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# Why Negotiation with a Single Syndicate May Be Preferred to Making Syndicates Compete: The Problem of Trapped Bidders*

We investigate the choice between hiring syndicates through competitive bidding and negotiation. Making syndicates compete can result in inferior terms because of inefficiencies like less effective search, possibly less total search, and trapped bidders. Empirical results are consistent with our hypotheses that purchasing syndicates search less under competition and that competition produces trapped bidders. The results also show that the primary market is rigidly divided under competition. When this occurs, total search under competitive bidding can be less than total search under negotiation. This may explain why competitive bidding is not favored in spite of its lower cost.

## I. Introduction

Capital-raising companies have repeatedly shown a preference to negotiate their underwriting contracts rather than award them through competitive sealed bid auctions. For example, *all* of the many thousand underwritten industrial offerings of the past 2 decades are negotiated offers (see the Securities and Exchange Commission's [SEC] *Registered Offerings Statistics* [*ROS*] tape, and various issues of *Investment Dealer's Digest*).[1] This appears somewhat con-

* We thank Mark Bagnoli, George Benston, Eli Berkovitch, Bill Beranek, Dave Blackwell, Michael Bradley, Bill Daly, Harry DeAngelo, David Denis, Diane Denis, Milt Harris, David Hirshliefer, Scott Masten, Bill Megginson, Merton Miller, Harold Mulherin, John Paul, Steve Slezak, Ted Snyder, Chester Spatt, Larry Wahl, Doug Diamond, the editor, and an anonymous referee. An earlier version of this article was presented at Emory University, the University of Georgia, the University of Michigan, the Securities and Exchange Commission, and the 1991 Western Finance Association meetings in San Francisco Sam Priyadarshi provided valuable computational assistance We also thank the First Boston Co for providing data about competitive bid equity offerings by electric utilities and Arthur Andersen & Co Inc for assistance in obtaining offering prospectuses. For partial financial support, Hansen thanks the Pamplin College of Business, and Khanna thanks the Michigan Business School.

1 While we did not verify every observation obtained

(*Journal of Business*, 1994, vol 67, no. 3)

0021-9398/94/6703-0005$01.50

trary to what existing empirical results suggest. Studies show that utilities required by law to select syndicates through competitive bidding pay lower underwriting fees than do utilities that hire their syndicates through negotiation. Indeed, this fee differential is often viewed by economists as evidence of competitive bidding's superiority over negotiation, despite its general disuse.[2] What makes this all the more perplexing are the long-standing arguments that using competitive bidding benefits issuers because it engages investment banks in more intensive competition (see West 1965) and it increases investment banks' search for investors (Kessel 1971). For these reasons, the overwhelming preference for negotiation remains one of the more puzzling phenomena of corporate finance.

Our review of extant models of syndicate behavior suggests no particular resolution to this anomaly. Many aspects, including risk management, certification, monitoring, and the possible incentive conflicts between issuers and investors, have been studied and provide important insights about investment banking (see, among others, Christianson 1965; Kraus and Stoll 1972; Mandelker and Raviv 1977; Baron 1979; Baron and Holmström 1980; Easterbrook 1984; Beatty and Ritter 1986; Booth and Smith 1986; Denis 1991; and Hansen and Torregrosa 1992). However, despite these varied inquiries, the economics of syndicate competition and syndicate formation under both negotiation and competition remains relatively unexplored. In this article we model the syndication process and provide a possible explanation for the disuse of competitive bidding even though it may be cheaper.[3]

We begin by examining the choice between competitive bidding and negotiation. Lead banks form syndicates after costly search of investors to discover their private values for a share of the offering. They then rank the searched values from the highest down and set the offer price at the value of the marginal investor. Under negotiation, one lead bank forms a single syndicate. Under competition, different lead banks search independently, form separate syndicates with different members, bid their respective offer prices in a first price, sealed bid auction, and the winner receives the offer.

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from the *ROS* tape, we did examine the few offerings that are recorded as competitive bid auction by industrial companies to discover that they all are errors of one kind or another.

2 Studies that compare underwriting fees paid by utilities in the alternate contracts include Logue and Jarrow (1978), Sorensen (1979), Fabozzi and West (1981), and Bhagat and Frost (1986) The fee gap is also documented for municipal offers (e.g., see West 1965; and Kessel 1971)

3 Some other explanations for the disuse of competitive bidding are that due diligence may be hindered (Carosso 1970) and that negotiation allows more efficient use of proprietary information needed to price the offer (Hansen 1986). Our model does not address these explanations, and we do not attempt to either support them or rule them out Our focus is on the search cost component of ex ante flotation costs that is incurred under both negotiation and competitive bidding. Other costs, like those that may arise from asymmetric information, the agency problem, or risk, are ignored.

One conclusion of our article is that, not only is total search by investment banks important, but so is "effective search" (i.e., the search conducted by only the purchasing syndicate). In our model, competitive bidding leads to redundant search by losing syndicates, which makes effective search lower than total search, thus reducing the offer price. It also leads to "trapped bidders," which are those members of losing syndicates who are willing to pay more than the winning offer price but are excluded from the final offer. Because of this, competing syndicates command fewer high-priced members than is possible under negotiation, which further deteriorates the issuer's offer terms. For both of these reasons, selecting syndicates through competition can be the inferior method for raising capital.

The model also illustrates that, when competitive bidding occurs in a divided primary market, it may reduce total search to below that under negotiation.[4] Under the zero-profit condition for syndicates, this translates into lower fees for competitive offers. However, because the lower fees are a result of lower search, issuers may not prefer the cheaper mechanism. Since our empirical analysis strongly suggests that a persistent division of the primary market occurs when competitive bidding is used, our model offers a plausible explanation for both the observed lower cost of competitive bidding and its general disuse.[5]

We also test the main implications from our model, using a sample of competitive offers by utilities. These utilities are required by the SEC (under Rule 124(b)) to use formal competitive bidding when they hire syndicates. This requirement fulfills the SEC's obligation under Rule U-50, to assure the fairness of underwriting fees paid by utility holding companies and their subsidiaries, as mandated by the Public Utility Holding Company Act. The competitive offers are compared with a matched sample of negotiated offers by utilities that are not required to use competitive bidding. We find that syndicate composition changes between comparable offers are less under competition than under negotiation and that negotiated syndicates are significantly larger. These results are consistent with more effective search under negotiation than under competition. Moreover, we report that, for the short period of time when certain utilities were not restricted by the SEC to use competitive bidding, none used this method. Instead, these firms switched to negotiation, and their resulting syndicate memberships surged threefold, to the level normally found under negotiation.

4. Thus, in contrast to Kessel (1971), competitive bidding can result in less total search of capital markets

5. Unlike the results in the previous paragraph, which, given our assumptions about competition, are somewhat general, this result is specific to the parameters we use It is easy to provide counterexamples in which the reverse holds However, in spite of being parameter-specific, this example illustrates a possible solution to the competitive bid puzzle

We also report evidence consistent with our hypothesis that excluded investors are a common phenomenon in competitive bidding. In addition, we are able to identify some members in losing syndicates who were willing to pay more than the auction winning offer price. This evidence supports our view that competitive bidding is characterized by trapped bidders. Moreover, these results and additional evidence demonstrate that the primary market is persistently and rigidly divided between established bidding syndicates. This lends support to our resolution of the competitive bid puzzle.[6]

## II. Negotiation versus Competitive Bidding

We consider a company that plans to sell three shares into a primary market of 10 potential investors. Fixing the number of shares sold permits evaluating syndicate performance with one statistic, the net proceeds raised (gross proceeds less syndicate compensation). Any investor can buy no more than one share, and each has a different private value for a share, ranging from $1 to $10. Thus, one investor has a private value of $1, another has $2, another $3, and so on, up to the $10 value.[7] Moreover, until searched, investors do not know who has which private value. Because investors' private values are independent of the syndication method, so are the prices paid for new shares. For concreteness, we call the set of potential buyers of new shares "investors," and a syndicate's "members" are those investors who have committed to buy the shares if the syndicate gets the offer.

Under negotiation, the lead bank forms a syndicate by searching investors sequentially, retains the three with the highest private values, then buys the new shares at the private value of its third highest member (its "third-order statistic," TOS), and receives its fee. Under competition, lead banks independently search and form syndicates, then submit their respective bids in a first price, sealed bid auction. The syndicate bidding the highest net proceeds wins the offering.

Since search is costly, a bank only searches investors who give it the "right of first refusal," that is, those who agree to join the syndicate if needed.[8] Without this property right, a free-rider problem arises under

6. Thus, we provide an alternative hypothesis to the claim by Bhagat and Frost (1986), that managers choose negotiation over competitive bidding because they can be more easily bribed.

7 This price variation may reflect random differences in investors' transaction costs or opinion, or what Merton (1987) calls conditional heterogeneity This assumption is tantamount to assuming a finite demand elasticity for the new securities. Recent evidence of downward-sloping demand for shares is reported by Bagwell (1992) and Shleifer (1986).

8. Search includes finding investors, researching their needs and tax considerations, keeping them "financially whole" and persuading them to buy the new securities (see Hansen and Torregrosa 1993). Different investor values may be modeled using affiliated

competition, as each bank has the incentive to avoid costly search and to try attracting already searched investors from a rival syndicate. In equilibrium, no bank has the incentive to search before knowing that it has won, and the competitive bid contract breaks down.

To maintain symmetry in our comparisons, we require that all lead banks act in the best interest of the issuing company, whether under competition or negotiation. We assume costless contracting, so there are no bargaining costs nor any problems with enforcing syndicate compliance with their contracts. We assume that all banks have the same cost of \$1 per investor searched and no other expenses and that the investment banking industry is highly contestable. Thus, syndicates earn zero profits in expectation. In our model, this means that the fees charged by the winning syndicate will equal expected total search costs.

### *A. The Negotiated Contract*

Under negotiation, the lead bank builds its syndicate by searching additional investors as long as the marginal benefit to the issuer is greater than the marginal cost of search. Thus, the optimal stopping rule is

NEGOTIATION STOPPING RULE. The bank searches until it gets a TOS of \$8, or a TOS of \$7 if less than five investors have been searched.

*Proof.* See the Appendix.

Under the negotiated contract, unless the lead bank can form its syndicate with a \$7 TOS early in its search, it keeps searching among investors until it locates the \$8 TOS.

Panel A of table 1 reports the frequency distribution of buyer search for this negotiated contract. About 15% of the time the lead bank searches no more than half the market, stopping with either the \$7 or the \$8 TOS. About 65% of the time the bank searches at least 80% of the market, netting the issuer the maximum attainable offer price. As panel B reports, the lead bank's effective search is 76.1% of the market, on average, and because one bank is searching, effective search and total search are the same. The resulting expected gross offer price is \$7.92, while the expected search cost is \$7.61, yielding expected net proceeds of $\$7.92 \times 3 - \$7.61 = \$16.15$.

