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A JOINT EXPERIMENTAL ANALYSIS OF INVESTOR BEHAVIOR IN IPO PRICING METHODS

Análise experimental conjunta do comportamento do investidor em IPOs

Análisis experimental conjunta del comportamiento del inversionista en IPOs

ABSTRACT

This article jointly examines the differences of laboratory versions of the Dutch clock open auction, a sealed-bid auction to represent book building, and a two-stage sealed bid auction to proxy for the "competitive IPO", a recent innovation used in a few European equity initial public offerings. We investigate pricing, seller allocation, and buyer welfare allocation efficiency and conclude that the book building emulation seems to be as price efficient as the Dutch auction, even after investor learning, whereas the competitive IPO is not price efficient, regardless of learning. The competitive IPO is the most seller allocative efficient method because it maximizes offer proceeds. The Dutch auction emerges as the most buyer welfare allocative efficient method. Underwriters are probably seeking pricing efficiency rather than seller or buyer welfare allocative efficiency and their discretionary pricing and allocation must be important since book building is prominent worldwide.

KEYWORDS | Auction, book building, experiment, competitive IPO, IPO.

RESUMO

Este artigo examina conjuntamente as diferenças de versões experimentais do leilão holandês, um leilão de lances fechados representando o book building, e um leilão similar de dois estágios encarnando o "IPO competitivo", uma inovação usada em algumas ofertas públicas iniciais de ações (IPOs) europeias. Investigamos a eficiência no apreçamento e na alocação e concluímos que o book building simulado é tão eficiente no apreçamento quanto o leilão holandês enquanto o IPO competitivo não é eficiente no apreçamento, independentemente do aprendizado do investidor. O IPO competitivo é o método mais eficiente na alocação ao emissor porque maximiza a captação. O leilão holandês emerge como o método mais eficiente para a alocação ao comprador. Os intermediários financeiros devem preferir a eficiência no apreçamento em vez de eficiência na alocação e sua discricionariedade nestes procedimentos deve ser importante porque o book building é proeminente no mundo.

PALAVRAS -CHAVE */ Leilão, book building, experimento, IPO competitivo, IPO.*

RESUMEN

El presente artículo examina de forma conjunta las diferencias entre las versiones de laboratorio de la subasta holandesa, una subasta de oferta cerrada para presentar las ofertas, y una subasta cerrada de dos fases para actuar como apoderados de la "IPO competitiva", una innovación reciente utilizada en algunas ofertas de acciones públicas iniciales en Europa. Hemos investigado la fijación de precios, asignación del vendedor, eficiencia en la asignación de beneficios del comprador, y hemos concluido que la emulación de la recepción de ofertas parece tan rentable como la subasta holandesa, aun después de la experiencia del inversionista, aunque la IPO competitiva no sea rentable, independientemente de dicha experiencia. La IPO competitiva es el método más rentable de asignación del vendedor pues maximiza las ganancias de la oferta. La subasta holandesa se presenta como el método de asignación de beneficios del comprador más eficiente. Los aseguradores probablemente buscan la asignación más eficiente más que la eficiencia asignativa del comprador o del vendedor, y su fijación de precios y asignación discrecional deben ser importantes dado que la colocación de acciones es mundialmente relevante.

PALABRAS CLAVES */ Subasta, recepción de ofertas, experimento, IPO competitiva, IPO.*

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INTRODUCTION

Setting the price is one of the key issues in an initial equity public offering (IPO) because there is no price history and often no clear price reference. Financial institutions around the world carry out the pricing process of IPOs in a competitive underwriting market and keep the information about the intensions of their customers private. Thus, it is very difficult to conduct natural experimental studies with real data unless local laws mandate its disclosure. Non-replicable case studies that use private and non-identified data may constitute an alternative. However, if there is no access to the actual pricing data, controlled experiments of a stock-offering environment are a surrogate to investigate the implications of different pricing methods, return levels and the unveiling of information.

Book building and the Dutch auction are the most discussed IPO bidding methods in the literature (Jenkinson & Ljungqvist, 2001, pp. 39-40; Sherman, 2005, p. 615). The competitive IPO is a relatively new method. It consists of a two-stage process that separates the decision to hire an advising bank to structure the offer from a competitive bid to appoint another bank to sell the offer. The competitive IPO aims to avoid the bait-and-switch problem in which an underwriter may pressure for a lower offer price after hired by the issuers. It intends to reduce pricing inefficiency when created and used for the first time (Jenkinson & Jones, 2009).

Our main contribution is to compare experimental versions of the Dutch auction, book building, and the competitive IPO pricing methods in the same experimental setting. Bonini and Voloshyna (2013) perform a similar analysis, but compare the new Ausubel (2004) auction method to conventional auctions separately from their comparison of book building to the competitive IPO.

