



A Theory of the Syndicate: Form Follows Function

Pegaret Pichler; William Wilhelm

The Journal of Finance, Vol. 56, No. 6 (Dec., 2001), 2237-2264.

Stable URL:

<http://links.jstor.org/sici?sici=0022-1082%28200112%2956%3A6%3C2237%3AATOTSF%3E2.0.CO%3B2-G>

The Journal of Finance is currently published by American Finance Association.

Your use of the JSTOR archive indicates your acceptance of JSTOR's Terms and Conditions of Use, available at <http://www.jstor.org/about/terms.html>. JSTOR's Terms and Conditions of Use provides, in part, that unless you have obtained prior permission, you may not download an entire issue of a journal or multiple copies of articles, and you may use content in the JSTOR archive only for your personal, non-commercial use.

Please contact the publisher regarding any further use of this work. Publisher contact information may be obtained at <http://www.jstor.org/journals/afina.html>.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

JSTOR is an independent not-for-profit organization dedicated to creating and preserving a digital archive of scholarly journals. For more information regarding JSTOR, please contact support@jstor.org.

A Theory of the Syndicate: Form Follows Function

PEGARET PICHLER and WILLIAM WILHELM*

ABSTRACT

We relate the organizational form of investment banking syndicates to moral hazard in team production. Although syndicates are dissolved upon deal completion, membership stability across deals represents a barrier to entry that enables the capture of quasi-rents. This improves incentives for individual bankers to cultivate investor relationships that translate into greater expected proceeds. Reputational concerns of lead bankers amplify the effect. We derive conditions under which restricted entry and designation of a lead banker strictly Pareto dominate, in which case it is also strictly Pareto dominant for the syndicate's fee to be greater than members' cost of participation.

IN 1997 ALONE, APPROXIMATELY \$1.3 trillion in new securities were sold in the U.S. public debt and equity markets. Most were underwritten by syndicates of investment banks organized for the sole purpose of selling the securities offering at hand. Although previous research and prominent textbooks emphasize the risk-sharing function of the syndicate (Wilson (1968), Mandelker and Raviv (1977), Chowdhry and Nanda (1996), and Ross, Westerfield, and Jaffe (1999)), we contend that the syndicate's unique organizational structure reflects, at least in part, an institutional response to the relationship-intensive nature of the investment banking industry.

To gain intuition for our argument, it is useful to think of securities offerings as having two stages. The first is a period of preparation for the issuing firm and market. During this stage, investment bankers coordinate the collection and dissemination of information relevant to the offering. We envision a bank's information-production capacity to be a function of investments in the development and maintenance of investor and client networks. The second stage includes the distribution of securities and secondary market support.

* Pichler is from the Carroll School of Management, Boston College; Wilhelm is from Saïd Business School, University of Oxford. We thank Andres Almazan, Thomas Chemmanur, Michel Habib, Cliff Holderness, Edie Hotchkiss, Naveen Khanna, Nathalie Moyen, Jay Ritter, Sheridan Titman, participants in the European Union TMR workshop on Initial Public Offerings at the London Business School and participants in seminars at CUNY Baruch College, Michigan State, and The University of Texas at Austin for helpful comments. We are particularly grateful to Rick Green (the editor) and our referee who provided numerous suggestions and to Mike Fishman for his careful insight on an earlier version of the paper. This paper was presented at the 1999 Western Finance Association and European Finance Association meetings. Wilhelm was supported in part by a grant from the Victor R. Simone, Sr. Research Fund at Boston College.

Considerations of optimal scale and scope apparently have prevented individual banks from maintaining the capacity demanded by most securities issuers. Collaboration among banks, however, is complicated by the fact that investment in network development involves day-to-day efforts that overlap with one another and are difficult to monitor (Eccles and Crane (1988)). Thus, individual bankers have a powerful incentive to free ride on one another in the preparation of an offering.¹

The moral hazard problem gains an additional dimension if potential team members can maintain the pretense of high-quality production capacity at minimal effort. Unless nurtured, the relationships and reputation that are necessary for a bank to be an effective syndicate member will decay. However, a bank that has been successful in the past might be tempted to rest on the laurels of past success and maintain the perception of high-quality relationships with minimal effort. If minimal effort cannot easily be distinguished from more extensive effort, then, from the issuer's perspective, it is important not only to promote the costly effort necessary to develop and maintain high-quality relationships, but also to discourage syndicate members from engaging in less costly, unproductive activities, designed to mislead issuers.

The purpose of our work is to demonstrate how the organizational structure of the syndicate can alleviate this problem. Syndicates differ from many strategic alliances in that each syndicate is organized for the execution of a narrow set of transactions associated with a single offering. However, the brief formal lifespan of syndicates belies the stable informal relationships among banks evidenced by extensive overlap in membership across syndicates (Eccles and Crane (1988) and Benveniste, Busaba, and Wilhelm (2000)). We contend that membership stability is a natural by-product of the central role of relationships and reputation in financial intermediation. Moreover, the inability to replicate these assets in the short run enables member banks to capture quasi-rents.

In contrast to the relatively stable membership of these production teams, internal structure is unstable as the identity of the lead banker changes from deal to deal. Potential syndicate members compete aggressively for the leadership role because it carries with it the bulk of the fees paid to the syndicate. However, leadership also carries greater responsibility for the outcome of the deal, and effectively places the leader in the limelight. As such, the selection of a lead banker acts as a monitoring mechanism that threatens those who might shirk in their day-to-day efforts with loss of reputation and future quasi-rents.

In our model, barriers to entry make it feasible for the issuer to share surplus with syndicate members. We demonstrate that by sharing surplus,

¹ In contrast, the bulk of distribution and secondary market support effort occurs after the formation of the syndicate and is more nearly deal specific. Moreover, syndicate managers routinely monitor distribution and trading behavior and penalize syndicate members who violate explicit or implicit agreements among members (see Benveniste, Busaba, and Wilhelm (1996), Benveniste, Erdal, and Wilhelm (1998) and Aggarwal (2000)). Similarly, analyst forecasts are readily compared to outcomes and serve as the basis for highly visible industry rankings.

the issuer can motivate a larger syndicate to exert effort. The random monitoring mechanism associated with the designation of a lead banker, enhances the value of sharing surplus with the syndicate. Thus, barriers to entry together with designation of a lead banker are characteristic of a Pareto-dominant organizational form.

Our analysis is in the spirit of existing work on moral hazard in team production (e.g., Alchian and Demsetz (1972), Gorton and Grundy (1997), and Holmström (1982)), but differs in that effort is exerted before the production team is organized. In contrast to most existing work in moral hazard, we also model production as a concave, rather than linear, function of effort. Because the model is quite general, it sheds light on any team-production setting in which output depends on effort exerted prior to forming a production team and suggests a rationale for variable project-specific leadership assignments within stable production teams.

The identification of benefits deriving from reputation and relationship-induced barriers to entry complements recent work by Anand and Galetovic (2000), Persons and Warther (1997) and Benveniste et al. (2000) and the more general “quality-assuring price” analysis of Klein and Leffler (1981). Our results also shed light on the debate surrounding a recent Justice Department investigation and civil lawsuit alleging collusive behavior among industry members as evidenced by clustering of underwriting spreads around the 7% level (Chen and Ritter (2000)). In our model, the issuer may optimally pay a fee in excess of the syndicate members’ participation costs because the positive effect on incentives so increases total proceeds as to more than offset the issuer’s smaller share. The optimal amount of surplus shared with the syndicate is increasing in issue size. As a result, even though the percentage underwriting spread is decreasing in issue size, the spread is a convex function of issue size that converges to a relatively flat fee structure for large issues.

In the following section, we provide a brief historical account of the syndicate that explains why risk sharing may be only one role for the syndicate and perhaps a less important role, at that. In Section II, we develop a model for analyzing moral hazard in team production. The analysis of the model is structured to shed light on the role of the three institutional features discussed above: the designation of a lead bank, the centrality of reputation, and the beneficial role of implicit barriers to entry created by reputation and relationships. Section III presents the first-best solution. Sections IV and V present the second-best solutions without and with a lead banker, respectively. Section VI presents the model’s empirical implications and Section VII concludes with some thoughts on why the syndicate’s role might be altered by recent advances in information technology. Proofs for all propositions and a list of variable definitions are provided in the Appendix.

I. A Brief History of the Underwriting Syndicate

Precursors to the underwriting syndicate can be traced to at least the 18th century when loan contractors organized to support the sale of British and French government loans (Carosso, 1970). Most historians credit Jay Cooke

with the introduction of the underwriting syndicate to U.S. financial markets in 1870 after having observed its use in France. Between 1880 and 1890, the syndicate primarily was used in the sale of railroad bonds, gaining wider use only after 1893.