### *B. Two Different Competitive Bid Contracts*

To enforce competition, the issuer must impose some conditions on how the competition will be conducted. Two minimal conditions are

values, as in Milgrom and Weber (1982), but this complicates computing the *n*th-order statistic and the updating process Since investors are still divided by competitive bidding, so that trapped bidders remain, we reach the main result in a simpler and more intuitive manner

TABLE 1 Syndicate Search Frequency and Equilibrium Outcomes in Negotiated and Competitive Syndications

| | Negotiation | Competition | |
|---|---|---|---|
| | | Open | Divided |
| A. Search distributions, total search: | | | |
| 1 | .000 | .000 | .000 |
| 2 | 000 | .000 | .000 |
| 3 | .031 | .000 | .000 |
| 4 | 079 | .000 | 000 |
| 5 | 046 | .000 | 000 |
| 6 | .077 | .224 | .267 |
| 7 | 115 | .143 | .214 |
| 8 | 161 | .243 | 369 |
| 9 | 215 | .162 | .050 |
| 10 | 276 | .228 | .100 |
| B Expected outcomes. | | | |
| Effective search | 7 61 | 4.55 | 4.25 |
| Total search | 7.61 | 8.03 | 7.50 |
| Offer price ($) | 7 92 | 6.35 | 5 90 |
| Fee ($) | 7 61 | 8.03 | 7.50 |
| Net proceeds ($) | 16.15 | 11 02 | 10.20 |

NOTE —Panel A entries are the total search probabilities under different contractual stopping rules Expected net proceeds in panel B equal three times the expected offer price less the expected search costs

imposed here. First, communication of information between rival lead banks, either ex ante or ex post, is prohibited. This does not, however, rule out one bank inferring some information about the other's search efforts from public information or information from its own searches. Second, bids submitted by the rival syndicates must be based on actual values of searched investors. Thus, the lead banks are required to submit "legitimate bids" and must, therefore, search at least three investors.[9] In addition, we assume that banks search sequentially, and because each bank takes the right of first refusal from each investor it searches, a searched investor is unavailable to a rival bank.

1. *Open competition.* Under "open competition," after searching three investors, one bank decides, on the basis of its own searches and its conditional expected searches of its rival, whether additional search is in the interest of the issuer. If it is, this bank searches one more investor. Then the rival must decide, on the basis of its own searches and its conditional expected searches of the first bank,

9. Without prohibiting communication and requiring legitimate bids, we may have a case of trivial competition in which one bank simply searches one investor then bows out, leaving the remaining investor pool to be searched by the rival bank. Alternately, with a frictionless secondary market, the competitive outcome will resemble the negotiated outcome Such restrictions are found in practice, as was evident in Salomon Brothers Inc 's scandal with U S Treasury auctions (see *Wall Street Journal* 1991, p C-1)

whether it should make a fourth search and so on. This results in the following stopping rule and the resultant expected number of searches and the expected offer price.

OPEN COMPETITION STOPPING RULE. Each bank searches until it gets four G's, or three G's with TOS of $7 or $8, or has BGGBB, BGB, or BBB.

*Proof.* See the Appendix.

This rule contains notation used in the Appendix proofs. There, a private value of $5 or less is denoted by a B (for "Bad"), a private value of $6 or more is denoted by a G (for "Good"), and a search sequence may look like BGGBB, as in the above rule. While the order of the first three searches in any sequence is not important (three investors must be searched), the order of later searches in the sequence is.

Table 1 reports the search frequency distribution and equilibrium outcomes for open competition. On average, open competition produces less expected effective search than negotiation (4.55 investors vs. 7.61). However, it produces more expected total search. Moreover, due to trapped bidders, there is a drop in the expected offer price from $7.92 to $6.35.[10] Consequently, expected net proceeds are less for two reasons—a lower expected gross offer price and more expected total search—resulting in higher syndicate fees.

The open competition search frequency highlights other aspects of search inefficiency. Because each syndicate must submit a legitimate bid, competition has increased the lower bound of total search above what is necessary under negotiation. Thus, it may happen that, when one bank stops searching with three initial very high priced investors, knowing that another search is not in the interest of the issuer, the rival bank conducts at least three wasteful searches. Also, as can be seen from the stopping rules developed above, the winning syndicate will at times stop with a lower third-order statistic under competition than under negotiation. Thus, open competition may cause oversearch of low-priced investors and undersearch of high-priced investors.

2. *Divided competition.* Competition may be robust but constrained to exist in a divided market. Such a possibility is raised by the data reported later, which suggests that the primary market is rigidly divided when syndicates are forced to compete. We consider divided competition in which investors are randomly separated into

10. Trapped bidders arise when the losing syndicate has members willing to pay more than the auction winning price for a new share. For example, suppose the winning syndicate has members who will pay $10, $9, and $7, and the loser has members who will pay $8, $6, and $5. So there is a trapped bidder in the losing syndicate who is willing to pay $8, even though the auction winning price is $7. Had the $8 investor been a member of the winning syndicate, the issuer would have realized an additional $3 in proceeds. In this fashion, trapped bidders reduce net proceeds.

two subgroups of equal size. When the issuer works out the details of search under divided competition, it writes the following stopping rule.

Divided Competition Stopping Rule. Each bank stops searching after three searches if they reveal at least two B investors, or after it locates four G investors, or after it has three G investors and its TOS cannot be raised by more than $1 by one more search revealing another G.

*Proof.* See the Appendix.

Table 1 reports the results for divided competition. The search distribution reveals a tendency for search to cluster between six and eight investors, with the total search reaching 9 or 10 investors 15% of the time. Expected effective search has declined further. Particularly noteworthy is that the total expected search under divided competition is below the total expected search under negotiation. Consequently, competitive offerings are cheaper than negotiated offerings. Also, constrained competition has predictably resulted in still lower net proceeds than under the other contracts.

In sum, given the downward sloped demand for shares and costly search, our model suggests that, for a given set of parameters, hiring syndicates through negotiation is superior to forcing them to compete, even though it may be more costly. Forcing syndicates to compete introduces search inefficiency into the capital acquisition process. In consequence, issuers are qualitatively better off using negotiation.[11] Moreover, our framework suggests that a finding that competitive bidding costs less than negotiation is not a reliable indication that it is better than negotiation.

## III. Empirical Evidence

The above discussion suggests that, if search is important, trapped bidders exist, and syndicate leaders work in the best interest of the issuing firm, then negotiation dominates competitive bidding. In this section we first report evidence consistent with the conclusions that syndicate search does matter and that more effective search takes place when issuers use negotiation. We then report evidence consistent with the conclusions that trapped bidders occur when competitive bidding is used and that the primary market is rigidly divided under competitive bidding.[12]

11. However, this does not mean companies should not pit banks in scrutinized tournaments to establish a long-term relationship Eccles and Crane (1988) discuss a case in which Union Carbide pitted challenger First Boston against incumbent Morgan Stanley for the right to future business.

12 We do not examine stock prices to test our hypotheses. Significant difficulties arise in comparisons of stock price reactions between the underwriting methods Only those utilities required by the SEC use competitive bidding Thus, stock prices have

### A. *The Data*

The First Boston Corp. provided detailed information about the outcomes of 88 competitive bid equity auctions by 25 different utilities during 1972–81. All offerings are by utilities required by the SEC to use competitive bidding. The sample period ends prior to the SEC's 1982 implementation of Rule 415.[13] Panel A of table 2 reports offer frequency by issuer and by number of bids. On average, each utility has 3.5 offers in the sample period and 3.1 syndicates bid on each of these offers. Panel A reports the frequency of offers by the number of the top 10 investment banks in either the winning or losing syndicate (these top banks are listed in panel B). The top 10 banks are the most active co-leaders of equity underwriting syndicates (see *Institutional Investor*) and competitive bid equity underwriting syndicates (see *Investment Dealer's Digest*). At least six of these top banks co-led bidding syndicates in every offer, but it is most frequently the case (57 offers) that all 10 banks participated as co-leads.[14] On average, 9.4 of the top 10 banks co-led either the winning or a losing syndicate in each offer. Panel B reports the participation frequency and the auction winning averages of the top 10 banks. Each bank co-led 82.9 syndicates, on average, participating in 94.2% of the auctions. Hereafter, these banks are called "top banks." On average, each top bank won 37.7% of the time.

### B. *Search*

Because we cannot observe syndicates' actual search for investors, we rely on proxy variables for search. We examine five proxy variables; the first two are based on changes in syndicate composition, and the remaining three are based on syndicate size.

1. *Comparisons based on syndicate composition changes.* The first two proxy variables are designed to yield evidence on the hypotheses that purchasing syndicate search is important and that more search takes place under negotiation than under competition. These proxy

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impounded in them the long-term effects of systematic use of the two methods More-over, while our model suggests that net proceeds are reduced by competition, this is not a useful proposition to test For example, had we cast our model with the assumption that net proceeds must be the same under either method, we would still find that competitive bidding is inferior, yet net proceeds would be the same regardless of underwriting method

13 Rule U-50 requires that registered public utility holding companies, and their subsidiaries, sell their securities through competitive bidding (see Logue and Jarrow 1978; Bhagat and Frost 1986) The SEC's *ROS* tape was examined along with various issues of *Investment Dealer's Digest* to confirm the First Boston sample Throughout, because of contract form differences (see Hansen 1989) underwritten rights offerings are excluded.