The analysis of pricing efficiency of these methods is another contribution. We define pricing efficiency in the IPO context as initial returns close to zero. Lowry and Schwert (2004) used the ex-post observed underpricing and midpoint of the preliminary price range update to measure IPO pricing efficiency, in the absence of actual bidding data. We analyze the implications for information aggregation of the three price methods with experimental bid data, instead.

A third contribution is to investigate efficiency from the point of view of buyer and seller allocations. The experimental design of the three methods allows joint comparisons, revealing which one of the three methods leads to maximization of proceeds to the seller (seller allocation efficiency) or to the greatest gains to buyers (buyer welfare allocation efficiency) and is supplemental to the Bonini and Voloshyna (2013) study.

We can observe the effects of learning in the joint experimental setting and infer its information aggregation effects on bidding behavior. Thus, we can compare outcomes in earlier and later rounds of the experiments and contrast them with those in Bonini and Voloshyna (2013). These authors used solely students as subjects. Our last contribution is to include financial market professionals, in addition to students, to account for differences related to business expertise.

Our results are consistent with the preference given to book building by underwriters in the real world. We conclude that book building is as price-efficient as the Dutch auction and both are more price-efficient than the competitive IPO. Price efficiency is greater after subjects become experienced. This is consistent with repeated underwriter consultation with a select group of investors in successive book buildings. The Dutch auction provided greater buyer welfare allocation efficiency. The competitive IPO showed greater seller allocation efficiency. Our experimental design also exposed the practice of "bait-and-switch" in the two-stage competitive IPO, which may be disguised in the one-stage book building.

The results have practical implications because they support book building, which is at least as price efficient as the Dutch auction. Moreover, institutional investors are the main buyers of IPOs in most markets and, supposedly, value frequent contacts with underwriters. Naturally, buyer welfare may influence policy makers to favor the Dutch auction but it leads to weaker relationships among the major participants in the process. Book building overtook auctions around the world, suggesting that policy makers recognized its pricing and allocation qualities, even though there may be a potential cost to issuers (Sherman, 2005). The competitive IPO did not solve the bait-and-switch problem and its greater complexity led to pricing inefficiency. Policy makers would need to be more innovative to devise another method to replace book building advantageously.

The next section offers a brief review of the literature, followed by the presentation of our experimental design in Section 3. Section 4 offers descriptive statistics and discusses the results for pricing and allocation efficiency for the three emulated methods with investor learning. Section 5 concludes.

LITERATURE REVIEW

Smith (1976) stressed the robustness and importance of experimental techniques for the understanding of economic phenomena as well as a primary tool to test and explore empirical predictions for verification in the real world. This study employs representations of three IPO pricing mechanisms and, natural-

ly, cannot reproduce all aspects of actual processes, which is a well-known limitation of experiments. For example, an actual book building is executed over a much longer time period than the Dutch auction and the experimental environment does not capture this. The Bonini and Voloshyna (2013) experiment, for instance, neither considered underwriter discretion in establishing the offer price, nor any non-random information asymmetries among investors. Their design did not consider differences in reputation between underwriters. The experiment design described in Section 3 does not include these aspects as well. Thus, some of the usual hypotheses about the positive average initial returns in IPOs are not addressed and are not the focus of this article.

We circumscribed our analysis to those pricing methods that have been more commonly employed in actual IPOs and more frequently discussed in IPO literature (the Dutch auction and book building), according to Sherman (2005), among others, and compared them to a newer method, the competitive IPO. There are many types of auctions and vast literature that analyzes them. Biais, Bossaerts, and Rochet (2002), Biais and Faugeron-Crouzet (2002), Zhang (2009), Trauten and Langer (2012), and Bonini and Voloshyna (2013) present theoretical and empirical experimental analyses emulating IPO auctions. Kagel (1995) surveys experiments with several types of auctions and comments on the difficulty to compare these methods using the results in the experimental literature because of their lack of isomorphism and the different weights attributed to the different dimensions of a problem, depending on how it is presented and analyzed.

Bonini and Voloshyna (2013) tried to address this isomorphism issue by means of pair comparisons of relatively similar methods, book building and the competitive IPO, on the one hand, and the uniform and Ausubel (2004) auctions, on the other. They are, to the best of our knowledge, the only authors to employ experiments to analyze the competitive IPO so far and conclude that book-building underpricing is larger and that the competitive IPO performs better in information revelation. In contrast to their work, we emulate and compare the Dutch uniform auction, book building, and competitive IPO jointly under the same experimental design, use allocation efficiency proxies, and include professional subjects. Their choice of pairing methods under the same experimental design makes it easier to compare within pairs and more difficult to compare across pairs. Our choice to emulate the three methods under the same experimental design addresses this limitation at the potential cost of homogenizing with a single design set-up.

