm.pt), 11/11/99; *Newspaper articles.
Does gov't restrict methods?	No	Yes	No	No	Used to, but since relaxed
Most commonly used method	Hybrid Book Building	Public Offer - only allowed method	Public Offer (only method used so far)	Hybrid Book Building	Public Offer, often as a hybrid with Book Building
* Public offer (Fixed price)	Yes, but rare except for retail tranche of hybrid	Yes		Yes	Yes - the most common
Advance payment?	No, not usually	Yes	No	Sometimes, but not usually	Yes
* Book Building	Yes -mainly for institutional.	No	Allowed, not used	Yes	Yes, hybrid with public offer tranche
Is it gaining popularity?	Yes			Yes, particularly for institutional inv.	Yes
When was it first used?	increasingly popular over last few years.				^June '95 Portugal Telecom privatization
* Tender/Auction	Yes, but "rarely used"	Only for privatizations to one buyer	Allowed, not used	Yes	"Very rare" now, but used in past
Discriminatory/uniform	Uniform price				Uniform price
Hybrid Methods?	Yes - bb for institutional and public offer for local retail with price set by bb.	No	No	Yes, particularly for privatizations - Book Building/Public Offer	Yes - bb for institutional, public offer for retail
General notes:	No changes in regulations in last 10 years. ^The main reason for the Public Offer tranche is that companies need a certain # of shareholders, holding shares of at least NOK 5 to 10 thousand, to list on the Oslo Stock Exchange. Small investors sometimes get their shares at a discount, and occasionally they are favored in the allocation process.	Offer price was set by the government up to June 30, 1995. ^May refund unused subscription funds through direct depost rather than mailing check. No company listed unless public offer subscribed by at least 250 applications. Prospectus published at least 7 but no more than 30 days before subscription period begins; share certificates sent to successful orders within 30 days of subscription close.	Only fifty companies quote in the only Stock Exchange, the Bolsa de Valores y Productos de Asuncion S.A. (BVPASA), most having opened their capital only partially. Most shares were placed among existing shareholders in virtue of the right of preferential option. The first stock negotiations in Paraguay took place in October 1993 (market less than 10 years old).	Book building used mainly for international transactions but sometimes for local issues. Most Peruvian companies are closed "family" companies. Therefore raising capital is seldom done through an IPO. Primary Public Offering Regulation, modified on October 12, 1998 considers that primary offers should be carried out through an exchange floor, to provide issues with a more transparent and regulated framework as well as to attract local and foreign investors.	Bookbuilding first used for instutional tranches of privatizations, but became popular for private company IPOs as well. Auctions popular for IPOs in the 1980s but 'very rare' in the 1990s. *No private Portugese company chose an auction after 1988, but the government still used auctions for privatizations until the insurance company Mundial Confianca's April 1992 tender left 34.6% of shares unsold.

Country	Singapore	South Africa	Spain	Sri Lanka	Sweden
Main sources:	E-mail - Stock Exchange of Singapore, 10/11/99; also the SES web page (www.ses.com.sg)	Web page and e-mail - Johannesburg Stock Exchange, 10/99; www.jse.co.za *Newspaper articles	E-mails, Bolsa de Bilbao 11/16/99; *COMISIÃN NACIONAL DEL MERCADO DE VALORES 9/23/99, 10/18/99; ^Euromoney, Apr.'99, p.99-102	Letter - Colombo Stock Exchange, 26 May, 1997	E-mail, OM Stockholm Exchange, 7/25/2000; ^Letter - Finansinspektionen (the Financial Supervisory Authority), 12/18/1996
Does gov't restrict methods?	Yes	Yes	*No	No	No
Most commonly used method	Hybrid Book Building	Hybrid Placing (similar to Book Building)	Hybrid Book Building	Public Offer	Hybrid Book Building
* Public offer (Fixed price)	Yes -traditional	Yes, but not popular except as part of hybrid	Yes - retail tranche	Yes - only commonly used method	Yes
Advance payment?	Yes; sometimes a fixed fee instead	Yes	No; deposits sometimes required	Yes	Yes, usually "a couple of days" before delivery
* Book Building	Yes	Placing - similar to bb in allocations but price set in advance	Yes - institutional & sometimes 100%	Allowed, not widely used	Yes, for institutional tranche