14 Merrill Lynch and White Weld receive full participation credit in deals after their 1978 merger, and so do Blythe Eastman and Paine Webber following their merger Prior to the combination of Bache and Halsey, Stuart & Co , Halsey, Stuart & Co. is tracked

TABLE 2 **Characteristics of 88 Competitive Offerings over 1973–81, the Frequency with Which the 10 Major Investment Banks Co-led the Offerings, and the Frequency with Which They Won the Auctions**

**A. Offering Frequency by Company, Number of Bids, and Number of Top Banks***

| Companies | Offerings | Bids | Offerings | Top Banks | Offerings |
|---|---|---|---|---|---|
| 7 | 1 | 2 | 32 | 6 | 2 |
| 9 | 2–3 | 3 | 27 | 7 | 2 |
| 5 | 4–5 | 4 | 15 | 8 | 10 |
| 5 | 7+ | 5 | 12 | 9 | 17 |
| | | 6 | 2 | 10 | 57 |

**B. Syndicates Co-led and Auctions Won by the 10 Major Investment Banks**

| | Syndicates Co-led | Auctions Won (%) | | Syndicates Co-led | Auctions Won (%) |
|---|---|---|---|---|---|
| Bache Halsey | 83 | 42.2 | Merrill Lynch | 82 | 35 4 |
| Blythe Eastman | 82 | 37 8 | Paine Webber | 83 | 34 9 |
| First Boston | 82 | 40.2 | Salomon Brothers | 83 | 43.4 |
| Goldman Sachs | 83 | 27.7 | Smith Barney | 82 | 47 6 |
| Kidder Peabody | 87 | 35.6 | White Weld | 82 | 31 7 |

* Number of companies refers to the number of different issuing companies in the sample, bids per offering is the number of bidding syndicates per offering, and number of top banks is the total number of the 10 top banks identified in panel B that are among the lead banks of the bidding syndicates

variables measure the change in composition of syndicates led by the same banks in pairs of similar offers by the same issuer. For a given offering pair, we define the lead banks of the two syndicates as not the same when 25% or more of the total banks leading the two offers are not in both syndicates.[15] A pair of offers is considered similar when the proceeds in either offer do not exceed the proceeds in the other offer by more than 100%.[16] Throughout the article, we always express proceeds in December 1985 dollars, using the consumers price index as deflator. Based on these criteria, 38 offerings are used to construct 19 pairs whose offers are similar in size and are underwritten by the same syndicate. Nine of the pairs have offers that are contiguous in

15 Specifically, the syndicate's lead banks are those banks listed on the cover of the offering prospectus, which may or may not contain some of the top banks. The fraction of banks that are the same is the ratio of twice the number of lead banks that appear in both offers, divided by the sum of the number of lead banks in each offer

16. We omit pairs whose proceeds differ by more than 100% to avoid contaminating the search proxy variable with changes that are more correctly attributed to changes in offer size. The sample average, within offer pair, proceeds change is 24% under competition and 38% under negotiation. Differences in these means are not statistically significant at conventional levels.

time, and 10 pairs have offers that are separated by other underwritten equity offerings by the issuing firm.[17]

We matched each pair of competitive offerings with a pair of negotiated offerings (as found in the *ROS* tape) that are approximately similarly separated in time and similar in size. To do so, we required the offering prospectus for each negotiated offer and that each offer pair meet the above noted lead bank criteria and the similar offer size criteria. Thus, in all, 76 equity offerings are used to construct 38 pairs, all by regulated utilities, with half using competitive bidding and half using negotiation.[18]

The first measure of syndicate composition change for an issuer's offer pair, denoted ΔSYN1, is

$$\Delta\text{SYN1} = \frac{1}{2}\sum_{j=1}^{n}\left|\frac{r_j^1}{R^1} - \frac{r_j^2}{R^2}\right|, \tag{1}$$

where $r_j^z$ is bank $j$'s ration (number of shares allocated) of the issuer's offer $z$ ($z = 1, 2$), $R^z = \Sigma_{j=1}^{n^z} r_j^z$, $n^z$ is the total number of banks in the syndicate for offer $z$, and $n$ is the total number of different banks in the two offers. Thus, ΔSYN1 measures the sum of the absolute changes in the syndicate members' percentage allocations between two competitive offers or between the two matched negotiated offers.[19] If all banks are in both syndicates and each is allocated the same percentage of each offer, then ΔSYN1 = 0. If some banks are not in both syndicates or if some bank's percentage allocations change, then ΔSYN1 increases. A larger ΔSYN1 registers more change in the syndicate's composition. Under the assumption that these changes are correlated with the search for investors, a larger ΔSYN1 proxies for more syndicate search.

One potential limitation of ΔSYN1 is that each lead bank's percentage change between the two offers is treated the same as any other member bank's percentage change. However, because lead banks tend

17 For example, the respective syndicates for Pacific Power & Light Company's offers in June 1973, March 1974, and May 1977 are similar and are led by seven, six, and eight investment banks, respectively Also, a different syndicate underwrote their September 1975 and December 1976 offers, whose syndicates were led by nine and eight banks, respectively These five offers are similarly sized, ranging in proceeds from $93 million to $118 million, and they yield two contiguous similar offer pairs led by the same banks (the 1973–74 pair and the 1975–76 pair) and one similar offer pair led by similar banks that is separated by other deals (the 1974–77 pair)

18 Many utilities are not required by Rule 50 to use competitive bidding. Unless noted, all negotiated offerings used in this study are by such exempt utilities (for one discussion of the exempt utilities, see Logue and Jarrow 1978).

19. The offering prospectus reports in the "Underwriters" (or "Purchasers") section every bank in the syndicate and its portion of the newly issued shares Prospectuses were obtained by a phone call to each utility and from the files of Arthur Andersen & Co., Chicago Seven competitive bid prospectuses could not be found

to have larger allocations, when they completely drop from the syndicate there can be unduly large swings in the percentage allocations that are not entirely reflective of changes in search.[20] To address this limitation we also recompute (1) but treat the entire set of lead banks as one composite lead bank. This second measure is denoted ΔSYN2.

The sample means for ΔSYN1 and ΔSYN2 under competitive bidding are 23.72% and 14.01%, and their respective medians are 22.97% and 15.63%. The respective means under negotiation are 32.54% and 26.62%, with respective medians of 35.03% and 25.78%. Student's $t$-statistics indicate that each of the means and medians is significantly greater than zero at better than the 0.01 level (all $t$-statistics exceed 10). This is consistent with the conclusion that search for buyers by underwriters is important.

Student's $t$-statistics also indicate that the mean values of ΔSYN1 and ΔSYN2 for negotiated offer pairs are significantly greater than their respective mean values under competitive bidding (respective $t$-statistics are 2.22 and 3.77 and respective associated $p$-values are 0.03 and 0.001). This is consistent with the conclusion that underwriter search is greater under negotiation than under competitive bidding. Moreover, Wilcoxon paired-sample signed-rank tests indicate that the median of ΔSYN1 under negotiation is significantly higher than the median of ΔSYN1 under competition ($Z$-statistic 2.10 with $p$-value of 0.04) and that the same is true for ΔSYN2 ($Z$-statistic 3.07 with $p$-value of 0.002). These test results are in agreement with the conclusion that there is more effective syndicate search for buyers under negotiation than under competition.

These mean and median comparisons do not hold constant other potentially relevant influences on syndicate change. Everything else being the same, we also expect cross-sectional changes in syndicate composition to increase with offer size since larger offers require a larger investor base. Moreover, we expect that syndicate composition changes for offer pairs separated by other underwritten equity offers may increase above the changes for pairs of contiguous offers. To further test if negotiated offers are characterized by greater composition changes than competitive offers, holding constant these potential effects, we use ordinary least squares regression.

Table 3 reports cross-sectional ordinary least squares regression results in which each of the two search proxy variables is regressed on three independent variables: ln(MSIZE) is the natural logarithm of the average amount of gross proceeds raised in the offer pair, OTHDEALS

20 For example, once Merrill Lynch and White, Weld & Co merged, White, Weld could no longer co-lead syndicates that previously rivaled Merrill Lynch co-led syndicates Consequently, there can be a somewhat large change in syndicate composition due to White, Weld's merger with Merrill Lynch

**TABLE 3 Ordinary Least Squares Regression of the Amount of Search, Measured by the Change in Syndicate Composition in Proximate Offerings, on Independent Variables**

| | Dependent Variables | | | | | |
|---|---|---|---|---|---|---|
| Independent Variables | ΔSYN1 (1) | ΔSYN1 (2) | ΔSYN1 (3) | ΔSYN2 (4) | ΔSYN2 (5) | ΔSYN2 (6) |
| Constant | −37.42 | 18 22*** | −25.91 | −37.09* | 10 31*** | −29.91 |
| | (−1 40) | (5 64) | (−1.01) | (−1 65) | (3.65) | (−1.34) |
| ln(MSIZE) | 5 43** | . . . | 4 00* | 4.54** | . | 3.65* |
| | (2 30) | | (1 73) | (2 28) | | (1 81) |
| OTHDEALS | | 5 81*** | 4 85** | | 3 90** | 3.03* |
| | | (2.82) | (2 33) | | (2 16) | (1 67) |
| NEGOT | 8.68** | 11.87*** | 11 27*** | 12 50*** | 14 66*** | 14.11*** |
| | (2 31) | (3 13) | (3.04) | (3 95) | (4 41) | (4 36) |
| Adjusted $R^2$ | 19 | .24 | 28 | .34 | .33 | 37 |
| $F$ | 5.4 | 6 9 | 5.9 | 10.5 | 10.2 | 8 3 |
| $N$ | 38 | 38 | 38 | 38 | 38 | 38 |

NOTE —$t$-statistics are in parentheses, ΔSYN1 and ΔSYN2 are indices of the mean change in a syndicate member's ration from one offer to another by the same company, ln(MSIZE) is the natural logarithm of the mean amount of gross proceeds raised in the two offers, expressed in December 1985 dollars using the consumers price index as a deflator. OTHDEALS is the number of other underwritten equity offerings by the issuer that occurred between the two offers, and NEGOT is a zero-one dummy variable equal to one if the offer is negotiated

* $p \leq$ 10

** $p \leq$ 05

*** $p \leq$ 01

is the number of other underwritten equity offers by the issuer that occur between the paired offers, and NEGOT is a zero-one dummy variable equal to one if the offer is negotiated. Columns 1–3 report the result for ΔSYN1 and columns 4–6 report the results for ΔSYN2.[21]

Column 1 results suggest, independent of the underwriting method, that the change in syndicate composition is greater for larger offer pairs. In addition, syndicate composition change under negotiation is significantly greater than under competitive bidding at the 0.05 level.

Column 2 reports the marginal effect on syndicate composition change of other underwritten equity offers between the paired offers, given the underwriting method. The results indicate that composition change increases as more offers transpire between the pair of deals. Controlling for the effect of other deals, the coefficient on the NEGOT dummy is statistically significant at the 0.01 level.

Column 3 reports the joint effects of offer size, other deals, and offering method on syndicate composition change. When considered together, the effect of size and other deals on composition change remain statistically significant. Moreover, the results indicate that negotiated offers are characterizedf by greater syndicate change.

The columns 4–6 results are in agreement with the columns 1–3 results. Thus, using either ΔSYN1 or ΔSYN2, the evidence reported in table 3 is consistent with the conclusion that there is greater search of investors when underwriting syndicates are hired through negotiation than through competitive bidding.

2. *Comparisons based on syndicate size.* While the above evidence is consistent with our model, it relies on syndicate composition change-based proxy variables.[22] To further test the search hypothesis, we consider two additional cross-sectional ordinary least squares regression tests which use size-based comparisons between competitive and negotiated offers. The sample is created by matching each competitive offer with a negotiated offer (found on the *ROS* tape) of similar offer size and time period. As offer prospectuses were required to complete these tests, the matched sample has 81 competitive offers and 81 negotiated offers.