Jenkinson and Ljungqvist (2001) and Sherman (2005) emphasize that a key feature of book building is the ability of underwriters to reward investors who reveal their opinion about the true value of the company. Investors that include more information in their bid, such as quantity and price, receive greater allocations and, in turn, help the underwriter set the offer price and allocate shares among investors. Cornelli and Goldreich (2003) sustain that book building is the best pricing method for IPOs because it is a more effective information discovery procedure.

Underwriters cannot exercise price and allocation discretion with auctions. In contrast to book building, investors do not have incentives to provide them with private information to secure favorable allocation. Underwriters would simply aggregate public information. Sherman (2005) and Jenkinson and Ljungqvist (2001, p. 93) point out that the increasing preference for book building in many markets suggests that there are advantages in the exercise of underwriter discretion in repeated interactions with investors, whereas auctions are a stand-alone event. Trauten and Langer (2012) employ experiments and sustain that there is room for underwriter discretion in the allocation of IPO shares. They conclude that high information acquisition costs might preclude investors from producing information in auctions, while underwriters may adjust the offer price to compensate for information costs in book building.

Jenkinson and Jones (2009) assert that the competitive IPO could address some potential agency problems of book building, but, so far, auctions have been the main alternative to book building. Wilhelm (2005) maintains that upholding their reputation is one of the reasons that may prevent underwriter abuses. He rejects many book building criticisms and lists problems with other pricing methods, considering, in particular, the technological possibilities for their implementation. Book building may not be the ideal pricing method but it solves the problem of aligning bids in various locations around the world and provides a channel for the flow of information among potential investors. Book building overcame technological problems to bring investors together with no sacrifice of lead underwriter discretion.

In Brazil, Leal and Bocater (1992) revise the international literature on IPO methods and ponder the consequences of changing from the fixed price method to auctions. Book building replaced the fixed price method since then. Rego and Parente (2013) investigate the application of the Anglo-Dutch auction design to two-stage electrical energy generation auctions and conclude they lead to lower energy prices in the second stage relative to the clearing price of the previous stage. Dutra and Menezes (2005) discuss electricity auction designs and favor the uniform over the discriminatory design due to lower price dispersion. Maurer and Barroso (2011) review the Brazilian practice with electricity auctions.

We close this section with our definitions of efficiency. We refer to efficiency in three different ways: pricing, seller al-

location, and buyer welfare allocation efficiency. Pricing efficiency is understood as accurate pricing, as expected when the competitive IPO was used for the first time (Jenkinson & Jones, 2009). Seller allocation efficiency is the maximization of the proceeds to the issuer, in the sense employed by Spatt and Srivastava (1991). Krishna (2002) discussed allocation efficiency as the maximization of value to buyers. Our measure includes only gains and potential gains to investors and, thus, we called it buyer welfare allocation efficiency.

Operationally, pricing efficiency occurs when initial returns are closer to zero. Seller allocation efficiency is attained when initial returns are the lowest. Inspired, somewhat loosely, by Sherstyuk (2009) and Goeree, Offerman, and Schram (2006), we computed buyer welfare efficiency as the average of the positive ratios between the sum of the value generated to each investor in each round, considering their actual allocations and prices, and the maximum value that could be generated with those allocations among the investors that would benefit the most from them, considering their individual evaluations. We present an expression for our measure of buyer welfare allocation efficiency in the results section but it is necessary to introduce our experiment design first, as presented in the next section.

EXPERIMENT DESIGN

Three variations of auctions reproduce, in the laboratory, selected key aspects of pricing under book building and the competitive IPO, such as each investor considering private information in recurrent interactions with a non-discretionary underwriter to inform quantity and price. This set-up is common in the literature and renders the experiment viable, but it distances our pricing mechanism from real book building because it does not include aspects such as the preferential or discriminatory allocation by underwriters, as well as their repeated interaction with their clients (Bonini & Voloshyna).

The uniform Dutch Clock descending-price open auction, henceforward called Dutch auction, is our auction pricing method. We use a sealed-bid uniform price auction, which is a variation of the Dutch auction used in IPOs, to approximate for book building, and a two-stage version of this sealed-bid uniform price auction to emulate the competitive IPO. The three methods will be called Dutch auction, "book building", and "competitive IPO" from now on, using the quote marks to denote the instances when it is important to highlight that we are specifically talking about our experiments. We only considered the average initial returns to investigate pricing efficiency and not price dispersion because actual book building is executed over a much longer period than the Dutch auction and we cannot capture this time difference in our experimental environment.