The modern syndicate is defined by a complex set of contracts including the agreement among underwriters, the purchasing agreement between the underwriters and the issuer, and the selling agreement between the underwriters and members of the selling group. The contractual framework was relatively plastic prior to World War II but, in general, evolved toward a more stable structure that limited the liability of the syndicate membership (Dewing (1953)). The significant innovation in this regard was probably the pricing of deals (and therefore determining the underwriter's commitment) only hours before beginning distribution and only after extensive canvassing of the institutional investor community.

Even as the syndicate began to take shape as an organizational form at the turn of the 20th century, kinship groups, bonded by a common culture that resulted in frequent personal interaction and intermarriage, remained an important foundation for informal alliances that supported transactions beyond the scope of any single (family) partnership (Supple (1957)). Presumably this would not have been the case if capital constraints or risk-sharing considerations were the only basis for the syndicate. Of course, the contracts that in theory would have made one person's capital and risk-sharing capacity as good as another's were incomplete and legal recourse was often costly or nonexistent.² However, even early observers commented on a role for the syndicate that went beyond risk-sharing:

No banker can wisely cover the whole gamut of investment securities, providing within his single organization a specialized and intelligent procedure of purchase; and yet a great variety of securities must be offered to the banker's customers in order to meet the demands of each investor's need for diversification. (Dewing (1934, p. 981))

Christenson (1965, p. 11) expands on this point by observing that banks chosen as syndicate managers had "acquired a reputation for good judgment in the evaluation of securities and for an excellent 'feel' for the market."

Prior to 1970, the NYSE required member firms to be privately held. By 1960, a number of investment banks had reorganized as private corporations. When the NYSE opened the door to public ownership of member firms, a first wave of banks including Donaldson Lufkin Jenrette, First Boston, Merrill Lynch, Dean Witter, and E.F. Hutton went public in short order. By 1987, all but Goldman Sachs among the larger banks were public corporations and no longer faced the risk-sharing problems that motivated early

² This point is borne out by Dewing's (1953) observation that disputes among bankers were generally settled without resort to the courts.

syndicates. Thus, we contend that by the mid-1980s, risk-sharing considerations in the syndication of securities offerings were surely of second-order importance. Yet, between January 1996 and December 1998, an analysis of 1,296 U.S. IPOs reveals that the mean syndicate size remains at 18.2 members (median = 18).³ Without discounting the role of institutional inertia, the survival of the syndicate in the face of advances in risk sharing suggests that there are other dimensions to its economic function.

II. The Model

We consider a model in which there are N risk-neutral bankers and a risk-neutral entrepreneur (the issuer) who maximizes expected net proceeds, net of any bankers' fees, from an initial public offering of equity. We model the "success" of a firm's offering as a function of the amount and quality of information produced by members of a syndicate of bankers underwriting the deal. Gross proceeds from the issue, P , are stochastic. The realized gross proceeds may take on one of two values. If the issue is successful then $P = V > 0$. This occurs with probability p . Otherwise $P = 0$.⁴

Investment bankers possess a production technology that determines the probability of a successful outcome. If a syndicate is formed with $S + L$ bankers and S members of the syndicate have exerted high-level effort whereas L members have exerted low-level effort, then $p = (1 - [\mu/(S + \alpha L)])$, where $0 \leq \alpha < 1$. Thus, expected gross proceeds are $\bar{P} = V(1 - [\mu/(S + \alpha L)])$. For simplicity, we make the following assumptions:

- $\alpha = 0$ so that only high-level effort contributes to total proceeds;
- $V = 1$, so P represents relative proceeds.⁵

The production function thus reduces to

$$\bar{P} = p = 1 - \frac{\mu}{S}. \quad (1)$$

The production technology is a reduced-form representation of how bankers add value when securities are issued. The production function's concavity reflects the idea that the efforts of individual bankers overlap with one another and so there is diminishing marginal benefit to adding bankers to the syndicate. We envision "effort" as being devoted to the development and maintenance of reputation or relationships with institutional investors with whom the N bankers have overlapping contact. In this context, μ might be

³ We thank Alexander Ljungqvist for providing this information.

⁴ A notation list, given at the beginning of the Appendix, may be useful in this and the following sections.

⁵ Later, we reintroduce V to examine the effect of issue size on the model's predictions.

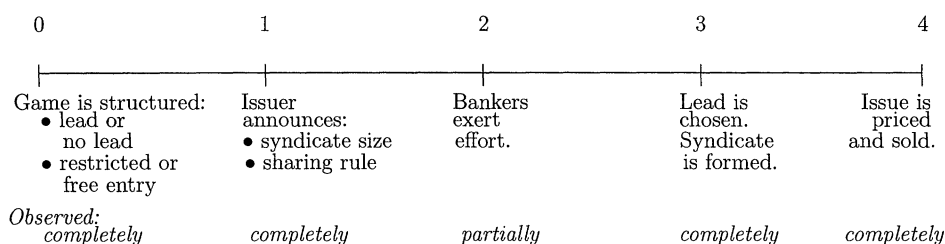


Figure 1. Timeline.

interpreted as reflecting uncertainty or capturing the marginal impact of high-level effort on proceeds.⁶

Equation (1) implies that the issuer wishes to have as many bankers as possible participating at high-level effort. However, there are costs associated with high-level participation and so it may be impossible to motivate a large number of bankers to exert such effort. We analyze this problem as a staged game in which the issuer's objective is to maximize expected net proceeds whereas the objective for each of the N bankers is to maximize his expected fee net of the cost of exerting effort.

The order of moves in the game is illustrated in Figure 1. At time zero, it is exogenously determined whether the syndicate has a lead banker or not and whether there is restricted or free entry within the banking industry. This is common knowledge among all players. In practice, syndicates are formed around a lead banker, but analyzing the no-lead regime highlights the potential benefits of this convention. Similarly, considering both restricted entry and free entry sheds light on the welfare implications of the centrality of reputations and relationships in the production of underwriting services.⁷

At time 1 the issuer announces the number of bankers invited to join the syndicate, S^* , and a sharing rule, for sharing gross proceeds with the syndicate. This is a take-it-or-leave-it offer. Although in practice such a contract would emerge from negotiations between the issuer and the banker(s), our

⁶ Alternatively, there is substantial literature devoted to the certification role of banker reputation in securities offerings (e.g., Booth and Smith (1986), Chemmanur and Fulghieri (1994)). Likewise, Benveniste and Spindt (1989) suggest that bankers add value by maintaining a mechanism for resolving problems related to asymmetric information among investors (e.g., Rock (1986)) but take the credibility of the mechanism for granted (see Benveniste, Busaba, and Wilhelm (1996)). In this context, we might envision effort as necessary for establishing and preserving credibility with investors of the banker's commitment to the mechanism. Finally, it can be shown that this general production technology is consistent with banker effort diminishing uncertainty in a model where investor risk aversion leads to newly issued securities being valued as a decreasing function of uncertainty.

⁷ Note that industry structure is not treated as a choice variable in the analysis. We model economic agents as making individually rational choices, given the environment in which they are acting. We will, however, be able to make statements about which type of industry structure most benefits the issuer and the investment bankers.

objective here is to determine the optimal syndicate from the perspective of the issuer, requiring, of course, that the bankers' responses be optimal. When the lead banker is introduced, the issuer delegates responsibility for determining the syndicate size. We provide conditions such that under the contract offered by the issuer, the lead banker optimally selects $S^* - 1$ additional syndicate members.

The issuer chooses the syndicate size and sharing rule to maximize expected net proceeds. When choosing these quantities, the issuer knows the game being played, the expected price function as given by equation (1) and the rule for selecting a lead banker and syndicate members at time 3. The issuer also has rational expectations as to how bankers will respond at time 2.

At time 2, each banker independently chooses from a set of three possible effort levels: effort $\in \{\text{no effort, low-level effort, high-level effort}\}$. No effort costs the banker nothing, low-level effort is exerted at cost (disutility) D_l , and high-level effort is exerted at cost D_h , where $0 \leq D_l < D_h$.⁸ Each individual knows his own level of effort, but other agents observe only the information partition: $\{0\}$ and $\{D_l, D_h\}$. That is, the issuer and other bankers know whether a particular banker has exerted effort, but cannot determine the level of effort exerted. When bankers choose their effort levels, they know the game being played, the syndicate size and sharing rule as set by the issuer at time 1, the price function as given by equation (1), and the rule for selecting a lead and syndicate members at time 3. Bankers also have rational expectations as to how the total syndicate fee will be shared within the syndicate. The solution method used at time 2 requires a Nash equilibrium among the bankers.

At time 3, the lead banker and syndicate members are chosen by applying a random selection rule that takes into account what has occurred and is observable from previous periods. A key aspect of the problem is that *the syndicate for a particular deal is formed after effort is exerted*. If there is no lead banker, then S^* syndicate members are chosen randomly from the set of all bankers who have exerted *some* effort.⁹ If no more than S^* bankers are in this set, then all bankers in the set are included in the syndicate. If more than S^* bankers are in this set, then each banker in the set has a probability S^*/M of being included, where M is the number of bankers who have exerted some effort. If the lead-banker game is being played, then the lead banker is randomly selected from the set of all bankers who have exerted

⁸ With issue size normalized to one, effort levels are relative to the size of the issue. All else equal, larger issues incur lower costs (D_l and D_h).