21 The per-offer pair mean proceeds is $107 million under competitive bidding and $101 million under negotiation, and the mean number of other deals is 0 95 under competitive bidding and 0.46 under negotiation. Differences in these means (and the medians) by offering type are not statistically significant at conventional levels

22 Another potential limitation with ΔSYN1 and ΔSYN2 is that they may not detect certain potentially relevant changes in composition For example, offers within a pair may differ in size, yet each bank is allocated the same proportion of each offer. In this case, each bank may change its search of investors yet ΔSYN1 is zero To address this shortcoming we examined variations of these measures, e g , $\Delta SYN1^* = \Sigma_{j=1}^{n} |r_j^1 - r_j^2|/(R^1 + R^2)$, and a similar variation ΔSYN2* We obtained qualitatively similar results using these measures and do not report them In addition, we examined these measures of syndicate change using dollar rations, rather than number of share rations, and obtained qualitatively similar results

The tests use three size-based proxy variables for search: the number of investment banks in the syndicate, denoted SYNM#; the number of investment banks in the syndicate per million dollars of gross proceeds, denoted SYNM$; and the number of the top banks listed in panel B of table 2, which are in the syndicate, denoted TOPB. These proxy variables assume that "wider" search (i.e., more banks) is better than "deeper" search (i.e., more dollars raised per bank).[23] For the sample, on average, negotiated syndicates hire 115 investment banks, 1.6 banks per million dollars, and 9.7 top banks. In contrast, competitive bid syndicates hire 47 banks, 0.6 per million dollars, and only 3.4 top banks. Student $t$-statistics indicate the negotiated means are significantly above the competitive means for all three proxy variables (all three $t$-statistics are above 10). Moreover, Wilcoxon matched-pair sign-rank tests reveal that the respective medians are significantly greater under negotiation (all three $Z$-statistics are above 8). This is consistent with more effective search under negotiation).

The first test compares effective search in competitive offers with effective search in negotiated offers. Columns 1–3 of table 4 report results from regressing each proxy variable on the natural logarithm of gross proceeds, ln(SIZE), and NEGOT, a dummy variable equal to one for the 81 negotiated offers. The results show that, as offer size increases, syndicates employ more banks, but fewer per dollar raised, and more top banks are in the purchasing syndicate. Controlling for the effect of offer size, the results show that purchasing syndicates under negotiation are significantly larger and employ significantly more of the top banks. This evidence is consistent with the conclusion that significantly less effective search takes place under competition. Thus, support for our search hypothesis is somewhat robust with respect to the choice of measures for search.

The evidence in columns 1–3 is also consistent with the competing hypothesis that other (unspecified) systematic differences exist between users of competition and negotiation that produce the observed differences in effective search. For example, perhaps, because only long-established utility holding companies use competitive bidding, less search is required for their offers, and their syndicates are systematically smaller regardless of how their underwriters are hired.

To address this competing hypothesis, we conduct a second test that makes use of the temporary switch to negotiation by utilities that normally use competition. This sample is made possible because the SEC temporarily suspended mandatory use of competitive bidding,

23. A sufficient condition for this is that the prices investors will pay for new shares fall as their capital commitment increases Alternately, these proxies presume that each bank represents a given set of final investors Evidence reported later is consistent with the conclusion that wider search is better than deeper search.

TABLE 4 Ordinary Least Squares Regression of Three Different Proxy Variables for Syndicate Search on Independent Variables

| | Dependent Variables | | | | | |
|---|---|---|---|---|---|---|
| Independent Variables | SYNM# (1) | SYNM$ (2) | TOPB (3) | SYNM# (4) | SYNM$ (5) | TOPB (6) |
| Constant | −116 26*** | 2 81*** | .02 | −126.72*** | 2.83*** | 24*** |
| | (−10 02) | (12 59) | ( 04) | (−11 39) | (13.84) | ( 50) |
| ln(SIZE) | 38.06*** | −.52*** | 79*** | 40.50*** | −.52*** | .73*** |
| | (14.61) | (−10.30) | (6 90) | (16.32) | (−11.40) | (6 96) |
| NEGOT | 68.57*** | 1.00*** | 6.28*** | 68.57*** | 1.00*** | 6 28*** |
| | (14.98) | (11.38) | (31.38) | (14.65) | (11 64) | (31.52) |
| SWITCH | | | | 76.15*** | .91*** | 5 81*** |
| | | | | (9 09) | (5.93) | (16 29) |
| Adjusted $R^2$ | .73 | .59 | .86 | .74 | 59 | 86 |
| $F$ | 220 | 117 | 447 | 117 | 117 | 369 |
| $N$ | 162 | 162 | 162 | 178 | 178 | 178 |

NOTE —$t$-statistics are in parentheses, SYNM# is the total number of investment banks in the syndicate, SYNM$ equals SYNM# − $G, where $G is real gross proceeds (in millions and as adjusted by the consumers price index), TOPB is the number of top banks listed in panel B of table 2 which are in the purchasing syndicate, ln(SIZE) is the natural logarithm of the gross proceeds raised, expressed in December 1985 dollars using the consumers price index as a deflator, NEGOT is a zero-one dummy variable equal to one for the 81 negotiated offerings in the matched sample, and SWITCH is a dummy variable equal to one for the 16 negotiated offerings made by utilities that normally use competitive bidding

*** $p \leq$ 01

permitting these companies to freely choose between negotiation and competitive bidding, during 1974–75. During this period, no utility used competitive bidding, and the utilities normally required to use competitive bidding switched and hired their syndicates through negotiation. After this period, these utilities switched back to competitive bidding. The prospectus for 16 negotiated offers made by some of the utilities normally required to use competitive bidding were obtained. We add these 16 offers to the above sample and denote them by SWITCH, a dummy variable equal to one for the 16 negotiated offers.[24]

The use of the SWITCH dummy variable permits testing the self-selection hypothesis. On one hand, if effective search is systematically less for issuers that use competitive bidding, then, when competitive bid users switch to negotiation, their effective search should remain the same, or nearly so, as it was before the switch. On the other hand, if there is less effective search due to the use of competitive bidding, then the size of the purchasing syndicate should surge to the negotiated level when competitive bid users switch to negotiation.

Columns 4–6 report results of testing the self-selection hypothesis. Note that inclusion of SWITCH and the 16 negotiated offers does not alter the coefficients on ln(SIZE) or NEGOT in a significant way. This supports the results of columns 1–3. In columns 4 and 6, the coefficients of SWITCH are statistically significantly greater than zero. This is consistent with the conclusion that hiring syndicates through negotiation results in significantly larger syndicates with significantly more top banks. The SWITCH coefficients indicate that, when competitive bid users switched to negotiation, their syndicates increased in size by 76.15 banks (col. 4), they hired 0.91 more banks per dollar raised (col. 5), and they hired 5.81 more top banks (col. 6). Moreover, these SWITCH coefficients are not statistically different from the respective NEGOT coefficients. This is consistent with the conclusion that, when users of competitive bidding are allowed to use negotiation, they hire syndicates of the same size as the other utilities that normally use negotiation. Based on these results, we reject the hypothesis that less search under competitive bidding is the result of a self-selection bias.[25]

24. The 16 offers are divided among 14 issuers, with seven of the 14 having completed a competitive offer prior to their negotiated offer and 12 of the 14 having completed a competitive offer after their negotiated offer.

25. The SEC's relaxation of Rule 50 coincides with economic recession, which raises the possibility that, due to a seasonal selection bias, issuers had to hire much larger syndicates. To test this hypothesis, for the 81 negotiated offerings we regressed the three search proxy variables on offer size and a recession dummy variable (REC) equal to one for offers during the period that coincides with the period of the 16 negotiated offers by users of competitive bidding. Our results reject this hypothesis. For example, we obtained ($t$-statistics in parentheses)

$$\underset{}{\text{SYNM\#}} = \underset{(9.70)}{74.47} - \underset{(-1.18)}{9.85}\text{REC} + \underset{(8.89)}{0.44}\ln(\text{SIZE}),$$

In sum, the results of tables 3 and 4 are consistent with the implications of our model, that underwriter search is important and that competition reduces effective search for investors. Note also that the results from the switch test in table 4 lend support to our using these variables to proxy for underwriter search. The dramatic surge in the size of the syndicates in the switch to negotiation suggests that it is more efficient for syndicates to go for a "wider" search rather than a "deeper" search.[26]

*C. Trapped Bidders*

Our model also suggests that hiring syndicates through competitive bidding results in some members who are willing to pay more than the winning price getting stuck in losing syndicates, that is, they are trapped bidders. In support of this hypothesis, we first show that some excluded investors who might otherwise join the purchasing syndicate are excluded from the purchasing syndicate when issuers use competitive bidding. We then show that some members of losing syndicates were willing to buy the new shares at prices above the auction winning price. We again rely on the assumption that the number of investment banks is a reasonable proxy for the number of investors.

One proxy measure of excluded investors is the number of top banks in losing syndicates who are not members of the auction winning syndicate. Panel A of table 5 reports the distributions of the top banks under competition and negotiation. Columns 4 and 5 suggest that, overall, the same number of top banks participate in competitive offers as participate in negotiated offers, when both winning and losing syndicates are pooled together. The median number of top banks is 10 under both methods. For each underwriting method, a total of at least five top banks participate in syndicates in every offering, and in 97% of the offers of each type there are a total of seven or more top banks. Using the Student's *t*-statistic, we cannot reject the hypothesis that more than nine top banks participate in each competitive offering as

which indicates that syndicates were a little smaller during the recession, but not significantly so Similar results are found for the other proxy variables

26. Dramatic changes occur in syndicate composition, size, and leadership when issuers switch to negotiation from competition and then back It is thus difficult to make meaningful comparisons between the negotiated syndicate and the competitive syndicate We found that some of the lead banks in four of the subsequent competitive offers were among the co-leaders of the negotiated offers. Most common is that the lead banks of the negotiated offers were not among the lead banks of the prior or subsequent competitive offers. Evidently, winning a competitive bid offer does not assure leading a negotiated offer, and vice versa. It is also common that the co-leaders of the negotiated offers were rival co-leaders in the prior and the subsequent competitive auctions In addition, almost all of the lead banks of winning and losing syndicates in the prior and subsequent competitive auctions joined as (nonlead) members of the negotiated syndicate These findings agree with our hypothesis of more effective search under negotiation

**TABLE 5** **Frequency of Participation of the Top 10 Investment Banks in the 81 Matched Negotiated Offers, in the 81 Competitive Bid Winning Syndicates, in the 81 Competitive Bid Losing Syndicates, and in Either the Winning or Losing Syndicate in the 81 Competitive Offers, and the Frequency of Investment Bank Membership in Both Winning Syndicates, in Contiguous Competetive Offers by the Same Company**

**A. Frequency of Top Bank Participation in Syndicates**

| Number of Top Banks Participating in the Syndicate (1) | Competition: Per Winning Syndicate (2) | Competition: Per Losing Syndicate (3) | Competition: Total per Competitive Offering (4) | Negotiations, Total per Negotiated Offering (5) |
|---|---|---|---|---|
| 0 | 4 | 0 | 0 | 0 |
| 1–2 | 19 | 2 | 0 | 0 |
| 3–4 | 39 | 15 | 0 | 0 |
| 5–6 | 13 | 29 | 3 | 2 |
| 7–8 | 6 | 26 | 10 | 5 |
| 9–10 | 0 | 9 | 68 | 74 |
| Total* | 274 | 484 | 758 | 783 |
| Mean | 3 4 | 6 0 | 9 4 | 9 7 |
| Median | 3 | 6 | 10 | 10 |

**B. Banks in Different Winning Syndicates of Contiguous Offerings†**

| | |
|---|---|
| 1. Average number of banks in the two different winning syndicates | 95 3 |
| 2 Average number of all banks that are members of each of the two different winning syndicates | 2 |

* The column total is the sum of the products of the column entries with the corresponding number of participating banks

† Prospectuses are available for 34 contiguous offerings that have different winning syndicates Offerings by an issuing company adjacent in time are contiguous

well as in each negotiated offering. Using the Wilcoxon signed-rank test, we cannot reject the hypothesis that the median number of top banks participating in each offer type is the same.