We compared the Dutch auction, "book building" and the "competitive IPO" in the same environment and with parameters from a single structure, enabling us to analyze them jointly. All experimental sessions were designed and conducted with the Zurich Toolbox for Readymade Economic Experiments (Fischbacher, 2007). A series of pilot tests and sessions precede the experiment sessions that produced our data. Three rounds of trial IPOs that allowed participants to practice the rules of the experiment preceded the beginning of each session. Data from these trial rounds were excluded from the analysis but their outcomes are qualitatively similar to those from the first twelve-rounds. Each session comprised of twenty-four rounds. Each round represents an IPO. We present our results for all rounds and the last twelve rounds only to appraise potential participant learning.

Participants in the experiment were selected from undergraduate and graduate business students and among employees of a large financial conglomerate, which also acts as an IPO underwriter. All subjects had previous exposure to financial concepts. Table 1 presents details about the participants.

There was a total of nine sessions in the whole experiment, each comprising twenty-four rounds (IPOs), and thus we collected experimental data for 216 (nine times twenty-four) IPOs, seventy-two (three sessions) for each of the pricing methods (Dutch auction, "book building" and "competitive IPO"). Each session lasted sixty to eighty minutes. Eighty-seven different subjects participated in the experiment and each one participated in only one session, regardless of the pricing method employed. There were five sessions with professionals and four with students. There were sessions with professionals and with students for each pricing method.

Fifty-six percent of the participants were professionals and only sixteen percent were women. The experience of professionals in years was three times longer than that of students and, on average, professionals were ten years older than students. Eighty-four percent declared some previous exposure to the stock market. We tested if the performance of professionals and students was different for each pricing method and found no statistically significant results. Two sample t-tests (bank professionals and students) on Dutch auction, "book building" and "competitive IPO" returns reported the following t-statistics (p-values), respectively: 0.838 (0.41), 1.079 (0.28) and -0.546 (0.59). This is consistent with the results of other studies about the use of professionals and students in auction experiments reported in Trauten and Langer (2012).

TABLE 1. **Subject characteristics**

	Students	Professionals	Both
Quantity	38	49	87
Average age in years	25.8	35.7	31.3
Maximum age in years	38	52	52
Minimum age in years	20	21	20
Number of women	11	3	14
Number of men	27	46	73
Number with stock market experience	25	48	73
Average professional experience in years	3.1	10.7	7.3
% undergraduate students	24	0	10
% with bachelor's degree	42	79	63
% with master's degree	34	21	27
Initial return - Dutch auction	-0.64%	1.00%	0.46%
Initial return – "book building"	0.61%	2.77%	1.33%
Initial return – "competitive IPO"	-5.21%	-6.41%	-6.01%
Overall initial return	-1.61%	-1.16%	-1.41%

Note: "Book building" refers to a sealed bid, uniform price auction, and "competitive IPO" to a two-stage version of it. We tested if the performance of professionals and students was different for each pricing method and found no statistically significant results. Two sample t-tests (bank professionals and students) on Dutch auction, "book building" and "competitive IPO" returns reported the following t-statistics (p-values), respectively: 0.838 (0.41), 1.079 (0.28) and -0.546 (0.59).

We follow the informational structure of Kagel and Levin (1986, 1999). Assume that shares have a true value V, which is the closing market price on the first trading day and a random variable drawn from a uniform distribution in the [10, 110] range before each round to allow for the same drawing probability of each value in the range because a price in the range is considered like any other, as in the Bonini and Voloshyna (2013) book building and competitive IPO experiments. This range, which is a departure point for the whole experiment, also represents customary stock price values in many markets. Participants are not aware of the value of V. An adjustment factor a in [0.8, 1.2] is then picked randomly. The value $mid = V \times a$ is the reference to build the price range with the lower and upper limits randomly drawn from the [0.70 × mid, 0.95 × mid] and [0.95 × mid, 1.3 × mid] ranges, respectively. The adjustment factor simply introduces more randomness in the building of the price range, which is consistent with the high uncertainty IPO environment, to prevent that an observant participant identifies a pattern during the rounds and devises a winning strategy. These ranges are used in the Dutch auction and in "book building" sessions only. Each participant i receives a private signal S_i about the value V. The S_i values for each participant are extracted independently from a uniform distribution defined in the [0.8V, 1.2V] range. This signal represents the private valuation each investor receives about the investment decision from their advisor and emulates both pessimistic and optimistic outlooks about the issue. This replicates the inaccuracy of the assessment that each investor receives and it is drawn randomly. Participants only know their own signals.

The Bonini and Voloshyna (2013) experiments are our departure point and we applied the same true value parameters they used and similar values for other parameters. They assert that they used a large V range to have a very large probability that S_i falls within the true value range. Even though we used parameters that are consistent with those employed in literature, it is possible that different values could change our results qualitatively. We would need to replicate the experiments under alternate set-ups to perform a sensitivity analysis of the parameters. We did not perform such analysis due to time and budget constraints and admit that this is a limitation in ours and other studies, such as Bonini and Voloshyna (2013).