⁹ Random selection is a simple way of capturing the consequences of imperfectly observable effort. If effort were perfectly observable, the issuing firm would simply select from the pool of banks that have exerted high-level effort. Random selection, like errors arising from imperfect observation of effort, permits the inclusion of banks that have exerted low-level effort. In addition, the random assignment of the lead banker's role has some similarities to the "rank-order tournaments" analyzed by Lazear and Rosen (1981) in the sense that the value of the "prize" is not wholly contingent on deal-specific output.

some effort. Each banker in this set has an equal probability of being chosen. The remaining syndicate members are chosen as in the no-lead game. Later, we examine agency problems between the issuer and lead banker triggered by disagreement over syndicate size.

At time 4, the issue is priced. The probability of a successful issue and total expected proceeds are given by equation (1), where S is the number of syndicate members who have exerted high-level effort. Total realized proceeds, P , are determined by a random draw. Bankers not chosen for syndicate membership receive nothing. Each nonlead syndicate member receives an equal share of the total syndicate fee. If there is a lead banker, this banker may receive a larger share of the fee. The sharing rule between the lead and nonlead bankers is developed later. Each banker who exerts effort has an equal chance of becoming the lead, and so bankers who exert effort have identical a priori expectations.

III. The First-Best Outcome

We establish a benchmark for measuring the benefits of restricted entry and designation of a lead banker by characterizing the first-best outcome when information production is not subject to a moral hazard (free riding) problem. In this case, all syndicate members exert high-level effort and the issuer sets the sharing rule so that each member receives, in expected value, exactly his cost of exerting high-level effort, D_h . In the absence of moral hazard, the nonlinearity of the production function ensures a well-defined first-best outcome with gross proceeds determined by the point where the marginal benefit and marginal cost of including an additional banker exerting high-level effort are equal.

Under first best, the issuing firm's optimization problem is

$$\max_S 1 - \frac{\mu}{S} - SD_h. \quad (2)$$

Solving the above equation we find that the first-best syndicate size is

$$S_{fb} = \sqrt{\frac{\mu}{D_h}} \quad (3)$$

and the first-best outcome generates expected total proceeds of

$$\bar{P}_{fb} = 1 - \sqrt{\mu D_h}. \quad (4)$$

If the issuing firm captures the entire surplus, then bankers are just compensated for the cost of producing high-level information. The issuing firm expects to receive net proceeds in the amount

$$\bar{Z}_{fb} = 1 - 2\sqrt{\mu D_h}. \quad (5)$$

Positive expected net proceeds requires $4\mu D_h < 1$. Thus, an offering will not be attempted even in the first-best world if the need to gather information is particularly severe (large μ) and the relative cost of information production (D_h) is high.

IV. Syndicate Formation in the Presence of Moral Hazard

Now we assume that all agents can observe realized proceeds but that individual effort levels are observable only by the banker exerting the effort. Consequently, fees can now only be tied to effort as it is reflected in realized proceeds. Thus, bankers may have an incentive to free ride on one another. If we let w_1 be the total fee paid to the syndicate when $P = 1$ and w_0 be the fee when $P = 0$, then the issuer maximizes expected net proceeds by solving

$$\max_{S^*, w_1, w_0} E[Z|S] = p(S)(1 - w_1) - (1 - p(S))w_0, \quad (6)$$

where S^* is the number of bankers that the issuer invites into the syndicate and $S \leq S^*$ is the number of syndicate members who exert high-level effort.

A. Participation and Incentive-Compatibility Constraints with No Lead Banker

As in the first-best world, the issuer must take into account the fact that bankers will exert high-level effort only if the marginal expected return to high-level effort is at least as large as the marginal cost. In a second-best world the issuer must also be concerned about the possibility of including in the syndicate bankers who have exerted only low-level effort. If bankers exerting low-level effort are included in the syndicate, they contribute nothing to the outcome but share in the proceeds. Thus, a necessary condition for the issuer's net proceeds to be maximized is that no banker exerts low-level effort. We define participation and incentive-compatibility constraints such that at least S^* bankers participate and such that no banker participates at low-level effort. We apply the Nash equilibrium strategy of showing that the equilibrium is a fixed point.

If $M - 1$ ($M > 1$) bankers exert high-level effort and $M \geq S^*$, then an additional banker M will exert the effort necessary to be considered for syndicate membership if the following participation constraint is satisfied:

$$\max \left[\frac{1}{M} (p(S^* - 1)w_1 + (1 - p(S^* - 1))w_0) - D_l, \right. \\ \left. \frac{1}{M} (p(S^*)w_1 + (1 - p(S^*))w_0) - D_h \right] \geq 0. \quad (7)$$

The probability of success, given that S^* syndicate members exert high-level effort, is $p(S^*)$; $p(S^* - 1)$ is the probability of success, given that $S^* - 1$ syndicate members exert high-level effort. The first term of equation (7) is

the participation constraint for low-level effort. The second term is the participation constraint for high-level effort. Each banker exerting at least minimal effort has probability S^*/M of being included in the syndicate. Each banker included in the syndicate receives a portion $1/S^*$ of the syndicate's total fee. Thus, the participation constraint simply requires that banker M 's expected share of proceeds equals or exceeds the cost of effort.

If realized total proceeds were a deterministic function of the effort exerted by the syndicate members, then a direct method for achieving first-best would be for the issuer to pay the syndicate only when proceeds from the offering indicate that all syndicate members have exerted high-level effort. Because this cannot be done, we require instead that exerting high-level effort be incentive compatible for all participating bankers. Incentive compatibility is achieved if, conditioned on $M - 1$ ($M > 1$) bankers exerting high-level effort, an M th banker who wishes to participate does so at high-level effort. The incentive-compatibility constraint is therefore

$$\frac{1}{M} (p(S^*) - p(S^* - 1))(w_1 - w_0) \geq D_h - D_l, \quad (8)$$

where $(p(S^*) - p(S^* - 1))(w_1 - w_0)$ is the marginal impact on the syndicate's expected fee of having an additional banker in the syndicate contributing at high-level effort. Equation (8) highlights the source of the free riding problem in that each banker expects to receive only a share $1/M$ of the result of his or her effort.

Even in the presence of uncertainty, it may be possible to achieve first-best (satisfy equation (8) with the first-best syndicate size and expected payment) by "punishing" the syndicate if a bad outcome ($P = 0$) occurs. If there are no limits on the issuer's ability to punish (and the syndicate members are risk neutral as we assume here), then first-best can always be achieved. We assume, however, that the investment bankers have limited liability so that

$$w_1 \geq 0 \quad \text{and} \quad w_0 \geq 0. \quad (9)$$

B. Optimal Syndicate Formation with No Lead Banker

Our first proposition establishes that, given the choice, the issuer prefers an industry structure that restricts entry such that the number of applicants to the syndicate (M) will not exceed the number of applicants that the issuer would optimally include in the syndicate (S^*).

PROPOSITION 1: *It is optimal from the issuer's perspective to have the number of syndicate applicants restricted to the optimal number of members in the syndicate.*

Because effort is exerted prior to the formation of the syndicate, free entry may result in wasted resources by leading more bankers to exert the effort necessary to vie for syndicate membership than will optimally be included ($M > S^*$). This result could be achieved in the absence of moral hazard, but

it is particularly relevant to the problem at hand. Although fees cannot be *directly* tied to effort, we will show that the number of bankers induced to exert high-level effort can be increased by offering a fee in excess of the cost of exerting high-level effort, D_h . (Recall that D_h is the fee paid in the first-best case.) However, if bankers compete freely for syndicate membership, they will enter until any such quasi-rents are competed away (until the participation constraint (equation (7)) is satisfied with equality), thereby undermining this strategy for improving incentives.

We explore the costs of free entry in the face of moral hazard by first determining the maximum syndicate size, S' , achievable when the issuer does not share surplus with the syndicate. This is obtained by satisfying both the participation constraint for high-level effort (see equation (7)) and the incentive-compatibility constraint (equation (8)) with equality (see the Appendix) which yields

$$S' = \frac{1}{2} \left(1 + \mu + \sqrt{(1 + \mu)^2 + \frac{4\mu \frac{D_l}{D_h}}{1 - \frac{D_l}{D_h}}} \right). \quad (10)$$

Keeping in mind that D_l and D_h are relative costs that decrease in issue size, equation (10) leads immediately to Proposition 2:

PROPOSITION 2: *The first-best syndicate size is more nearly achieved for smaller issues and as the cost of exerting low-level effort approaches that of exerting high-level effort. If first-best cannot be achieved, then the optimal syndicate size will be strictly less than the first-best size.*

Both S_{fb} and S' depend on the value of effort as represented by μ . But whereas the first-best syndicate size is inversely related to the cost of high-level effort $1/D_h$, S' depends on the relative costs of low-level and high-level effort D_l/D_h . As D_l and D_h converge, S' goes toward infinity and the first-best outcome is more likely feasible. If, however, both marginal relative costs of effort diminish, as would be expected as issue size increases, then S_{fb} increases whereas S' is unaffected. In this case the moral hazard problem increases.¹⁰

If S_{fb} is greater than S' so that first-best cannot be achieved, then the issuer may benefit from restricted entry by optimally offering a contract that shares surplus with the syndicate. Proposition 3 states this result and the conditions under which the benefits from restricted entry are most pronounced.