Is it gaining popularity?	Yes		Yes		Yes
When was it first used?	1st - 1995, 2nd - 1999; Officially allowed since March 2000				
* Tender/Auction	Allowed; not used since 1994.	No	*Allowed, "not habitually used"	Allowed, not widely used	Not used
Discriminatory/uniform	Uniform price				
Hybrid Methods?	Yes - simultaneous hybrids for both auctions and bookbuilds	Yes - placing and public offer.	Yes - bb/public offer		Yes - bb/public offer
General notes:	First 2 auctions, in '91, '92, were discriminatory. Fund managers disliked them, suggested single price, which was used from '93 on. 12 of 21 IPOs in '93 and 11 of 33 in '94 were auctions. No auctions since. One bb in '95, 2nd in 1999, a possible third one on the way. Rest of the 20 IPOs in '95, 21in '96, 37 in '97, 21 in '98, 30 thru Sept. '99 all public offer. Electronic Share Application (ESA) and electronic balloting since 1993. 96% of applications thru ESA in 1996, 99% since.	For placing, 30% of the shares must be offered to the sponsoring broker, who must allocate a reasonable number to other brokers (usually 30% of his allocation). They arrange for private clients or institutions to take up parcels of shares, subject to a fee, to ensure sufficient spread of shareholders. A third method, introduction, is allowed for companies that want to be listed but do not need to raise capital. *Telkom privatization, 2003, was first use of simultaneous (rather than sequential) hybrid, i.e., first open pricing.	More and more public offer orders are becoming binding even before final price is set. Sometimes discounts are offered for orders placed before a certain date. Shifting shares between retail & institutional tranches based on demand must be foreseen in prospectus. ^Most offerings have retail tranches that tend to be heavily oversubscribed; private issues sometimes don't bother to include international institutional investors, because local demand is strong.		Hybrids allow open pricing. However, "as a protective measure for the retail investor, a maximum price must be set in advance. The maximum price is normally set above the indicative price range." Privatizations are rare but are usually large and thus use book building.

Country	Switzerland	Taiwan	Thailand	Turkey	United Kingdom
Main sources:	E-mail - - Switzerland Stock Exchange, 11/24/99; ^Letter - Zurcher Borse (Zurich Stock Exchange), 4 June 1996	E-mail Chinese Securities Association, 11/2/99; ^Chiang, Qian and Sherman (2009)	Letter - Securities and Exchange Commission, 14 May 1996; ^Asiamoney, Nov. 2000, "Ratchaburi brings back sweet Thai memories"	E-mail - Istanbul Stock Exchange (intercrd@imkb.gov.tr), March 1999; Fax, Istanbul Stock Exchange, 17 June 1996	General sources; *Brennan and Franks (1997); ^Levis (1990); ~Chambers (2007)
Does gov't restrict methods?	No	Yes	Yes	Yes	Yes, but three options
Most commonly used method	Book Building	Hybrid Book Building	Public Offer ^or Hybrid Book Building/Public Offer	Public Offer	Public Offer (but book building for large, international issues)
* Public offer (Fixed price)	Yes - most common in 1980s	Yes; dominant for many years	Yes - most common	Yes - most common	Yes - most popular
Advance payment?	No	No - only processing fee of NTD30	Yes	^Yes	^Yes
* Book Building	Yes - 1st for large, internat'l IPOs, now for domestic also	Hybrid w/ 50% public offer	Yes - for large IPOs such as privatizations	Allowed; became popular in the late 1990s; first used in 1997	*Placing - similar in terms of allocation
Is it gaining popularity?	Yes	Yes	^Yes, as market recovers from Asia crisis	No	
When was it first used?	Became popular "in last 4 years" (i.e., since around 1995)	2004			
* Tender/Auction	Allowed - not used in 1990s	Hybrid w/ 50% public offer; previously		Allowed; popular in 1994-1995, then	Allowed, not popular
Discriminatory/uniform		Discriminatory		^Uniform price	Uniform price
Hybrid Methods?	Yes - bb/public offer	Yes - auction or bb with public offer	Yes - book building with public offer; ^price set by bb before open of subscription period	Yes - bb/public offer	Yes, although many bookbuilds do not have a retail tranche