The experiment reflects two major characteristics of IPOs: high uncertainty and the establishment of a set of experienced investors. The group of investors (participants) in each session (a set of twenty-four pricing rounds, or IPOs, using one of the three pricing methods analyzed) is the same, as in the actual frequent

interactions between banks and institutional investors. These investors interact continuously with their banks through their orders. We did not expect any interaction between subjects in the Dutch auction and "book building" rounds and, in fact, they were not allowed to communicate during the experiment.

We expect some sort of collusive behavior between subjects assigned to the same group in the "competitive IPO". Participants are divided into groups of investors in this case because it is important to isolate clients from the same bank in this procedure. However, participants do not know who the other members of their group are and they are not allowed to communicate. Although there is evidence reporting little bonding between subjects in auction experiments, as noticed by Sherstyuk (1999, 2002), these results usually apply to double oral auctions. We offer more details about our "competitive IPO" experiment below.

All participants received a financial reward as an incentive. Each subject received at least the equivalent to five US dollars, enough to recruit participants, and each could earn, depending on performance, as much as $25. We follow Smith (1976) regarding the importance of control in experiments by setting a compensation system for participants. Their individual performance is reflected in the amount of money each one receives at the end of each session. Although the wealth effects of compensation among professionals were expected to be lower than among students, we did not observe signs of less motivation among bank professionals. In fact, after the sessions, bank professionals appeared to be more concerned about their performance than students.

We designed procedures to capture as many of the characteristics of each pricing method as possible without losing the parsimony that allowed the controlled environment experiments. Each participant received 500 units of the experiment currency at the beginning of each session. Profits and losses were recorded for each session round. One stock offering traded in each round consisting of thirty identical items (shares). Participants received their individual private information about the offering price (S_i), representing their particular advisory system, and the preliminary price range for the offering, representing the preliminary information gathered by banks in the real world. The offer would be cancelled no demand existed for all shares. The profit (or loss) recorded in each round is equal to the positive (negative) difference between market price (V) and price paid by the investor, multiplied by the amount he or she received in the allocation procedure. Total profit or loss at the end of a session is equal to the sum of the profit or loss in each of its rounds. The instructions provided to participants are available upon request.

Dutch auction design

Participants inform the quantity of shares they want to buy considering the prices suggested by the virtual auctioneer, which falls in time during the round in proportion to the actual price level V. This procedure is necessary to prevent small decreases in price level, which could lead to very time-consuming rounds.

"Book building" design

Investors may inform the quantity of shares they are willing to buy and the maximum unit price they are willing to pay for them in each offer (round). The book is built and the clearing price for all allocated investors is the lowest bid informed at the time a bid clears the thirty stocks in the offer. The allocation is made among those that bid at or above the clearing price in proportion to the quantities requested. As in the Dutch auction, participants know their individualized private signal (S_i) and the public price range. They are not aware of the bids and allocations of other participants, but are aware of their own allocation and gains or losses from previous rounds. In "book building", all investors belong to the same group, which means all investors are clients of one bank, contrasting to the "competitive IPO", described in the following section.

"Competitive IPO" design

Price formation here is similar to that in "book building". The difference is the insertion of a preliminary step before the submission and processing of bids. Investors are divided into groups of three participants each. Each group represents the set of customers of one bank. Groups are formed randomly at the beginning of the session and remain the same throughout the twenty-four rounds (IPOs) in the session. Participants do not know who their fellow group members are and cannot communicate among themselves, whether or not they belong to the same group.

RESULTS AND DISCUSSION

Table 2 shows that initial returns are not significantly different from zero for the Dutch auction and "book building" and are significantly negative (overpricing) for the "competitive IPO" for all rounds and the last twelve rounds. The proxy for price efficiency is the average initial return that is closest to zero. Thus, our initial results indicate that the Dutch auction and book building are equally price efficient while competitive IPO is significantly less efficient.

Price dispersion was larger in the "competitive IPO", considering all rounds, and in the Dutch auction, for the last twelve rounds. "Book building" also presented maximum initial return in a single offering while the overall minimum occurred under the "competitive IPO". The Dutch auction had the highest minimum initial return. However, a variance ratio test, not reported, between the highest standard deviation for the competitive IPO and the Dutch auction for all rounds is not statistically significant, suggesting that price dispersion does not differ among methods. We also performed a Jarque-Bera normality test on the distribution of initial returns for all sessions and cannot reject it for the Dutch auction and book building (p-values of 0.23 and 0.59, respectively). Thus initial return dispersion falls within normality for these two methods. Yet, normality was rejected for the competitive IPO at the 1% level. We observed that participants had more difficulty to develop a winning strategy with this method.