¹⁰ If D_l goes to zero, then S' becomes independent of the cost of effort ($S'|_{D_l=0} = 1 + \mu$). Also, although our base model (with issue size not normalized to one) assumed that the cost of effort is independent of issue size, the result that first best is more nearly achieved for smaller issues does not require independence. All that is necessary is the much weaker assumption that the ratio of individual cost of effort to issue size is decreasing with issue size.

PROPOSITION 3: *When entry is restricted:*

- (1) *The issuer can expand the syndicate while maintaining high-level effort from all members by offering an expected fee that exceeds the syndicate's cost of high-level effort.*
- (2) *The issuer optimally shares surplus with the syndicate if and only if not doing so leads to a syndicate that is "small" relative to the first-best syndicate. This condition is more easily achieved when the relative cost of high-level effort is low.*
- (3) *Sharing surplus with the syndicate is more beneficial to the issuer as the marginal impact of high-level effort on proceeds increases and as the cost of high-level effort decreases.*

With restricted entry, the issuer can offer a contract such that each syndicate member expects a payoff of $D_h + y$, where $y \geq 0$. This contract supports a syndicate with S_{nl} members, each of whom exerts high-level effort, where

$$S_{nl} = \frac{1}{2} \left(1 + \mu + \sqrt{(1 + \mu)^2 + \frac{4\mu \frac{D_l + y}{D_h}}{1 - \frac{D_l}{D_h}}} \right). \quad (11)$$

If there is free entry, then the largest syndicate that can be motivated is S' , regardless of the value of y . The syndicate size under restricted entry, S_{nl} , differs from S' only in the premium y . Thus it is clear that restricting entry and sharing surplus with the syndicate provides for a larger syndicate and therefore greater gross proceeds. Result (2) of Proposition 3 draws attention to the issuer's trade-off. Sharing surplus with the syndicate provides for a larger membership of bankers, each of whom exerts high-level effort but at the cost to the issuer of receiving a smaller share of the expected proceeds. The issuer gets more "bang for his buck" when S' is small relative to S_{fb} . The concavity of the production function is such that for relatively large values of S' (i.e., when the moral hazard problem is not particularly severe) there is no strictly positive benefit to the ability to share surplus with the syndicate. Because D_h is a relative cost that decreases in issue size, sharing surplus is more attractive as the issue size increases. The marginal impact of high-level effort on proceeds is reflected in μ so result (3) simply states that as this benefit increases and its cost (D_h) declines, the benefits of restricting entry increase.¹¹ The condition under which the issuer optimally shares surplus with the syndicate is derived in the Appendix.¹²

¹¹ The latter effect is due to the concavity of the production function.

¹² In an earlier version of the paper, we modelled proceeds as drawn from a continuous probability distribution. In that model, the issuer optimized over the sharing rule and a reservation value for proceeds (below which the issue would be cancelled). It was shown that increasing the reservation value also induces greater effort, but without the dissipation of

The observation that in team-production settings, more agents can be motivated to high-level effort by payments in excess of reservation fees is not new (e.g., see Gorton and Grundy (1997)). But our analysis suggests further that *when effort is exerted before the production team is formed, limiting competition through restricted entry permits the principal to form a larger team of agents, each of whom will have sufficient incentive to exert high-level effort*. This result is extended when we consider the role of a lead banker in forming a syndicate.

V. Delegation of Syndicate Formation to a Lead Banker

In this section, we explore the conditions under which selecting a lead banker for the syndicate further mitigates moral hazard. In practice, lead banker status carries both costs and benefits. The lead banker generally determines which bankers join the syndicate and on what terms. This enables the lead to capture a larger share of the syndicate fee and is also likely to have a positive impact on the lead's future income stream by increasing the probability of participation in future syndicates. However, the lead banker's visibility is a double-edged sword. Nanda and Yun (1997) find that lead underwriters of IPOs that suffer negative initial returns suffer wealth losses in excess of losses attributable to secondary market price stabilization. Moreover, the damage to reputation appears to be borne largely by the lead even when comanagers are present.

We capture these features of the institutional setting by assuming that after being chosen to lead an offering, the lead banker, unlike other members of the syndicate, can be observed to have exerted either high-level or low-level effort and can be penalized for shirking. At time 3, the lead banker is randomly selected from the set of bankers whose effort levels are in the set {low-level, high-level}. The lead then chooses the remaining syndicate members. We assume that the lead, like the issuer, is unable to distinguish between low- and high-level effort on the part of other bankers. At time 4, after the issue has been priced and sold, the syndicate's fee is divided between the lead and remaining syndicate members. The lead's effort level is then publicly revealed. As in the no-lead case, the individual effort levels of the remaining syndicate members are not revealed. In addition to these changes to the game, we now simplify the analysis by setting the cost of low-level effort, D_l to zero and by focusing only on the case of restricted entry where $M = S$.

A. Formation of the Syndicate by a Lead Banker

Delegating responsibility for syndicate formation to a lead banker introduces an additional agency problem because the lead banker seeks to maximize his or her (rather than the issuing firm's) expected payoff from the

shared surplus in the presence of free entry. Numerical experimentation showed, however, that for most parameter values sharing surplus (with restricted entry) provided a more efficient means of inducing extra effort.

transaction. Thus we begin by determining the optimal syndicate size from the lead banker's perspective. The lead banker's expected payoff is

$$\pi_L = (1 - \lambda(S - 1))pw_1, \quad (12)$$

where λ is the fraction of this fee that is received by each nonlead syndicate member. As was demonstrated in the last section, it is never strictly optimal for the issuer to set $w_0 > 0$. We will thus assume $w_0 = 0$ throughout this section so that pw_1 is the expected total fee paid to the syndicate.

Assuming that all syndicate members, including the lead, exert high-level effort, the lead banker will invite $S^h - 1$ additional bankers to the syndicate where¹³

$$S^h = \sqrt{\frac{(1 + \lambda)\mu}{\lambda}}. \quad (13)$$

If the lead has not exerted high-level effort (but all other bankers have), then the lead banker will invite $S^l - 1$ additional bankers to join the syndicate where

$$S^l = \sqrt{\frac{\mu}{\lambda}} + 1. \quad (14)$$

The issuer's objective is to form a syndicate of size $S^* = \min[S_{fb}, S_{ld}]$, where S_{ld} is the number of bankers that can be motivated to work at a high level within the lead-bank framework. The issuing firm can always prevent the lead from forming a larger syndicate by offering a contract such that no more than S^* bankers will participate. Thus, the additional agency problem reduces to the threat that the lead will want to form a syndicate that is smaller than S^* . Equation (13) implies that a sufficient condition for resolving the potential agency conflict between the issuer and lead (assuring that $S^h \geq S_{ld}$) is that the sharing rule among syndicate members satisfy the following constraint:¹⁴

$$S^h \geq S^* \Rightarrow \lambda \leq \frac{\mu}{(S_{ld})^2 - \mu}. \quad (15)$$

Equation (15) places an upper bound on the nonlead syndicate members' share of the syndicate fee. For the moment, we assume that λ satisfies this condition so that the lead's incentives are aligned with the issuer's. We will return to an analysis of equation (15) after determining the value of S_{ld} .

¹³ S^h is determined by inserting $p = 1 - (\mu/S)$ into the equation for π_L and then finding the value of S that maximizes π_L . S^l is determined in the same way, but with $p = 1 - [\mu/(S - 1)]$.

¹⁴ We use S^h here because in equilibrium the lead banker exerts high-level effort.

B. The Penalty Function

At time 4, a lead banker identified as having exerted low-level effort incurs a penalty. We model the penalty as the loss of expected profits from participation in future deals:

$$\Omega = (\Pi_h - D_h) \frac{b}{\rho}, \quad (16)$$

where Π_h is the expected revenue from participating in an issue after exerting high-level effort, b is the probability of being included in any given deal and ρ is the discount rate that applies to the period of time between deals. The variable Π_h must be at least as large as D_h ; otherwise the banker will not participate, so $\Omega \geq 0$. The penalty takes on a strictly positive value if expected future per-deal revenues are strictly greater than D_h .¹⁵ As the frequency of deals increases, ρ is diminished and the expected penalty increases.