However, column 3 reveals that most (64%) of the top banks under competitive bidding are in losing syndicates and that, on average, six top banks do not participate in the purchasing syndicate. Moreover, some of the losing syndicates have nine or ten top banks, but none of the winning syndicates have more than eight top banks. Using the Student's $t$-statistic, we cannot reject the hypothesis that the number of top banks in the winning syndicate is less than four. Furthermore, as revealed in the prospectus, the top banks in the losing syndicates do not later become members of the purchasing syndicate.

In sum, while the total number of top banks participating in each offer type is the same, under competition fewer than four are typically in the purchasing syndicate, while under negotiation typically all 10 are in the purchasing syndicate. This shows, that at least as far as the top banks are concerned, forcing syndicates to compete results in excluded investors.

A second measure of excluded investors is the extent to which other investment banks are not in the purchasing syndicate. However, the First Boston Corp. data does not report the non-lead-bank membership of losing syndicates, nor are there any offer prospectuses for the losers. A reasonable proxy measure of bank membership in losing syndicates is obtained by tracking the bank membership of different auction winning syndicates in successive offers by the same company.[27] By observing bank membership of these different winning syndicates, it is possible to reconstruct the number of banks excluded from the purchasing syndicates.

Panel B reports data from contiguous pairs of competitive bid auctions by the same company that are won by different syndicates (i.e., syndicates having different lead banks). Row 1 reports the average total number of member banks in the two winning syndicates is 95. However, row 2 reports that, on average, no banks are members of both of the different winning syndicates. This is consistent with excluded investors being characteristic of competitive bidding.[28]

Note further that the top bank exclusion evidence and the member bank exclusion evidence suggest that, under competitive bidding, the primary market is rigidly and persistently divided between different syndicates, regardless of whether they win or lose. Recall that our model illustrates that, when the primary market is so divided, less total search may occur under competition than under negotiation. This proxy assumes that banks which are present in future winning syndicates are also "in the market" at other times. Given the evidence of divided markets, our analysis provides a possible explanation for why issuers do not use competitive bidding, despite its lower cost.[29]

### D. *Losers' High Prices*

While the above evidence is consistent with trapped bidders, it does not reveal whether some trapped bidders were willing to pay more for

27. For example, Utah Power & Light had six three-bid competitive offers One syndicate was led by White Weld & Co. et al , another was led by Salomon Brothers et al , and another was led by Kidder, Peabody & Co. et al. The White Weld-led syndicate won three offers, the Salomon-led syndicate won two, and the Kidder-led syndicate won one

28 A contiguous offer pair having different winning syndicates is Middle South's April 1980 $89 million offer won by First Boston Corp. et al. and their October 1980 $97 million offer won by Kidder, Peabody & Co. et al. There were 81 banks in the First Boston et al syndicate, and the Kidder et al syndicate had 82 banks. However, no bank was a member of both syndicates.

29 Syndicate membership rigidity is consistent with many hypotheses These include, but may not be limited to, possible cost economies of syndicate formation and coordination, a preference to avoid the economic damage from possibly inviting charges of collusion from faulty interpretations of arrangements for sharing syndicate members, or an institutionalization of the right of first refusal

the shares than some members of the winning syndicate. Unfortunately, the prices that inframarginal members of winning and losing syndicates were willing to pay are not available, so we cannot make the preferred direct comparisons. However, limited evidence that some members of losing syndicates had higher valuations than the winning bid can be obtained from the reported gross offer bid prices. This is possible because differences in rival syndicates' bids generally reflect differences in their members' private values and differences in syndicates' overall costs, a feature we have not modeled. Thus, our model does not explain the possibility that ranking syndicates by their gross offer prices may differ from their rankings based on the net offer prices. However, the data show it is not unusual for winning and losing syndicates to have both different gross offer prices and different fees. It is thus possible to observe gross offer price reversals. Such evidence may provide the additional needed support for the trapped bidders hypothesis.

Table 6 reports that there are gross offer price ties between winning and losing syndicates in 48 of the auctions. This is consistent with the conclusion that trapped bidders are a significant problem in many competitive bid offers. The table also reports that there are gross offer price reversals in 13 of the competitive offers.[30] This supports the conclusion that the trapped bidders problem in competitive bid offers is economically significant.

## IV. Concluding Remarks

This article examined the process of syndicate formation under regimes of negotiation and competition. The model illustrates that forcing syndicates to compete may not be good for issuing companies because it results in less effective search and trapped bidders. We suggest that in addition to total search, the meaningful search statistic for issuers is effective search, the search undertaken by the purchasing syndicate. Since competitive bidding leads to redundant search by the losing syndicate, effective search can be less than total search. For all of these reasons, and contrary to the view that competitive bidding enhances search efficiency, our model suggests that search is more efficient under negotiation.

Empirical evidence is reported supporting two important implications of the model. First, using reasonable proxy variables for effective search, a number of tests show there is significantly less effective

30 For example, the Salomon Brothers et al syndicate won El Paso Electric's August 1979 \$12 million offer at a net price of \$11 329, and the Goldman Sachs et al 's losing bid was \$11 274 But clients in the Goldman et al. syndicate bid a gross price of \$11 80, and the Salomon et al syndicate paid 5¢ less. We assume that syndicate sales are at the gross price as required by law, so the spreads contain no amounts paid to members for their transaction costs

TABLE 6 Frequency of Gross Offer Price Ties and Reversals

| | N |
|---|---|
| 1 Offers in which losing syndicate's gross offer price tied the winning syndicate's offer price | 48 |
| 2 Offers in which a lower ranked syndicate's offer price exceeds a higher ranked syndicate's offer price | 13 |

NOTE—These data are from the sample of 88 competitive offerings described in table 2

search under competitive bidding than under negotiation. Second, we report evidence of trapped bidders in competitive bid auctions and show that some were willing to pay more than the auction winning price for new shares.

The model also illustrates a plausible resolution of the competitive bid puzzle. When competition between bidding syndicates is conducted in a divided market, there may be less total search than is expected under negotiation. Under this constraint, competitive bidding will be both less expensive than, and inferior to, negotiation.

From a policy perspective, the results of this study suggest that mandatory use of competitive bidding, as under Rule U-50, may in fact result in less efficient financing and, thus, a higher cost of capital for issuing firms.

## Appendix

## Derivation of the Underwriting Contracts

### I. Negotiation

*A. Negotiation Search Stopping Rule*

In the negotiated contract, the lone lead bank stops searching when the TOS is $8 or when it is $7 and four or less investors have been searched. The proof recognizes that, because the bank searches in the interest of the issuer, it will search as long as the expected benefit of search to the issuer exceeds the incremental search cost. The expected benefit to the issuer is the expected increase in the TOS × 3, which is the number of buyers needed to pick up the issue Examined are the outcomes based on what the TOS is when the bank decides whether to search one more investor. Throughout, let the number of searches already made be $S$, the expected net benefit of one more search be NB, and the probabilities of searching a G (B) investor be $p(G)$ ($p(B)$).

*B Proof*

TOS = $8: once the TOS is $8, the three highest valued investors are known. *Stop search.*

TOS = $7. when the TOS = $7, one of the high values of $8, $9, or $10 has not been searched. If and when this high valued investor is searched, the TOS becomes $8 and the issuer's benefit will be $3. Next are the conditions when it is beneficial to the issuer for the bank to search for this buyer.

If $S = 8$: the next search must reveal the missing \$8, \$9, or \$10 for sure. Thus, NB = \$1 × 3 − \$1 = \$2, so one more search will be made. *Search.*

If $S = 7$: the next search will either reveal the missing high value or the situation will be as expected when $S = 8$. Thus, NB = \$(1/3) × 3 + \$(2/3) × 2 − \$1 = \$4/3. *Search.*

If $S = 6$: the next search will either reveal the missing high value or the situation will be as expected when $S = 7$. Thus, NB = \$(1/4) × 3 + \$(3/4) × 4/3 − \$1 = \$3/4. *Search.*

If $S = 5$: NB = \$(1/5) × 3 + \$(4/5) × 3/4 − \$1 = \$1/5. *Search.*

If $S = 4$: NB = \$(1/6) × 3 + \$(5/6) × 1/5 − \$1 = −\$1/3. *Stop search*

Similarly, if $S = 3$: NB = \$(1/2) × 3 + \$(6/7) × (−1/3) − \$1 = −\$6/7. *Stop search.*

Thus, when the TOS is \$7, the net benefit to search is positive only when the bank has already searched at least five investors.

TOS = \$6: now there are two unsearched investors with higher prices and the syndicate already has a pair of investors with prices above \$6 which must be one of the following:

| | | | |
|---|---|---|---|
| 1 | \$10, \$9 | \$10, \$8 | \$9, \$8 |
| 2 | \$10, \$7 | \$ 9, \$7 | \$8, \$7 |

If the syndicate's pair is from row 1, the next search of a high price results in a TOS of \$7 or \$8 with equal probability of 1/2. If the pair is from row 2, that next high search has a \$7 TOS with probability 1. Thus, the stopping rule when the bank has a TOS of \$6 depends on whether the syndicate has high values from row 1 or 2. Now consider the net benefit of one more search:

If $S = 8$: for both rows, one more search reveals both remaining higher values and the TOS will be \$8. NB = \$(2) × 3 − \$1 = \$5. *Search.*

If $S = 7$ and existing members are in row 1, the next high search will yield a TOS of \$7 or \$8 with equal probability. However, as already shown, for a TOS of \$7 and $S = 8$, search continues. Thus, search will continue until a TOS of \$8 is discovered. The net profit from the next search is the expected marginal benefit of that search, conditional on getting a price above \$6; NB = \$(1/3)6 + \$(2/3)5 − \$1 = \$4 1/3. *Search.*

If $S = 7$ and existing members are in 2: NB = \$(1/3)5 + \$(2/3)(3 + 2) − \$1 = \$4. *Search.*

If $S = 6$ and existing members are in 1: NB = \$(1/4)6 + \$(1/4)(3 + 4/3) + \$(2/4)(13/3) − \$1 = \$3 3/4, where the first term is the probability of getting a TOS of \$8 in the next draw times the increase in revenue and the second term is the probability of getting a TOS of \$7 in the next draw times the sum of the increase in revenue this round plus the net benefit from searching one more round. Search continues one more round with a TOS of \$7 and $S = 7$ since the stopping rule for a TOS of \$7 and $S = 7$ is to search one more round. The \$4/3 is the expected net benefit of that additional search. The third term is the probability that the TOS remains the \$6 (in which case, as shown above, search continues) times NB of \$13/3 of continuing search. *Search.*

If $S = 6$ and existing members are in row 2: NB = \$(2/4)(3 + 4/3) + \$(2/4)(4) − \$1 = \$3 1/6. *Search.*

To complete this case, note that the net benefit is less if the bank has its high value pair from row 2. Thus, for the remaining cases the row 2 NB are examined.