Table 3 portrays mean difference statistics. There is no significant difference between the initial returns in the Dutch auction and "book building". Initial returns are significantly larger with both "book building" and the Dutch auction relative to the "competitive IPO". The "competitive IPO" led to a much larger number of negative initial returns than the other two pricing methods. Investors perform much worse when the "competitive IPO" is employed. This is consistent with the Bonini and Voloshyna (2013) conclusion of greater investor information revelation in the competitive IPO. After some practice, it seems that investors fared better with the Dutch auction. Although the "competitive IPO" aimed to reduce pricing uncertainty, the greater incidence of negative returns in this method in our experiment does not suggest it will reach this goal. Finally, it seems that participant learning did not affect results because there were no significant differences between all rounds and the last 12 rounds. Even though the results above suggest that the Dutch auction and book building are equally price efficient, Sherman (2005) and Wilhelm (2005) argue that underwriter discretion is important, particularly when information acquisition costs are high, explaining the worldwide dominance of book building.

TABLE 2. **Descriptive initial return statistics**

Panel A – Initial Returns – All Rounds				
	Dutch Auction	**"Book building"**	**"Competitive IPO"**	**All**
Mean	0.46% (0.47)	1.33% (1.32)	-6.01% (-4.88)*	-1.41%
Median	0.38% (0.91)	0.92% (0.86)	-5.12% (0.81)	-1.53%
Standard Deviation	8.22%	8.59%	10.45%	9.67%
Maximum	19.04%	25.14%	17.32%	25.14%
Minimum	-13.38%	-17.75%	-44.99%	-44.99%
# Positive	37	41	16	94
# Negative	35	31	56	122
Panel B – Initial Returns – Last 12 Rounds				
Mean	1.62% (1.04)	-0.12% (-0.09)	-4.67% (-3.26)*	-1.06%
Median	1.89% (0.83)	0.62% (0.85)	-5.02% (0.86)	-1.74%
Standard Deviation	**9.39%**	**7.95%**	**8.60%**	**8.99%**
Maximum	19.04%	15.66%	14.32%	19.04%
Minimum	-13.38%	-17.75%	-31.87%	-31.87%
# Positive	20	19	8	51
# Negative	16	17	28	57

Note: "Book building" refers to a sealed bid, uniform price auction, and "competitive IPO" to a two-stage version of it. t-statistics for two-sided mean (equal to zero) for 72 observations (24 rounds times 3 sessions per method) for all rounds and 36 observations for the last 12 rounds. Wilcoxon z-tests p-values for the median in parenthesis. * denotes significance at 1%.

TABLE 3. **Mean initial return differences**

Panel A – All Rounds		
	t test (t statistic)	**Wilcoxon test (v statistic)**
Dutch Auction vs. Book building	-0.62	-0.48
Book building vs. Competitive IPO	4.61**	4.05**
Dutch Auction vs. Competitive IPO	4.13**	3.85**
Panel B – Last 12 Rounds		
Dutch Auction vs. Book building	0.85	0.79
Book building vs. Competitive IPO	2.33**	2.38**
Dutch Auction vs. Competitive IPO	2.96**	2.47**

Note: "Book building" refers to a sealed bid, uniform price auction, and "competitive IPO" to a two-stage version of it; significance at 10% and 5% denoted by * and **, respectively.

Table 4 presents the differences between the bids and the private signals (S_i) received by each investor in the "book building" and "competitive IPO" sessions. The results indicate that the "competitive IPO" is more likely to result in bids greater than the price signaled as private information. Table 5 shows the final price relative to the midpoint of the preliminary price range. The largest adjustment took place with the Dutch auction, the only method showing a positive adjustment significantly larger than the other two methods in the last twelve rounds. The average price adjustment was significantly negative in the "competitive IPO" relative to the other two pricing methods. This evidence is once more consistent with Bonini and Voloshyna (2013).

TABLE 4. **Information revelation: bid premium over private price signal**

Panel A – All Rounds			
	Book building	**Competitive IPO**	**Difference t test**
Mean	-8.11%	4.53%	-6.24**
Median	-2.36%	0.07%	
Standard Deviation	28.70%	46.21%	
Panel B – Last 12 Rounds			
Mean	-6.75%	3.20%	-4.14**
Median	-1.41%	0.05%	
Standard Deviation	30.25%	33.66%	

Note: "Book building" refers to a sealed bid, uniform price auction, and "competitive IPO" to a two-stage version of it; significance at 10% and 5% denoted by * and **, respectively.