To keep things simple, we assume that all deals are a priori identical and that the current contract provides the best estimate of the sharing rule for future deals.¹⁶ Satisfying the high-level participation constraint requires that the contract take the form $w_1 = [S(D_h + y)]/p$, where $y \geq 0$ and p , the probability of a successful offering, is an increasing function of S .

The expected per-deal net revenue for a banker who exerts high-level effort is thus $\Pi_h = D_h + y$ and the penalty function is simply¹⁷

$$\Omega = \frac{yb}{\rho}, \quad (17)$$

where $b = S/N$ and N is the number of bankers available to participate in any given issue.¹⁸

C. Participation and Incentive-Compatibility Constraints with a Lead Banker

The issuer's optimization problem as given by equation (6) is unchanged, but the participation and incentive-compatibility constraints do change when there is a lead banker. If at least $S - 1$ bankers have exerted high-level

¹⁵ Klein and Leffler (1981) also model the value of reputation as accruing from the possibility of earning revenues above the cost of production.

¹⁶ Of course, some issuing firms may have greater than (or less than) average bargaining power, so that the best estimate of future sharing rules will differ from the current negotiated value, but the findings of Lee et al. (1996) suggest that this is a second-order consideration.

¹⁷ These functions assume restricted entry and high-level effort for all syndicate members for future deals.

¹⁸ We think of N as the number of banks that have expertise, or the ability to acquire expertise, in the type of issues being considered. N is exogenous and it is assumed that $N \geq S$.

effort, then the participation constraint is now satisfied for an *Sth* banker if¹⁹

$$\max[\Pi_l, \Pi_h - D_h] \geq 0, \quad (18)$$

where Π_l (Π_h) represents the expected revenue to the *Sth* banker if he exerts low-level (high-level) effort. The *Sth* banker exerts high-level effort if the incentive-compatibility constraint is satisfied:

$$\Delta \equiv \Pi_h - \Pi_l \geq D_h. \quad (19)$$

The revenue functions associated with low- and high-level effort are:

$$\Pi_l = \frac{1}{S} ([\pi_L | \text{low level effort}] - \Omega) + \frac{(S-1)\lambda w_1}{S} \left(1 - \frac{\mu}{S-1}\right) \quad (20)$$

$$\Pi_h = \frac{1}{S} [\pi_L | \text{high level effort}] + \frac{(S-1)\lambda w_1}{S} \left(1 - \frac{\mu}{S}\right). \quad (21)$$

The first term in each revenue function is the lead banker's expected revenue multiplied by the probability of being designated the lead banker. The second term is the expected revenue of a nonlead syndicate member multiplied by the probability of being included as a nonlead syndicate member.

If the lead banker's incentives are aligned with the issuing firm's so that the lead chooses the syndicate size that the issuer prefers, then the revenue functions are

$$\Pi_l = \frac{w_1}{S} \left(1 - \frac{\mu}{S-1}\right) - \frac{\Omega}{S} \quad \text{and} \quad \Pi_h = \frac{w_1}{S} \left(1 - \frac{\mu}{S}\right), \quad (22)$$

where Ω is a function of S and y . Since each banker has a probability $1/S$ of receiving the lead-bank designation, Ω/S is the expected penalty for exerting low-level effort. Because the bankers are risk neutral they care only about the expected value of their revenue and so the within-syndicate sharing rule λ cancels out.

D. Optimal Syndicate Formation with a Lead Banker

The issuer's problem can now be stated as:²⁰

$$\max_{S, w_1} (1 - w_1) \left(1 - \frac{\mu}{S}\right), \quad (23)$$

¹⁹ Recall, we are assuming that $D_l = 0$. Also, in order to simplify the notation, we will use S instead of S^* in what follows.

²⁰ Apart from the penalty function, the problem stated here is simpler than that in Section IV because we use the result that w_0 is optimally set to zero, we assume restricted entry, so that we need not worry about the participation constraint at low-level effort, and we assume that $D_l = 0$.

subject to:

$$\frac{w_1}{S} \left(1 - \frac{\mu}{S} \right) \geq D_h \quad (24)$$

$$\frac{w_1 \mu}{S} \left(\frac{1}{S-1} - \frac{1}{S} \right) + \frac{\Omega}{S} \geq D_h. \quad (25)$$

When entry is restricted, the optimal mechanism may maintain a positive penalty function by sharing surplus with the syndicate. Sharing surplus takes the form of offering a contract such that $w_1 = [(D_h + y)S]/(1 - (\mu/S))$ where $y > 0$, so that the contract offer is strictly larger than that necessary to ensure participation. Proposition 4, which is analogous to Proposition 3, establishes the benefits from doing so.

PROPOSITION 4:

- (1) *For any given contract offer that is strictly larger than that necessary to ensure participation, delegating responsibility for syndicate formation to a lead banker produces a strictly larger syndicate (whose entire membership exerts high-level effort), and therefore greater proceeds, than a syndicate formed in the absence of a lead banker.*
- (2) *The condition such that the issuing firm will optimally share surplus is less restrictive for a syndicate formed with a lead banker than for a syndicate formed without a lead banker.*
- (3) *Forming the syndicate with a lead banker Pareto-dominates forming the syndicate without a lead banker.*

Results (1) and (2) follow from the fact that *sharing surplus plays a dual role when the syndicate is organized by a lead bank*. In addition to increasing incentives in the same way as with no lead, sharing surplus gives value to reputation. As the amount of shared surplus increases, so does the value of reputation and the impact of the penalty, thus heightening incentives to exert high-level effort.

This result is related to Holmström's (1982) results on moral hazard in teams except that designating a lead bank does not generally produce the first-best outcome, because the issuer is limited by three concerns. First, monitoring is random. Second, we assume limited liability, so that each banker can lose no more than the expected value of future profits. And third, we assume that the principal (issuing firm) is never harmed by increased effort on the part of the bankers. Assuming otherwise introduces an additional moral hazard problem, as addressed by Gorton and Grundy (1997).

Result (3) of Proposition 4 follows directly from results (1) and (2). If the condition holds such that the issuer optimally shares surplus, then forming the syndicate with a lead *strictly* Pareto-dominates forming the syndicate without a lead. If the condition does not hold, then the issuer optimally sets $w_1 = D_h S / (1 - (\mu/S))$ and $S_{ld} = S_{nl} = S'$. Thus, designating a lead banker is always Pareto-optimal, even if it is not *strictly* Pareto-optimal.

When the syndicate is formed by a lead banker and each nonlead member receives $D_h + y$, the number of bankers that can be motivated to exert high-level effort is

$$S_{ld} = \frac{1}{2} \left(1 + \mu + \sqrt{(1 + \mu)^2 + \frac{4\mu y \left(1 + \frac{1}{\rho N}\right)}{D_h - \frac{y}{\rho N}}} \right). \quad (26)$$

For any value of $y > 0$, S_{ld} is strictly greater than the size of syndicate that can be motivated without a lead, as given in equation (11).

We now return to the sharing rule within the syndicate. Solving for S_{ld} implies the following result.

PROPOSITION 5: *The sufficient condition for the lead banker's and the issuer's incentives to be aligned requires that the lead banker's share of the total syndicate fee be strictly larger than the average fee received by the other syndicate members.*

In Section V.A we determined that the lead banker may have incentives to put together a syndicate that is smaller than the syndicate size preferred by the issuer. A sufficient condition for the lead banker's incentives to be aligned with the issuer's incentives is that an upper bound be put on each nonlead syndicate member's share of the total spread. This upper bound was given in equation (15): $\lambda \leq \mu / ((S_{ld})^2 - \mu)$. By inserting equation (26) into equation (15) it is seen that this condition requires λ to be less than $1/S_{ld}$ and thus the lead to be allocated a disproportionate share of the syndicate fee. If bankers are risk averse, then the value of λ that results in optimal risk sharing will exceed that given by equation (15).

VI. Deal Size and Frequency

By reintroducing the parameter V for issue size, we can prove the following proposition.

PROPOSITION 6:

- (1) *If it is strictly Pareto-optimal to share surplus with syndicate members, then the optimal amount shared and syndicate size are strictly increasing in issue size.*
- (2) *The condition under which the issuer optimally shares surplus with the syndicate is more easily satisfied as issue size increases.*

Because $S_{fb} = \sqrt{\mu V / D_h}$, in a first-best world, the issuer increases the size of the syndicate with the size of the offering. But larger offerings create greater profit opportunity regardless of effort level. This aggravates the moral

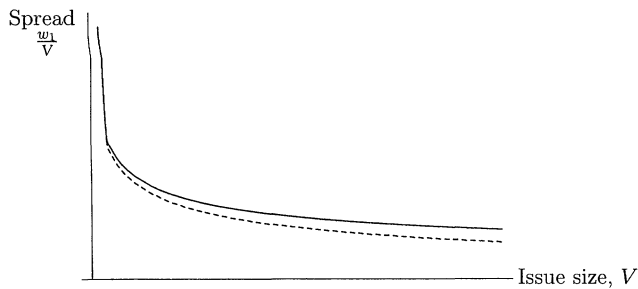


Figure 2. Underwriting spread versus issue size. The solid curve (—) represents the spread when the syndicate is formed by a lead manager. The dashed curve (---) represents the spread when the syndicate is formed without a lead manager.

hazard problem in the second-best world. Increasing the size of the syndicate in a second-best world requires sharing surplus with the syndicate. The issuer's incentive to do so increases with issue size.