If $S = 5$ and current members are in row 2: NB = \$(2/5)(3 + 3/4) + \$(3/5)(19/6) − \$1 = \$2 2/5. *Search.* Same is again true for members of row 1.

If $S = 4$ and current members are in row 2: NB = \$(2/6)(3) + \$(4/6)(12/5) − \$1 = \$8/5. The first term is times 3 since search stops if the next search yields a TOS of \$7, with $S$ of 4 or less (since the TOS will be \$7), and either of the last two high values will yield the TOS of \$7. *Search.*

If $S = 3$ and existing members are in row 2: NB = \$(2/7)(3) + \$(5/7)(8/5) − \$1 = \$1. *Search.*

Thus, if the TOS is \$6, the bank searches one more investor. The same holds for a TOS below \$6. Thus, the stopping rule is, Stop with TOS of \$8, and if $S < 5$, also stop if the TOS is \$7. Q.E.D.

The above proof yields the frequency distribution of searches in table A1.

*C. Expected Negotiation Outcomes*

From this distribution, expected number of searches is 7.61, the expected effective searches is also 7.61, the expected gross price is (\$1 × 8 + .086 × 7)/1.086 = \$7.92, and the expected net proceeds are \$3 × .92 − \$7.61 = \$16.15

## II. Competition

For developing the stopping rule under competition, the following corollary is useful.

COROLLARY 1. When syndicates are searching in the best interest of the issuer and compete, and there is no communication between them, then the syndicate having (probabilistically) the highest combination will continue searching. A syndicate having probabilistically inferior investors will stop searching.

*Proof.* Available on request from us. Q.E.D.

**TABLE A1 Frequency Distribution of Searches**

| Total Search | Frequency Computation | Frequency |
|---|---|---|
| 3 | 4/10 × 3/9 × 2/8 | 1/30 |
| 4 | 4/10 × 3/9 × 2/8 × 6/7 × 3 | 3/35 |
| 5 | 3/10 × 2/9 × 1/8 × 7/7 × 6 | 1/20 |
| 6 | 3/10 × 2/9 × 1/8 × 10 | 1/12 |
| 7 | 3/10 × 2/9 × 1/8 × 15 | 1/8 |
| 8 | 3/10 × 2/9 × 1/8 × 21 | 7/40 |
| 9 | 3/10 × 2/9 × 64/8 | 8/15 |
| 10 | | 0 |

NOTE.—For the probability computations note that when $S = 3$ or 4, search may stop with a third-order statistic (TOS) of \$7 or \$8, and when $S = 5$ or more, a TOS of \$8 is needed. The frequency distribution for a TOS of \$7 or \$8, for $S = 4$, has a multiple of three in it because the draw below \$7 or \$8 can take place in either of the first three selections, that is, \$3\$7\$8\$10, \$7\$3\$8\$10, or \$7\$8\$3\$10 Note, the B cannot occur at the fourth position because there is no stopping at GGGB Also, note that the frequency sums to 1 086 since the probability of a \$7 TOS when $S$ is 3 or 4 is 086

*A. Open Competition*

*Open competition search stopping rule.* In open competition, each bank should continue searching until it has four G's, or it has three G's with a TOS of \$7 or \$8, or BGGBB, BGB, or BBB.

*Proof.* Until specified otherwise, values of \$5 or below are considered B while \$6 and higher are considered G. The proof examines the reactions of bank 1 to its posterior frequencies of unsearched investors' private values, which are updated as its own search reveals information. To begin, because each bank must search at least three investors to get a legitimate TOS, banks 1 and 2 can have one of BBB, BGB, BGG, or GGG after their third search At this point let bank 1 be the first to pick the fourth investor, after which bank 2 can pick its fourth investor (if it is optimal for it to do so) and so on.

To examine bank 1's behavior, consider its posterior distribution of bank 2's first three searches, conditional on bank 1's first three searches (see table A2).

If bank 1 has BBB or BGB, then, as seen from the above table, the probability that bank 2 has strictly better investors is higher than the probability that bank 2's investors are the same or worse. Thus, by corollary 1, with BBB or BGB, bank 1 stops in the expectation that bank 2 will continue searching. This is symmetric.

Let bank 1 have BGG. Now it will search as the probability that bank 2 has worse draws is higher. What is its probability of getting a G or a B in the next search? See table A3

Thus, bank 1's probability of finding a G on the next search, $p(\mathrm{G})$, is 3/35 + 9/35 + 3/35 = 3/7, and its $p(\mathrm{B}) = 1 - 3/7 = 4/7$. Given these probabilities, it will search one more buyer after its first three searches are BGG. To see this, consider the worst case of having BGG investors with private values \$5, \$6 and \$7, in which event one more search of a G raises bank 1's TOS by only \$1. Since $p(\mathrm{G}) = 3/7$, NB = \$3/7 × 3 − \$1 = \$2/7: *search* even under this worst case.

More difficult to determine is whether bank 1 will search further after it has GGG As the following shows, the answer depends on the level of the bank's TOS. There are 10 different combinations, and each must be separately checked. The combinations in dollars are: 8, 9, 10; 7, 9, 10; 7, 8, 9, 7, 8, 10; 6, 8, 10, 6, 9, 10; 6, 8, 9; 6, 7, 8; 6, 7, 9; and 6, 7, 10.

**TABLE A2** **Bank 1's Distribution of Bank 2's First Three Searches, Conditional on Bank 1's First Three Searches**

| Bank 1's First Three Searches | BBB | BGB | BGG | GGG |
|---|---|---|---|---|
| BBB | 0 | 5/35 | 20/35 | 10/35 |
| BGB | 1/35 | 12/35 | 18/35 | 4/35 |
| BGG | 4/35 | 18/35 | 12/35 | 1/35 |
| GGG | 10/35 | 20/35 | 5/35 | 0 |

NOTE —For example, the probability that bank 2 has buyer set BGB when bank 1 has buyer set BBB is computed as ${}^2C_2{}^5C_1/{}^7C_3$ = 2/7 × 1/6 × 5/5 × 3 = 5/35.

TABLE A3 **The Probability of Getting G or B in the Next Search**

| | Bank 1's Probability of Searching a | |
|---|---|---|
| With Probability: | G | B |
| 4/35* | 3/4 | 1/4 |
| 18/35 | 2/4 | 2/4 |
| 12/35 | 1/4 | 3/4 |
| 1/35 | 0 | 1 |

* As seen from this distribution, when bank 1 has BGG, the other bank has BBB with probability 4/35 For that outcome, there is one unsearched B and three unsearched G's remaining, which gives probabilities $p(G) = 3/4$, and $p(B) = 1/4$ The other numbers are similarly determined

If bank 1 has \$8\$9\$10, its TOS is \$8. *Stop.*

If bank 1 has GGG in the set {\$6\$8\$9, \$6\$8\$10 or \$6\$9\$10}, it can achieve a higher TOS of \$7 or \$8 with equal probability if its future search reveals another G, which is possible with probability 2/7. NB = \$(2/7) × [(1/2) × 3 + (1/2) × 6] − \$1 = \$2/7. *Search.*

If bank 1 has GGG's in the set {\$6\$7\$8, \$6\$7\$9, \$6\$7\$10, \$7\$8\$9, \$7\$8\$10, or \$7\$9\$10}, another search can raise the TOS by \$1. For the set {\$6\$7\$8, \$6\$7\$9, \$6\$7\$10}, there are two unsearched G values that will do so, and for the set {\$7\$8\$9, \$7\$8\$10, or \$7\$9\$10}, there is only one unsearched G that will do so. Thus, the stopping rule may be different for each set:

$$\text{GGG} = \{\$7\$8\$9, \$7\$8\$10, \$7\$9\$10\}. \tag{A1}$$

When bank 1 already has a TOS of \$7, it no longer regards the \$6 buyer as good. To increase its TOS, it must now locate the lone remaining buyer whose value is strictly above \$7. Thus, the probability that the next search raises the TOS by \$1 is 1/7, and the expected gain from just one more search is \$(1/7) × \$3 − \$1 = −\$4/7. However, this does not mean that the bank should necessarily stop searching as more search may be sufficiently profitable to offset losses on the fourth search. For example, if the bank has investors \$7\$8\$9, it is searching for the \$10 buyer on its fourth search, but it will consider all branches on the search tree depicted in figure A1. On the tree, the search starts from the left, increasing sequentially from node to node, yielding either another buyer with a value below \$7 and possible more search, or stopping if it finds the \$10 buyer. Let a value below \$7 be $N$. The conditional probabilities for each outcome are encircled and derived in the figure.

Suppose then, that bank 1, rather than finding the remaining value above \$7 on its fourth search, obtains a value below \$7. Now it must decide whether to stop or make a fifth search. However, before it makes its fifth search, bank 2 gets the opportunity to make its fourth search if it is optimal for it to do so As the case is for bank 1, bank 2 does not know bank 1's investor set but has a distribution over it given its own searches. But bank 2 knows bank 1's set

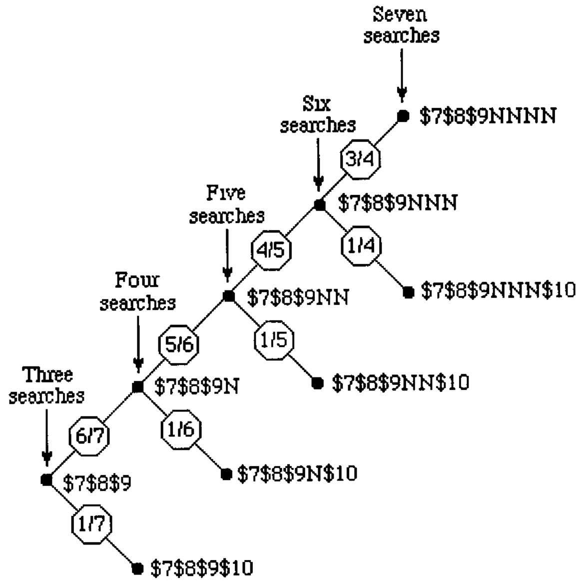


FIG. A1

of strategies and that it searches after bank 1 has already searched. Due to symmetry, bank 2 will not search if its first three searches are BBB or BGB, but it will search if its first three are BGG or GGG.