Subjects clearly employed the bait-and-switch strategy in the "competitive IPO", in line with the intuition presented in Jenkinson and Jones (2009) for book building. The initial high bids served only to obtain the preliminary price range to increase their chances of selection as the winning bank. However, subjects offered lower prices when asked to provide the actual bid, which were still higher than those in the other two methods were. This could indicate the occurrence of a tacit collusive behavior between participants under the "competitive IPO" pricing mechanism, even though they could not communicate with each other. Our results suggest that actual competitive IPOs require that the first phase advisory institution must carefully link the bids presented by the institutions competing for distribution of the IPO to its offer value estimate to avoid setting price ranges that are too high. Under the assumption of no collusive behavior between the advisory institution and the distributing institution, the advisory institution could use discretion in selecting the distributing institution that presented the bid closest to its estimate for the value of the offer, rather than the highest bid, as in our design. Otherwise, bait-and-switch strategies will still be employed, as our results suggest.

TABLE 5. **Final price position (final price over price midrange)**

Panel A – All Rounds			
	Dutch Auction	**Book building**	**Competitive IPO**
Mean	2.26%	-0.22%	-34.21%
Standard Deviation	11.00%	8.32%	17.68%
Maximum	33.37%	17.72%	-7.03%
Minimum	-25.42%	-18.99%	-84.00%
	t test (t statistic)	**Wilcoxon test (v statistic)**	
Dutch Auction vs. Book building	1.52	1.04	
Book building vs. Competitive IPO	14.76**	7.37**	
Dutch Auction vs. Competitive IPO	14.86**	7.34**	
Panel B – Last 12 Rounds			
	Dutch Auction	**Book building**	**Competitive IPO**
Mean	3.91%	-0.57%	-35.39%
Standard Deviation	9.23%	8.61%	18.16%
Maximum	33.37%	17.72%	-7.17%
Minimum	-11.20%	-18.99%	-84.00%
	t test (t statistic)	**Wilcoxon test (v statistic)**	
Dutch Auction vs. Book building	2.13**	1.70*	
Book building vs. Competitive IPO	10.39**	5.22**	
Dutch Auction vs. Competitive IPO	11.58**	5.22**	

Note: "Book building" refers to a sealed bid, uniform price auction, and "competitive IPO" to a two-stage version of it; significance at 10% and 5% denoted by * and **, respectively.

"Book building" was the only method in which returns declined after the subjects learned about the process and had time to develop strategies, although they were not significantly different from zero in Table 2. Subjects gradually posted higher price bids after unsuccessful allocations in the initial rounds. Greater price bids lead to lower initial returns to investors. In the Dutch auction, on the other hand, returns to investors increased, suggesting lower price bids. Kagel and Levin (1986) documented that agents learn to avoid overpaying for an asset in an auction, the winner's curse, by participating in subsequent auctions, which is consistent with our evidence.

The proxy for seller allocation efficiency was the lowest average initial return, which maximizes proceeds to the seller. The "competitive IPO" emerged as the most seller allocation efficient method in Table 5. However, as discussed before, underwriters probably strive for pricing efficiency rather than seller allocation efficiency and, in actuality, should prefer book building, given that most investors are experienced in the IPO market and would like to use their discretion in pricing and allocation. It is also noteworthy that if sellers are planning to return to the market in the near future, the competitive IPO may not leave, on average, a good taste in the investor's mouth, in contrast with what its proponents desired (Jenkinson & Jones, 2009).

Buyer welfare allocation efficiency (BWE) was defined as $[\Sigma(V\text{-}S_i)\times kq_i] / [\Sigma(V\text{-}S_j)\times 10]$, where kq_i is the allocation of each participating investor i in the round, V is the true value of the offer, and S_i is the private signal or assessment of each investor, as defined in Section 3. Note that the offer size is 30 shares and the maximum allocation per investor in each round is 10 shares. Thus, in the denominator, j stands for the three investors with the lowest S_i, i.e., those who would benefit the most from the maximum allocation of 10 shares. The intuition is that BWE represents

how close the actual allocations and gains resulting from one of the pricing methods get to the allocations and gains to the investors that would benefit the most from that pricing method.

Table 6 shows the averages of a positive BWE from each round for each pricing method and that the Dutch auction is the most buyer welfare allocation efficient method. The "competitive IPO" comes out as the worst method. In this regard, our results support the views of those that advocate in favor of auctions, such as Trauten and Langer (2012). Nevertheless, if underwriters elected book building as their method of choice, then our results suggest they seek pricing efficiency, and not buyer welfare allocation efficiency – at least, as measured by our proxy, and that information costs are high, as suggested by Trauten and Langer (2012).