Although Proposition 6 tells us that the fee premium offered to the syndicate is increasing in issue size, it does not speak directly to the fraction of gross proceeds, or spread, paid to the syndicate (w_1/V in our model). If the issuing firm does not optimally share surplus with the syndicate, then the syndicate size is independent of issue size and the spread is decreasing in issue size. However, when it is optimal to share surplus with the syndicate, the issuer jointly optimizes over the spread and the syndicate size. We cannot obtain a closed-form analytical solution to this problem, but it can be solved numerically. Figure 2 illustrates the outcome of this numerical analysis.²¹

The convexity of the spread function in Figure 2 is consistent with the fee structure observed in practice, and reflects two interacting effects. First, total proceeds are increasing in issue size; thus the percentage spread needed to cover syndicate members for their cost of participation is falling. Second, the incentive to free ride and therefore the optimal premium for the issuer to pay above this participation cost is also increasing. If the syndicate is formed by a lead banker, then an additional benefit is obtained from sharing surplus, and so the issuer optimally pays a larger spread than if the syndicate were not formed by a lead. At the same time, however, the issuer's expected net proceeds are higher with a lead banker than without a lead.

²¹ The numerical analysis begins by defining net proceeds to the issuer as a function of both the syndicate size and the premium (over D_h) paid to the syndicate members, and then defining the syndicate size as a function of this premium. We can then determine the optimal premium (which, of course, is restricted to be nonnegative). The syndicate size, spread and proceeds are then calculated as functions of this premium. Figure 2 was created in Mathematica with this algorithm assuming that $\mu = 1$, $D_h = 0.5$, $D_l = 0$, and $N_p = 20$. The spread, w_1/V , ranges in value from about 33% to 9%, and V ranges in value from 6 to 250. This decreasing convex functional form was achieved for all combinations of parameter values attempted.

Figure 2 was drawn assuming the cost of exerting effort, D_h , is independent of issue size. If, instead, the cost of exerting effort is increasing with issue size (but at a slower rate than issue size), then the optimal spread would converge more quickly toward a constant as issue size increases. This prediction is consistent with the clustering of percentage underwriting spreads observed by Chen and Ritter (2000). A key insight from our analysis is that the issuing firm may prefer this outcome over a perfectly competitive setting in which it captures the entire surplus from a smaller pool of proceeds.²²

Finally, the model predicts that during hot markets, spreads for syndicates organized by a lead banker will decrease and net proceeds will increase as more activity gives the penalty function more impact. However, testing this prediction is not straightforward because in cold markets the impact of the penalty function may be so weak that for some firms it will be impossible to satisfy the nonnegative net proceeds constraint. Thus, a meaningful test of the theory will require accounting for sample truncation during cold markets.

VII. Conclusion

It strains belief that the modern syndicate survives as nothing more than a risk-sharing device. Even if this were the case, it remains difficult to explain the syndicate's transitory (albeit stable) organizational structure. In this paper, we have taken some initial steps toward a deeper understanding of the link between the economic function of the securities underwriting syndicate and its rather unusual organizational form. Our analysis sheds light on why economic efficiency might be served by competition for the designation of a lead banker, followed by cooperation in the distribution effort. We also demonstrate why limited entry and seemingly high underwriting spreads can benefit both investment bankers and issuing firms.

If investment banks are purely competitive, then one would expect the issuing firm to capture the entire surplus from its offering. However, we demonstrate that in the presence of moral hazard, first-best may be unattainable and attaining the second-best outcome may require the issuing firm to share the surplus with the syndicate. As a result, even if investment banks are otherwise purely competitive, it will be Pareto-optimal within a wide range of parameter values for entry to be restricted so that surplus can be shared with bankers included in the syndicate.

Our analysis makes no formal effort to define the legal boundaries of banking firms as evidenced by our using the terms bank and banker more or less interchangeably. However, we think it is reasonable to assert that the boundaries of production teams that comprise the underwriting capacity of a single bank are effectively defined by the limits of any single banker's ability to monitor his or her peers. We suggest that the syndicate makes possible the larger scale production teams necessary for most securities offerings by pro-

²² We make no predictions here regarding the quantitative value to which the spread may optimally converge.

viding a discrete complement to the continuous monitoring that occurs within banking firms.

If recent advances in information technology reduce the cost of monitoring and/or the industry's heavy dependence on investor relationships, the role for the syndicate described here might be substantially diminished.²³ Wit Capital, for example, essentially bypasses institutional investors in favor of establishing direct contact with individual investors. The bidding and secondary market trading behavior of these "e-syndicate" investors already is stored and monitored electronically. Even if this "relationship" with retail investors sacrifices some of the subtle information gained through traditional relationships with institutional investors, it may be more productive on a cost-adjusted basis. Although we believe that reputation will remain central to the process of financial intermediation, the net result of advances in information technology could be to substantially alter the mechanisms by which reputations are established and maintained within the industry.

Appendix

Notation

Exogenous parameters: (The exogenous parameters are all common knowledge.)

μ = price parameter that represents uncertainty about issue value

V = price parameter that represents issue size. In most of the paper, V is set to 1.

D_l = cost to a banker for exerting low level effort ≥ 0

D_h = cost to a banker for exerting high level effort $> D_l$ (When V is normalized to 1, D_l and D_h are relative to issue size.)

ρ = discount rate; ρ decreases with frequency of deals

N = number of bankers in the market

Endogenous parameters:

P = issue price (for entire issue) = total issue proceeds

M = number of bankers who exert at least low-level effort

S^* = syndicate size announced by issuer at time 1

S = number of bankers who are in the syndicate and exert high-level effort $\leq S^*$

p = probability that issue is successful. This is a function of S .

\bar{P} = expected issue price, also a function of S .

Z = net proceeds received by issuer

w_1 = total fee paid to the syndicate when issue is successful

w_0 = total fee paid to the syndicate when issue is unsuccessful

S_{fb} = first-best syndicate size

²³ See Wilhelm (1999) for further development of this argument.

S' = maximum number of bankers that can be motivated to exert high-level effort when the high-level participation constraint is exactly satisfied

y = amount above D_h paid by issuer (in expected value) per syndicate member, $y \geq 0$

S_{nl} = maximum number of bankers that can be motivated to exert high-level effort when there is restricted entry but no lead banker

S_{ld} = maximum number of bankers that can be motivated when there is restricted entry and a lead banker

S^h = optimal syndicate size from the perspective of the lead banker if the lead banker has exerted high-level effort

Ω = penalty realized by a lead banker who has exerted low-level effort

Π_h = expected revenue for exerting high-level effort in lead regime

Π_l = expected revenue for exerting low-level effort in lead regime

λ = fraction of syndicate's fee that goes to each nonlead syndicate member

Proof of Proposition 1: The proof of Proposition 1 follows from looking at equations (7) and (8). Both the high-level participation constraint and the effort constraint are eased as M is made smaller. The lower bound on M is S . Q.E.D.

Derivation of S' and proof of Proposition 2: Incentive compatibility requires that

$$\left(\frac{\mu}{S^* - 1} - \frac{\mu}{S^*} \right) (w_1 - w_0) \geq S^* (D_h - D_l) \quad (27)$$

$$\Rightarrow \mu(w_1 - w_0) \geq (S^*)^2 (S^* - 1) (D_h - D_l).$$

If the participation constraint for high-level effort is exactly satisfied, then

$$\left(1 - \frac{\mu}{S^*} \right) w_1 + \left(\frac{\mu}{S^*} \right) w_0 = S^* D_h. \quad (28)$$

It is clear from the incentive compatibility constraint that we should optimally set $w_0 = 0$. (It cannot be negative.) Thus,

$$w_1 = \frac{(S^*)^2 D_h}{S^* - \mu}. \quad (29)$$

Incentive compatibility gives

$$(S^* - \mu)(S^* - 1) \leq \frac{\mu D_h}{D_h - D_l}. \quad (30)$$

Setting this to equality to find the largest possible syndicate size when the participation constraint is binding provides the following result:

$$S'^2 - (1 + \mu)S' - \frac{\mu D_l}{D_h - D_l} = 0 \Rightarrow \quad (31)$$

$$S' = \frac{1}{2} \left(1 + \mu + \sqrt{(1 + \mu)^2 + \frac{4\mu D_l}{D_h - D_l}} \right).$$

Because the above expression represents an upper bound, first-best can be achieved if and only if $S' \geq S_{fb} = \sqrt{\mu/D_h}$.