Since GGG is not possible for bank 2 (as bank 1 already has GGG), examine bank 2's decision after it draws BGG Since bank 2 picks second, its posterior over bank 1's holdings is presented in table A4

Given the posterior distribution, does bank 2 search if it has BGG? Note that the probability of stopping ($p$(st )) and the probability of searching ($p$(se.)) cannot be estimated yet as bank 1's decision to search or stop after GGG depends on bank 2's stopping rules. Thus, first check whether bank 2's stopping rule is affected by this probability. Toward this end, note that, when bank 1 has BGG and bank 2 has BGGG, no more G's remain. Consequently, the next search must yield a B Thus, bank 2's response can be estimated without identifying the probabilities $p$(st.) and $p$(se.).

Given that bank 2's investors are BGG, the probability that bank 2's fourth search will reveal a B or a G is given in table A5.

Thus, the $p$(G) in the next round is $(4/35)(3/4) + (18/35)(1/2) + (9/35)(1/3) = 3/7$, and $p(B) = 1 - 3/7 = 4/7$ Thus, the minimum net benefit from one more search when bank 2 has BGG is $\$(3/7) \times 3 - \$1 = \$2/7 > 0$. Also, the probability of having better searches than bank 1 is higher than the probability of having worse searches than bank 1. Consequently, bank 2 will search.

Now return to bank 1's decision whether to search one more after its fourth search revealed a value of less than $7 Bank 1's posterior probability over bank 2's searches is given below. Since the $6 value is useless for bank 1, but still represents a G for bank 2 and affects bank 2's stopping rule, two cases need to be considered: one when bank 1's fourth search is $6, and one when

**TABLE A4 Bank 2's Distribution of Bank 1's First Three of Four Searches, Conditional on Bank 2's First Three Searches**

| Bank 2's Search | BBB | BGB | BGGG | BGGB | GGG | GGGB |
|---|---|---|---|---|---|---|
| BGG | 4/35 | 18/35 | 3/35* | 9/35† | 1/35 × p(st )‡ | 1/35 × p(se )§ |

* 12/35 × (probability that bank 1 searches a G on fourth search) = 12/35 × 1/4 = 3/35
† 12/35 × (probability that bank 1 searches a B on fourth search) = 12/35 × 3/4 = 9/35
‡ 1/35 × (probability that bank 1 stops after GGG) = 1/35 × p(st )
§ 1/35 × (probability that bank 1 searches after three G's) = 1/35 × p(se )

**TABLE A5 The Probability That Bank 2's Fourth Search Will Reveal a B or a G**

| Bank 1's Possible Searches | Posterior Probability of Bank 2 over Bank 1's Searches | Probability of Getting a G Is. | Probability of Getting a B Is. |
|---|---|---|---|
| BBB | 4/35 | 3/4 | 1/4 |
| BGB | 18/35 | 1/2 | 1/2 |
| BGGG | 3/35 | 0 | 1 |
| BGGB | 9/35 | 1/3 | 2/3 |
| GGG | 1/35 | 0 | 1 |

**TABLE A6 Bank 1's Posterior Distribution**

| Possible Bank 2 Searches | Probability |
|---|---|
| BBB | ${}^4C_3{}^2C_0/{}^6C_3 = 4/20$ |
| BGB | ${}^4C_2{}^2C_1/{}^6C_3 = 12/20$ |
| BGGB | ${}^4C_1{}^2C_2/{}^6C_3 = 4/20$* |

* This is because, given bank 1's searches of GGG, bank 2 will necessarily get a B on its fourth search after it has BGG

it is \$5 or less. Since the worse case is when bank 1's fourth search is \$5 or less, we consider only that case. Thus, in table A6 we give bank 1's posterior distribution when its four searches are three G's with values of \$7 and above, and one B.

Given this posterior distribution, bank 1 searches the lone available G above \$7 with probability (1/2)(2/3) if bank 2 has BBB, with probability (1/2)(1/3) if bank 2 has BGB, and with probability 0 if bank 2 has BGGB. Thus, NB of one more search is \$[(4/20)(1/3) + \$(12/20)(1/6)] × 3 − \$1 = −\$1/2.

It can be similarly shown that bank 1's expected net benefit of one more search after it has GGGBB is \$(1/5) × 3 − \$1 = −\$2/5 To do so, it is necessary to check what bank 1's posterior distribution over bank 2's searches is when its own searches are GGGBB. The bank knows that bank 2's possible draws are BBB (and stop search), BBG (and stop search), BGG (and continue search as shown before). Since bank 1 has three G's, the next draw for bank 2 will give BGGB necessarily. The question to be answered is whether bank 2 will search once more after having BGGB. Because of symmetry, this is equivalent to asking what bank 1's decision would be with BGGB. Unfortunately, the decision appears to depend on what bank 2 would do if it searches three G's (the problem we are solving here). That is not important though Once bank 2 gets GGG, bank 1 will search B's for sure in all future searches. So, what bank 2 does after GGG does not affect bank 1's decision. Thus, the relevant posterior distribution that bank 1 will look at to make this decision is in table A7

This posterior gives $p(G) = 1/2$ and $p(B) = 1/2$. Thus, the minimum NB = \$1/2 × 3 − \$1 = \$0 5. Thus, bank 1 will make the fifth search. Using symmetry again, bank 2 will also search with BGGB

Thus, bank 1's posterior distribution after it has GGGBB is in table A8. This posterior gives $p(G) = (1/10)(1/2) + (6/10)(1/4) = 1/5$; NB = \$(1/5) × 3 − \$1 = −\$2/5.

It can be similarly shown that after it has GGGBBB, bank 1's NB from another search is \$(3/4) × 3 − \$1 = \$5/4.

Thus, after bank 1 already has GGG belonging to buyer set {\$7\$8\$9, or \$7\$8\$10, \$7\$9\$10}, then NB = \$(1/7) × 3 − \$1 + \$(6/7){(1/6) × 3 − 1 + (5/6)[(1/5) × 3 − 1 + (4/5) × (5/4)]} < 0. Thus, when bank 1 has GGG with minimum of \$7 *Stop*

GGG = {\$6\$7\$8, \$6\$7\$9, \$6\$7\$10}. (A2)

Now, bank 1's next search may yield one of two G investors with prices above \$7 with probability 2/7, and $p(B) = 5/7$ If bank 1 obtains GGGG, its TOS will increase by \$1 and NB = \$(2/7) × 3 − \$1 = −\$1/7 This, however, does not mean the bank should stop searching after three G's. What happens over the rest of the tree must be checked before concluding what is the equilibrium strategy.

Thus, check what happens when bank 1 has GGGG, GGGGB, GGGGBB, GGGB, GGGBG, GGGBB, GGGBBG, and GGGBBB.

If bank 1 has GGGG, then its posterior distribution over bank 2's investors is BBB with probability 1/2 and BGB with probability 1/2. With probability of 1/2, the unconditional probability that the next search is a G is 1/3 and NB = \$(1/3) × (1/2) × 3 − \$1 = −\$0.5 *Stop*. It can be similarly shown that it is profitable to stop if the next search reveals a B. Also, once the bank has four G's it will stop. This is true whether the buyer set is GGGG or GGGBG or GGGBBG.

If bank 1 has GGGB, then its posterior distribution over bank 2's investors is BBB with probability 4/20, BGB with probability 12/20, and BGGB with

**TABLE A7 Bank 1's Distribution of Bank 2's Searches, Conditional on Bank 1's First Four Searches**

| Bank 1's Searches | BBB | BGB | BGGB | BGGG | GGG |
|---|---|---|---|---|---|
| BGGB | 1/20 | 9/20 | 6/20 | 3/20 | 1/20 |

**TABLE A8 Bank 1's Distribution of Bank 2's Searches, Conditional on Bank 1's Five Searches**

| Bank 1's Searches | BBB | BGB | BGGBB |
|---|---|---|---|
| GGGBB | 1/10 | 6/10 | 3/10 |

probability 4/20. Further search will be valuable only if bank 2 has stopped searching with either BBB or BGB. Otherwise, bank 2 already has two G investors, and bank 1 cannot produce value with further search. When bank 2 has BBB, bank 1's $p(G) = 2/3$ and when bank 2 has BGB, bank 1's $p(G) = 1/3$. Thus, NB = \$[(4/20) × (2/3) + (12/20) × (1/3)] × 3 − \$1 = \$(1/3) × 3 − \$1 = 0. *Search*

If bank 1 has GGGBG after its fifth search, it should *stop*. If instead, bank 1 obtains GGGBB (with conditional probability 2/3), search is again beneficial if bank 2 has BBB or BGB. If bank 2 has BGGBB, then bank 1 will not be able to search any more. This will reveal information, and bank 1 will update on that basis. When bank 1 has GGGBB, its posterior distributions will initially be that bank 2 has BBB with probability 1/10, BGB with probability 6/10, and BGGBB with probability 3/10. But, if bank 2 has BGGBB, bank 1 will discover that information. Thus, its posterior distributions are BBB with probability (1/10)(10/7) and BGB with probability (6/10)(10/7). When bank 1 has GGGBB: NB = \$(10/7) × [(1/10) × 1 + (6/10) × (1/2)] × 3 − \$1 = \$5/7. *Search*

If bank 1 has GGGBBG after six searches it should *stop*. If, instead, bank 1 has GGGBBB (with conditional probability 3/7), it knows bank 2 cannot have BBB and must have BGB, so that, for sure, one further search will locate a G buyer who will raise the TOS by \$1. Thus, NB = \$(3/7) × 3 − \$1 = \$2/7. *Search.*

Thus, after bank 1 already has GGG investors \$6\$7\$8 or \$6\$7\$9 or \$6\$7\$10: NB = \$(2/7) × 3 − \$1 + \$(5/7)[(1/3) × 3 − 1 + (2/3)(5/7 + 2/7)] = \$1/3 > 0. So it is profitable in expectation to continue searching when its GGG belongs to the group \$6\$7G or \$6GG.

Consequently, with GGG, there is probability 4/10 that the bank will stop searching, and with probability 6/10, the bank will continue searching. These probabilities will need to be considered when estimating the expected amount of search and expected bid prices. Thus, the stopping rule which gives the issuer the highest expected net price is

Stop Searching Rule. Stop searching with BBB, or BGB, or three G's in the set {8, 9, 10; 7, 8, 9, 7, 8, 10; 7, 9, 10}, or four G's, or BGGBB. Continue searching with BGG or three G's in the set {6, 7, 8; 6, 7, 9, 6, 7, 10; 6, 8, 9; 6, 8, 20; 6, 9, 10} until four G's This rule gives the expected search and expected bid in the table below. Q.E.D.

*Open competition equilibrium outcomes* The open competition distribution of expected search and associated expected bid price is given in table A9.