TABLE 6. **Buyer Welfare Efficiency (BWE) by pricing method**

Panel A – All Rounds			
	Dutch Auction	**Book building**	**Competitive IPO**
Mean	78.10%	45.20%	31.46%
Standard Deviation	13.34%	31.13%	31.57%
Maximum	99.51%	100.00%	98.04%
Minimum	43.47%	0.00%	0.00%

	t test (t statistic)	**Wilcoxon test (v statistic)**	
Dutch Auction vs. Book building	8.24**	5.95**	
Book building vs. Competitive IPO	2.62**	2.71**	
Dutch Auction vs. Competitive IPO	11.54**	6.72**	
Panel B – Last 12 Rounds			
	Dutch Auction	**Book building**	**Competitive IPO**
Mean	82.33%	43.51%	31.39%
Standard Deviation	12.73%	33.32%	32.26%
Maximum	99.51%	85.73%	98.04%
Minimum	43.47%	0.00%	0.00%

	t test (t statistic)	**Wilcoxon test (v statistic)**	
Dutch Auction vs. Book building	6.53**	4.64**	
Book building vs. Competitive IPO	1.57	1.87*	
Dutch Auction vs. Competitive IPO	8.81**	4.81**	

Note: "Book building" refers to a sealed bid, uniform price auction, and "competitive IPO" to a two-stage version of it. Significance at 10% and 5% denoted by * and **, respectively; BWE = [Σ(V-Si)×kqi] / [Σ(V-Sj)×10], where kqi is the allocation of each participating investor i in the round, V is the true value of the offer, and Si is the private signal or assessment of each investor. The offer size is 30 shares and the maximum allocation per investor in each round is 10 shares. In the denominator, j stands for the three investors with the lowest Si, those that would benefit the most from the maximum allocation of 10 shares.

CONCLUSIONS

We used a descending-price clock auction to emulate a Dutch auction, a one-stage sealed-bid auction to emulate book building, and a two-stage sealed bid auction to emulate the competitive IPO in our experiments. We conclude that book building may be the IPO pricing method that benefits bidding investors the most, at the expense of the issuing firm and selling shareholders, provided that our emulated "book building" is seen as a reasonable approximation of the actual process for the key variables we examined.

After investor learning, "book building" was the more price-efficient method compared to the "competitive IPO", with price efficiency defined as the average of initial returns closest to zero. "Book building" exhibited greater price formation stability, lower dispersion of initial returns and average deviation around the true offering price than the "competitive IPO". The results for "book building" were better than the results for the Dutch auction, but without statistical significance. However, actual book building allows underwriter discretion to adjust for greater investor information costs. This finding contradicts the argument of Sherman and Titman (2002) that accuracy in the offer pricing leads to larger initial returns.

Book building is the most widely adopted IPO pricing method around the world and, thus, our results suggest that underwriters seek pricing efficiency, if our proxies for this concept are good. This evidence is consistent with Trauten and Langer (2012) as well. Our results also suggest that "book building" could be better than the Dutch auction after some learning, but we did not obtain significance for this difference, consistently with Zhang (2009). "Book building" emerges as the method where learning leads to gains more often, even though it is price-efficient. This evidence is consistent with the preference underwriters demonstrate for book building and with the recurrent consultations between them and their clients. Book building may be more cost effective and stimulates relationships between investors and underwriters, who certainly prize them. Our experimental results in favor of book building agree with those in other articles, such as Cornelli and Goldreich (2003) and Wilhelm (2005).

The Dutch auction may be a better pricing method when investors are not necessarily experienced and relationships between the underwriter and investors are not appreciated or allowed. The Dutch auction comes out as the most buyer welfare allocative efficient method and the "competitive IPO", in contrast, provided the best results for the issuing firm and selling shareholders (at the expense of investors), emerging as the most seller allocative efficient method. This last result is in line with the findings of Bonini and Voloshyna (2013).

The "competitive IPO" was the least price efficient method, with or without learning, which somewhat goes against the motivation for its conception in the real world and this evidence contradicts Bonini and Voloshyna (2013) who believe there is room for hybrid methods to price IPOs. We also found evidence the bait-and-switch strategy in the "competitive IPO", suggesting it is important to create rules to discourage this practice wherever the technique is deployed. Although bait-and-switch may be better disguised in the context of book building, our competitive IPO experiment clearly exposed the problem since the competition for mandates is an explicit part of the offering procedure.

The evidence in this article derives from a setting in which bidders are informed and few have attained their optimal bid. Thus, it is not likely that they would do so in the more complex actual IPO auctions. One can also argue that experiments do not lead to realistic conclusions and are vulnerable in terms of the principle of parallelism, and thus, the extensibility of results. However, this kind of debate is mere speculation without actual data available for inspection or analysis to support the difference between laboratory data and real world data (Smith, 1980, 1982).

Future research could address issues of investor experience in its design and possibly run each session twice, with participants returning at another date. The "book building" design could be modified to consider underwriter discretion to favor allocations to its clients. Another possible extension is to allow communication between subjects and, thus, potential explicit collusion as opposed to the tacit collusion that may have been present in our competitive IPO experiment. Finally, a sensitivity analysis of key parameters could be carried out with alternate sessions.

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