- (1) It is clear that S' is decreasing in $D_h - D_l$. Variables D_h and D_l are both relative to issue size, so S' is independent of issue size. Variable S_{fb} is increasing in issue size.
- (2) Syndicate size can be increased only by increasing w_1 . But, if this is done, then the issuer will optimally choose a syndicate size smaller than S_{fb} . Q.E.D.

Proof of Proposition 3: If the issuer shares surplus with the syndicate, then the high-level participation constraint will be nonbinding. The incentive compatibility constraint will be binding, and satisfied with equality. The approach of this proof will be to determine the issuer's optimal syndicate size, given that equation (8) is satisfied with equality and subject to the participation constraint being satisfied. Incentive compatibility (equation (8)) satisfied with equality (and $M = S$) gives

$$w_1 = \frac{(D_h - D_l)(S^3 - S^2)}{\mu}. \quad (32)$$

The issuer's objective is

$$\begin{aligned} \max_S Z(S) &= (1 - w_1)p(S) \\ &= \left(1 - \frac{(D_h - D_l)(S^3 - S^2)}{\mu}\right) \left(\frac{S - \mu}{S}\right) \\ &= \left(\frac{1}{S} - \frac{(D_h - D_l)(S^2 - S)}{\mu}\right) (S - \mu), \end{aligned} \quad (33)$$

subject to

$$w_1 p(S) \geq D_h S \Rightarrow \frac{(D_h - D_l)(S - 1)(S - \mu)}{\mu} \geq D_h \Rightarrow S \geq S' \quad (34)$$

$$\begin{aligned} \frac{\partial Z(S)}{\partial S} &= \left(\frac{-1}{S^2} - \frac{(D_h - D_l)(2S - 1)}{\mu}\right) (S - \mu) + \frac{1}{S} - \frac{(D_h - D_l)(S^2 - S)}{\mu} \\ &= \frac{\mu}{S^2} - \frac{(D_h - D_l)((2S - 1)(S - \mu) + S^2 - S)}{\mu} \end{aligned} \quad (35)$$

$$\begin{aligned} \frac{\partial^2 Z(S)}{\partial S^2} &= \frac{-2\mu}{S^3} - \frac{(D_h - D_l)((2S - 1) + 2(S - \mu) + 2S - 1)}{\mu} \\ &= \frac{-2\mu}{S^3} - \frac{2(D_h - D_l)(3S - \mu - 1)}{\mu}. \end{aligned} \quad (36)$$

Because $S' \geq 1 + \mu$, the second derivative is clearly negative for any value of $S \geq S'$. Thus, if the expression given in equation (35) is strictly positive at $S = S'$, then there exists an optimal syndicate size $S^* > S'$. That is, if

$$D_h - D_l < \frac{\mu^2}{S'^2((2S' - 1)(S' - \mu) + S'(S' - 1))}. \quad (37)$$

The above can also be written as

$$S' \sqrt{\frac{(D_h - D_l)((2S' - 1)(S' - \mu) + S'(S' - 1))}{\mu D_h}} < \sqrt{\frac{\mu}{D_h}} = S_{fb} \quad (38)$$

$$\begin{aligned} & (2S' - 1)(S' - \mu) + S'(S' - 1) \\ &= \frac{1}{2} \left(\mu(1 - \mu) + \sqrt{(1 + \mu)^2 + \frac{4\mu D_l}{D_h - D_l}} + (1 + \mu)^2 + \frac{4\mu D_l}{D_h - D_l} \right) \\ & \quad + \frac{1}{4} \left(\mu^2 - 1 + (1 + \mu)^2 + 2\mu \sqrt{(1 + \mu)^2 + \frac{4\mu D_l}{D_h - D_l}} + \frac{4\mu D_l}{D_h - D_l} \right) \\ &= \mu + \frac{\mu D_l}{D_h - D_l} + \frac{1}{2} \left((1 + \mu) \sqrt{(1 + \mu)^2 + \frac{4\mu D_l}{D_h - D_l}} + (1 + \mu)^2 + \frac{4\mu D_l}{D_h - D_l} \right) \\ &= \frac{\mu D_h}{D_h - D_l} + S'(2S' - 1 - \mu). \end{aligned} \quad (39)$$

Thus, we can write the above condition as

$$S_{fb} > S' \sqrt{1 + \frac{(D_h - D_l)S'(2S' - 1 - \mu)}{\mu D_h}} > S'. \quad (40)$$

We next derive the second-best syndicate size, S_{nl} . The participation constraint is satisfied by setting $w_1 = S^2(D_h + y)/(S - \mu)$, where $y \geq 0$. Setting the incentive-compatibility constraint as binding and assuming that $M = S$, the largest syndicate that can be motivated is determined by

$$\begin{aligned} S_{nl}^2 - (1 + \mu)S_{nl} - \frac{\mu(D_l + y)}{D_h - D_l} &= 0 \Rightarrow \\ S_{nl} &= \frac{1}{2} \left(1 + \mu + \sqrt{(1 + \mu)^2 + \frac{4\mu \left(\frac{D_l}{D_h} + \frac{y}{D_h} \right)}{1 - \frac{D_l}{D_h}}} \right). \end{aligned} \quad (41)$$

Setting $y > 0$ is clearly more productive in increasing syndicate size when D_h decreases and μ increases. Q.E.D.

Proof of Proposition 4: The main difference between this proof and that of Proposition 3 is that we are not able to sign the second derivative here, so we can prove sufficiency only. Sufficiency proves that the parameter range in which it is Pareto-optimal to share surplus is strictly larger with a lead than without a lead. The other difference is that in this proof we optimize over the spread increment y , rather than over syndicate size. The two approaches are equivalent, but in this proof optimizing over y greatly decreases the necessary algebra.

1. We set $w_1 = S^2(D_h + y)/(S - \mu)$, where $y \geq 0$. Also, $\Omega = Sy/\rho N$. We consider only the case in which the moral hazard problem is binding, so that the incentive-compatibility constraint is binding (and the optimal syndicate size will be at least $S' = 1 + \mu$):

$$\begin{aligned} \frac{w_1 \mu}{S^2(S-1)} + \frac{\Omega}{S} &= \frac{(D_h + y)\mu}{(S - \mu)(S - 1)} + \frac{y}{\rho N} = D_h \Rightarrow \\ S^2 - (1 + \mu)S + \mu &= \frac{(D_h + y)\mu}{D_h - \frac{y}{\rho N}} \Rightarrow \\ S^2 - (1 + \mu)S - \frac{\mu y \left(1 + \frac{1}{\rho N}\right)}{D_h - \frac{y}{\rho N}} &= 0 \Rightarrow \\ S_{ld} &= \frac{1}{2} \left(1 + \mu + \sqrt{(1 + \mu)^2 + \frac{4\mu y \left(1 + \frac{1}{\rho N}\right)}{D_h - \frac{y}{\rho N}}} \right). \end{aligned} \quad (42)$$

The above is clearly greater than S_{nl} if $y > 0$ (and D_l is set = 0 in the expression for S_{nl}).

2. Thus, the issuer can do strictly better with a lead for all parameter values such that $\exists y > 0$ such that

$$Z_{ld}(y) = 1 - \frac{\mu}{S_{ld}} - S_{ld}(D_h + y) > Z' = 1 - \frac{\mu}{S'} - S'D_h \quad (43)$$

$$\frac{\partial Z_{ld}}{\partial y} = \left(\frac{\mu}{S_{ld}^2} - y - D_h \right) \frac{\partial S_{ld}}{\partial y} - S_{ld} \quad (44)$$

$$\frac{\partial^2 Z_{ld}}{\partial y^2} = -\frac{2\mu}{S_{ld}^3} \left(\frac{\partial S_{ld}}{\partial y} \right)^2 - \frac{2\partial S_{ld}}{\partial y} + \left(\frac{\mu}{S_{ld}^2} - y - D_h \right) \frac{\partial^2 S_{ld}}{\partial y^2} \quad (45)$$

$$\begin{aligned}
 \frac{\partial S_{ld}}{\partial y} &= \frac{\mu \left(\frac{\left(1 + \frac{1}{\rho N}\right)}{D_h - \frac{y}{\rho N}} + \frac{y \left(1 + \frac{1}{\rho N}\right) \frac{1}{\rho N}}{\left(D_h - \frac{y}{\rho N}\right)^2} \right)}{\sqrt{(1 + \mu)^2 + \frac{4\mu y \left(1 + \frac{1}{\rho N}\right)}{D_h - \frac{y}{\rho N}}}} \\
 &= \frac{\mu D_h \left(1 + \frac{1}{\rho N}\right)}{\left(D_h - \frac{y}{\rho N}\right)^2 (2S_{ld} - 1 - \mu)} > 0,
 \end{aligned} \tag{46}$$

where $\partial^2 S_{ld} / \partial y^2 > 0$. Thus, we are not able to prove necessity, but we do have sufficiency, so that if $(\partial Z_{ld} / \partial y)|_{y=0} > 0$, then we know that $\exists y > 0$ such that $Z_{ld}(y) > Z'$. Thus,

$$\frac{\partial Z_{ld}}{\partial y} = \left(\frac{\mu}{(S_{ld})^2} - y - D_h \right) \frac{\mu D_h \left(1 + \frac{1}{\rho N}\right)}{\left(D_h - \frac{y}{\rho N}\right)^2 (2S_{ld} - 1 - \mu)} - S_{ld}. \tag{47}$$