General notes:	Most recent privatization was Swisscom (national telecommunications enterprice) in 1998, which used book building. ^The tender method was used in a few cases, during the boom phase of the late 80's, but with little success	Regulatory restrictions limited use of book building for many years. ^Auctions were popular for several years but were abandoned for fixed price public offers. In 2004, bookbuilding became popular and seems to have replaced fixed price public offers. From 1995-2007, there were: 90 auctions from 1995-2003, with 92% of these from 1996-2000; 156 bookbuilds from 2004-2007; and 755 fixed price public offers from 1995-2006. Multiple bids allowed but total bids < 3% of shares sold. Orders non-binding.	Allotment to company's supporters cannot exceed 10% of total. At least 30% of IPO shares must be allotted to public for subscription, unless allotted portion not fully subscribed. Allotments of top 20 corporate or individual subscribers must be publicly disclosed. ^ Price for hybrids set by book building BEFORE the Public Offer subscription period begins.	Auctions popular for two years: 18 of 24 IPOs in '94 & 7 of 29 in '95 used BB, but none of the 17, 27 or 20 IPOs in '96, '97 or '98 respectively used BB (except perhaps Taç Yatirim Ortakligi A,S,, listed w/ IPO date in '95, 1st trading date in '98). The rest of the IPOs in these years were Fixed Price Public Offers except for a few (6 in '95, 3 in '96 and 1 in '98) using Sales on the Exchange. ^Issuer must set binding price margin (range) during registration & inform Capital Markets Board (CMB) about final price (w/in margin) 3 days before IPO.	Auctions had periods of heavy use in 1960s and 1983-84. *Of 69 IPOs from 1986-89, 64 were Public Offer, 4 tender and 1 a hybrid tender/public offer. It's not clear how many placings occurred in this period. ^Before the Big Bang on 27 Oct. 1986, placings were not allowed for issues over GBP 3mn. ~Auctions (i.e., tenders) were used in the UK from 1960 to 1986, but accounted for only 8% of all IPOs in that time, while fixed price public offer was the most popular method in those years.

Country	United States	Vietnam
Main sources:	Prospectuses for specific offerings from the US SEC (Securities and Exchange Commission) Edgar website.	HoChiMinh Stock Exchange (HOSE) website, www.hsx.vn; ^ General media sources
Does gov't restrict methods?	No	Yes
Most commonly used method	Book Building	Auction
* Public offer (Fixed price)	No	No
Advance payment?		
* Book Building	Yes	No
Is it gaining popularity?	Already dominant	
When was it first used?		
* Tender/Auction	Yes - 22 IPO auctions from 1999-2009	Yes
Discriminatory/uniform	Uniform price	Discriminatory
Hybrid Methods?	Not yet; the need to reconfirm orders once the final price is set would complicate the process but could be worked out, as it has with auctions	
General notes:	2 main methods, firm commitment (book building) and best efforts. Book building is more common, used for larger issues. There have been 22 uniform price IPO auctions so far in the US (from 1999 through 2009). 19 of the auctions used the OpenIPO method developed by WR Hambrecht, while three companies - Netsuite, Rackspace, and Google - used auctions that were not lead-managed by WR Hambrecht and had somewhat different features. All auction issuers so far have reserved the right to use a "dirty" auction, but transparency is low in the US, so it is usually not clear in practice whether or not an issuer chose to set the price below market-clearing. Instinet used what it called a hybrid book building/auction in May, 2001. A unique feature of US auctions lead-managed by WR Hambrecht is that many issuers have reserved the right to relay information on bidding trends to favored investors during the bidding period, although such leakage of bidding information is usually illegal in auctions.	Auctions began in 2005; were "open" (all bidders in the same room) until May, 2007. ^For 1st "silent" (sealed bid) auction for Bao Viet (Vietnam Insurance), May 2007, 30% of bidders forfeited 10% deposits rather than pay remainder for their winning bids, after seeing auction results. Vietcom Bank's Dec. 2007 auction 25% oversubscribed at reserve price but only 90% of shares later paid for. Potential bidders pay deposit a few days before auction, and number is announced. Shares trade only OTC for months before official listing.

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