From this distribution, expected number of searches is 8.03, the expected effective search is 3[1/42 + 1/7 + (3/21)(4/10)] + 4[(4/14)(4/10) + (2/42)(6/10)] + 3(1/42)(4/10) + 5[(5/42)(6/10) + (3/42)(4/10) + 3/42 + (5/126)(6/10)]

**TABLE A9** **The Open Competition Distribution of Expected Search and Associated Expected Bid Price**

| Total Number of Searches with Searched Buyer Combinations | Probability | Expected Bid Price |
|---|---|---|
| 6: | | |
| BGB BBB | 1/42* | $2.60† |
| BGB BGB | 1/7 | 3.33 |
| BBB GGG | 1/21 × 4/10 | 7.25‡ |
| BGB GGG | 2/21 × 4/10 | 7.25 |
| 7 | | |
| BBB BGGG | 1/14 × 4/10 | 7.25 |
| BGB BGGG | 3/14 × 4/10 | 7.25 |
| BBB GGGG | 1/42 × 6/10 | 7.50 |
| BGB GGGG | 1/42 × 6/10 | 7.50 |
| 8. | | |
| GGG BGGBB | 1/42 × 4/10 | 7.25 |
| BBB BGGGG | 2/42 × 6/10 | 7.50 |
| BBB BGGBG | 1/42 × 4/10 | 7.25 |
| BGB BGGGG | 3/42 × 6/10 | 7.50 |
| BGB BGGBG | 6/42 × 4/10 | 7.25 |
| BGB BGGBB | 3/42 | 4.60 |
| BBB GGGBG | 2/126 × 6/10 | 7.50 |
| BGB GGGBG | 1/42 × 6/10 | 7.50 |
| 9 | | |
| BBB GGGBBG | 1/126 × 6/10 | $7.50 |
| BGB GGGBBG | 1/42 × 6/10 | 7.50 |
| BBB BGGGBG | 1/42 × 6/10 | 7.50 |
| BGB BGGGBG | 1/14 × 6/10 | 7.50 |
| BBB BGGBGG | 1/42 × 6/10 | 7.50 |
| BGB BGGBGG | 1/14 × 6/10 | 7.50 |
| BGGG BGGBB | 3/42 × 4/10 | 7.25 |
| 10 | | |
| BGGBB BGGBG | 3/42 | 6.50 |
| BGGBB BGGGB | 3/42 × 6/10 | 6.00 |
| BGGBB GGGBB | 1/42 × 6/10 | 7.50 |
| BGB GGGBBBG | 1/42 × 6/10 | 7.50 |
| BGB BGGGBBG | 1/14 × 6/10 | 7.50 |
| BGB BGGBGBG | 1/14 × 6/10 | 7.50 |

* The probability 1/42 comes from the following, BGB, BBB occurs with probability (5/10)(5/9)(4/8)(3/7)(2/6)(1/5)(2 × 3) = 1/42 This expression has multiples of two because of symmetry and three since G in BGB can occur in the first, second, or third position without affecting the bid

† This is developed as follows given the searched buyer's combination winning a third-order statistic (TOS) of $2, $3, and $4 are possible The combinations that will give a winning TOS of $2 are {4, 3, 2, 5, 3, 2, G, 3, 2, G, 4, 2} Since G can take values from $6 to $10, the total combinations are 18 It can be similarly shown that the total number of combinations that will give a winning TOS of $3 is 11 The only winning combination that will give a TOS of $4 and yet belong to BGB or BBB are {G, 5, 4}, that is, five in number Thus, the expected winning bid is $2 × (18/34) + $3 × (11/34) + $4 × (5/34) = $2.6

‡ The expected bid takes into account that the only times when search is stopped with GGG is if GGG belongs to the set {8, 9, 20, 7, 8, 9, 7, 8, 10, 7, 9, 10} Since this gives a TOS of $8 with probability 1/4, and $7 with probability 3/4, the expected bid is $7.25

+ 6[(1/126)(6/10) + (9/42)(6/10)] + 4(3/42)(4/10) + 5[3/42 + (1/42)(6/10)] + 6(3/42)(6/10) + 7(7/42)(6/10) = 4.55, the expected gross price is $6.35, and the expected net proceeds are $6.35 × 3 − $8.03 = $11.02.

*B. Divided Competition*

Now the 10 investors are segmented between the two lead banks, with each segment containing five investors. Each bank searches within its own segments, so the maximum number of searches it can do is five. This will naturally affect search and the stopping rule. The only difference occurs after GGG. Now lead banks with GGG stop without further search for not only the combinations {8, 9, 10; 7, 9, 10; 7, 8, 10; 6, 7, 8}, as in the case without division, but also for the combinations {6, 7, 10; 6, 7, 9; 6, 7, 8}. That is, it is best to stop searching whenever the next good search increases the TOS by $1 or less. Thus, there is less search with division than without it

*Divided competition search stopping rule.* Just as in the case of open competition, if bank 1 has BBB or BGB, then the probability that bank 2 has investors that are strictly better is higher than the probability that bank 2's investors are the same or worse. Thus, with BBB or BGB, bank 1 stops searching in the expectation that bank 2 continues searching. This is symmetric. Moreover, bank 1 is working in the best interest of issuers, and it will search one more buyer after its first three searches are BGG

In divided markets, each bank can search no more than five investors. This alters the benefits to searching. Let bank 1 have GGG. What is the $p$(G) or $p$(B) in the next search? (see table A10).

Thus, $p(G) = 2/7$ and $p(B) = 5/7$. Should bank 1 search one more buyer? For the GGG buyer set {$6$7$8, $6$7$9, $6$7$10, $7$8$9, $7$8$10, $7$9$10, $8$9$10}, if an additional search yields a G, bank 1 can increase its TOS by at most $1, and possibly not at all Thus, NB = $(2/7) × 3 − 1 < 0, or worse. Checking for what happens if the next search is a B does not change the outcome since expected returns are negative up to five searches. As can be seen from the proof without division, the positive returns from further searches occur only for total search greater than five. Thus, the optimal rule for these combinations is *Stop*.

For the GGG buyer set {$6$8$9, $6$8$10, $6$9$10}, if another search uncovers a G, bank 1 can increase its TOS by $2 with probability 1/2 and by $1 with probability 1/2. Thus, NB = $2/7 × [(1/2) × 6 + (1/2) × 3] − $1. *Search.*

Thus, with BGG, bank 1 will continue searching; with GGG, bank 1 will search 3/10 of the time and stop 7/10 of the time; and with BBB or BGB, bank 1 will stop.

*Divided competition expected outcomes.* The above stopping rule identifies the various combinations of total search. Because of symmetry, bank 1 and bank 2 can have feasible combinations of investors from the following sets.

| | |
|---|---|
| BBB | BGGG |
| BGB | GGG |
| BGGBB | GGGBG |
| BGGBG | GGGG |
| BGGGG | GGGBB |

**TABLE A10 Bank 1's Probability of Searching G or B on Next Search**

| With Probability: | G | B |
|---|---|---|
| 2/7 | 2/4 | 2/4 |
| 4/7 | 1/4 | 3/4 |
| 1/7 | 0 | 1 |

**TABLE A11 Probability That a Total Search Will Equal 6, 7, 8, 9, or 10**

| Total Search Equals | Probability |
|---|---|
| 6 | 112/420 |
| 7 | 90/420 |
| 8 | 155/420 |
| 9 | 21/420 |
| 10 | 42/420 |

The many possible ways for total search to equal 6, 7, 8, 9, or 10 are summarized in table A11 in the frequency distribution of total searches.

From this distribution, the expected number of total searches is 7.5. To find the expected bid price, the expected bid price for each possible search combination is first derived.

For example, for six searches, the expected bid price is derived as follows. For search combination BGBBBB, with probability 1/42, the TOS can be $4, $3, or $2. The $4 TOS occurs with any combination like G$5$4, which can occur five ways since G takes values from $6 to $10. A $3 TOS can occur with G$5$#, G$4$3, and $5$4$3, which is 11 possible combinations, and a $2 TOS can occur in one of the 18 combinations; G$5$2, G$4$2, G$3$2, $5$4$2, $5$3$2, and $4$3$2. For search combination BGBBBB, the expected bid is $2.6. Also see the dagger footnote in table A9 for the open competition case.

With combinations like BGBBGB, the TOS can be $4 with five combinations and $3 with 10 combinations, giving an expected bid of $3.33.

For combinations that win with GGG, the expected bid is $6.7 because search stops after GGG for combinations like $6$7$8, $6$7$9, $6$7$10, $7$8$9, $8$9$10, $7$8$10, and $7$9$10. Thus, the TOS is $6 with probability 3/7, $7 with probability 3/7, and $8 with probability 1/7

For GGGG winning combinations, the expected bid is $7.5 as the TOS can be $7 or $8 with equal probability. This is because search continues after GGG only when the bank can get a TOS of $7 or $8 with the next draw.

For combinations with three consecutive G's and continued search without finding another good buyer (e.g., GGGBB), the expected bid price is $6 since the bank continues after GGG only if it has a TOS of $6.

**TABLE A12 Expected Bid Price Yields for Each Search Frequency**

| Total Search | Frequency | Expected Bid ($) |
|---|---|---|
| 6 | 112/420 | 4 47 |
| 7 | 90/420 | 6.75 |
| 8 | 155/420 | 6.16 |
| 9 | 21/420 | 6.70 |
| 10 | 42/420 | 6.36 |

With three nonconsecutive G's, that is, BGGBG, the expected bid is \$6.5 since the TOS can be \$6 or \$7 or \$8 with respective probabilities 6/10, 3/10, and 1/10.

With three G's between the losing and winning syndicate, the expected bid is complicated. This combination is BGBBGGBB. Now, BGB can win if the first bank has G\$5\$4 and the second has GG\$3\$2\$1, but all other combinations result in BGGBB winning the auction. If the first bank's investors are then G\$5\$3, G\$5\$2, and G\$5\$1, the second bank has BGGBB with TOS of \$4. If the first bank's investors are G\$4\$3, G\$4\$2, G\$4\$1, G\$3\$2, G\$3\$1, G\$2\$1, then the second bank's TOS is \$5. Thus, when there are only three G's between the syndicates, the expected bid price is \$4.6.

Thus, if there are six searches, the expected bid price is $(1/42) \times \$2.6 + (6/42) \times \$3.33 + (2/40) \times (7/10) \times \%6.70 + (4/42) \times (7/10) \times \$6.70 = \$4.47$.

The bid prices for other numbers of total search can be similarly derived. The expected bid price for each search frequency is reported in table A12. As mentioned before, the expected number of searches from this distribution is 7.50. Also, the expected number of effective searches is $3[1/42 + 1/7 + (3/21)(7/10)] + 4[(4/14)(7/10) + (2/42)(3/10)] + 3(1/42)(7/10) + 5[(16/42)(3/10) + 10/42 + (1/42)(7/10)] + 4(21/420) + 5[(4/42)(3/10)] + 3/10) = 4.25$, the expected gross price is \$5.90, and the expected net proceeds are $\$5.90 \times 3 - \$7.50 = \$10.20$.

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