Using the fact that $S_{ld}|_{y=0} = S' = 1 + \mu$:

$$\begin{aligned}
 \left. \frac{\partial Z_{ld}}{\partial y} \right|_{y=0} &= \left(\frac{\mu}{(S')^2} - D_h \right) \frac{\mu \left(1 + \frac{1}{\rho N}\right)}{D_h (2S' - 1 - \mu)} - S' \\
 &= \frac{\mu^2 \left(1 + \frac{1}{\rho N}\right)}{D_h (1 + \mu)^3} - \frac{\mu \left(1 + \frac{1}{\rho N}\right)}{1 + \mu} - (1 + \mu)
 \end{aligned} \tag{48}$$

$$\left. \frac{\partial Z_{ld}}{\partial y} \right|_{y=0} > 0 \Leftrightarrow D_h < \frac{\mu^2 \left(1 + \frac{1}{\rho N}\right)}{(1 + \mu)^2 \left(\mu \left(1 + \frac{1}{\rho N}\right) + (1 + \mu)^2 \right)}. \tag{49}$$

Equation (49) is a sufficient equation such that the issuer strictly prefers paying more than the reservation value D_h . This condition is clearly less restrictive than equation (37) given in the proof of Proposition 3. (Again assuming that $D_l = 0$.) Q.E.D.

Proof of Proposition 5: We know that $S_{ld} \geq 1 + \mu$, thus equation (15) gives

$$\lambda \leq \frac{\mu}{(S_{ld})^2 - \mu} = \frac{1}{\frac{(S_{ld})^2}{\mu} - 1} \leq \frac{1}{\frac{S_{ld}(1 + \mu)}{\mu} - 1} = \frac{1}{S_{ld} + \frac{S_{ld}}{\mu} - 1} < \frac{1}{S_{ld}}. \quad (50)$$

Note: This result is only strengthened if $D_l > 0$. Q.E.D.

Proof of Proposition 6: (1) When we reintroduce V , the functional forms for S_{nl} and S_{ld} are unchanged. For any given value of y , they are both independent of V . However, the issuer's optimal function is affected: $Z(y) = V - [\mu V/S(y)] - S(y)(y + D_h)$. If the condition holds such that there is a strictly positive optimal value of y , then in the no-lead case the optimal value of y is the lowest positive value of y that satisfies

$$\frac{\partial Z_{nl}(y)}{\partial y} = 0 \Rightarrow V - \frac{(D_h + y)(S_{nl})^2}{\mu} - \frac{D_h(S_{nl})^3(2S_{nl} - 1 - \mu)}{\mu^2} = 0, \quad (51)$$

where S_{nl} is an increasing function of y . (We write this equation assuming $D_l = 0$, but it makes no difference for the results here. We also apply the fact that $(\partial S_{nl}/\partial y)|_{D_l=0} = \mu/(D_h(2S_{nl} - 1 - \mu))$.) Let y^* be the optimal value of y . y^* is clearly increasing in V .

In the lead case, we will assume that ρN is large enough so that $\partial^2 Z_{ld}/\partial y^2$ is negative throughout the range $S(y) \in (S', S_{fb})$. This ensures that the optimality condition is well defined. Applying results from the Proof of Proposition 4, the optimal value of y satisfies

$$\begin{aligned} \frac{\partial Z_{ld}(y)}{\partial y} = 0 \Rightarrow \\ V - \frac{(D_h + y)(S_{ld})^2}{\mu} - \frac{\left(D_h - \frac{y}{\rho N}\right)^2 (S_{ld})^3(2S_{ld} - 1 - \mu)}{\mu^2 D_h \left(1 + \frac{1}{\rho N}\right)} = 0, \end{aligned} \quad (52)$$

where S_{ld} is an increasing function of y . The optimal value of y , y^* , as determined by equation (52), is again increasing in V .

(2) This follows directly from equations (37) and (49). When V is no longer normalized to one, D_h and D_l are replaced with D_h/V and D_l/V . Q.E.D.

REFERENCES

- Aggarwal, Reena, 2000, Stabilization activities by underwriters after new offerings, *Journal of Finance* 55, 1075–1103.
- Alchian, Armen, and Harold Demsetz, 1972, Production, information costs, and economic organization, *American Economic Review* 62, 777–795.
- Anand, Bharat N., and Alexander Galetovic, 2000, Information, nonexcludability, and financial market structure, *Journal of Business* 73, 357–402.

- Benveniste, Lawrence M., Walid Y. Busaba, and William J. Wilhelm, 1996, Price stabilization as a bonding mechanism in new equity issues, *Journal of Financial Economics* 42, 223–255.
- Benveniste, Lawrence M., Walid Y. Busaba, and William J. Wilhelm, 2002, Information externalities in primary equity markets, *Journal of Financial Intermediation*, forthcoming.
- Benveniste, Lawrence M., Sina Erdal, and William J. Wilhelm, 1998, Who benefits from price stabilization of initial public offerings? *Journal of Banking and Finance* 22, 741–767.
- Benveniste, Lawrence M., and Paul A. Spindt, 1989, How investment bankers determine the offer price and allocation of new issues, *Journal of Financial Economics* 24, 343–362.
- Booth, James R., and Richard L. Smith, 1986, Capital raising, underwriting and the certification hypothesis, *Journal of Financial Economics* 15, 261–281.
- Carosso, Vincent P., 1970, *Investment Banking in America: A History* (Harvard University Press, Cambridge, MA).
- Chemmanur, Thomas J., and Paolo Fulghieri, 1994, Investment bank reputation, information production, and financial intermediation, *Journal of Finance* 49, 57–79.
- Chen, Hsuan-Chi, and Jay Ritter, 2000, The seven percent solution, *Journal of Finance* 55, 1105–1131.
- Chowdhry, Bagwhan, and Vikram Nanda, 1996, Stabilization, syndication and pricing of IPOs, *Journal of Financial and Quantitative Analysis* 31, 25–42.
- Christenson, Charles, 1965, *Strategic Aspects of Competitive Bidding for Corporate Securities* (Division of Research, Graduate School of Business Administration, Harvard University, Boston, MA).
- Dewing, Arthur S., 1934, *The Financial Policy of Corporations*, 3rd ed., (The Ronald Press Co., New York).
- Dewing, Arthur S., 1953, *The Financial Policy of Corporations*, vol. II, 5th ed. (The Ronald Press Co., New York).
- Eccles, Robert G., and Dwight B. Crane, 1988, *Doing Deals* (Harvard Business School Press, Boston, MA).
- Gorton, Gary, and Bruce Grundy, 1997, Executive compensation and the boundary of the firm: The case of short-lived projects, Working paper, University of Pennsylvania.
- Holmström, Bengt, 1982, Moral hazard in teams, *Bell Journal of Economics* 13, 324–340.
- Klein, Benjamin, and Keith B. Leffler, 1981, The role of market forces in assuring contractual performance, *Journal of Political Economy* 89, 615–641.
- Lazear, Edward P., and Sherwin Rosen, 1981, Rank-order tournaments as optimum labor contracts, *Journal of Political Economy* 89, 841–864.
- Lee, Inmoo, Scott Lochhead, Jay Ritter, and Quanshui Zhao, 1996, The costs of raising capital, *Journal of Financial Research* 19, 59–74.
- Mandelker, Gershon, and Artur Raviv, 1977, Investment banking: An economic analysis of optimal underwriting contracts, *Journal of Finance* 32, 683–694.
- Nanda, Vikram, and Youngkeol Yun, 1997, Reputation and financial intermediation: An empirical investigation of the impact of IPO mispricing on underwriter market value, *Journal of Financial Intermediation* 6, 39–63.
- Persons, John C., and Vincent A. Warther, 1997, Boom and bust patterns in the adoption of financial innovations, *Review of Financial Studies* 10, 939–968.
- Rock, Kevin, 1986, Why new issues are underpriced, *Journal of Financial Economics* 15, 187–212.
- Ross, Stephen A., Ross W. Westerfield, and Jeffrey Jaffe, 1999, *Corporate Finance*, 5th ed. (Irwin McGraw-Hill, Boston, MA).
- Supple, Barry E., 1957, A business elite: Geman-Jewish financiers in nineteenth-century New York, *The Business History Review* 31, 143–178.
- Wilhelm, William J., 1999, Internet investment banking: The impact of information technology on relationship banking, *Journal of Applied Corporate Finance* 12, 21–27.
- Wilson, Robert, 1968, The theory of syndicates, *Econometrica* 36, 119–132.