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Information Externalities and the Role of Underwriters in Primary Equity Markets[1]

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Firms that go public produce information that influences the production decisions of their rivals as well as their own production decisions. If information-production costs are borne primarily by pioneering firms, market failures can occur in which both pioneers

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and followers remain private and make ill-informed investment decisions. Solving this coordination problem requires a transfer between pioneers and followers that leads to a more equitable distribution of information-production costs. We contend that investment banks can enforce such a transfer by effectively bundling IPOs within an industry. This suggests an explanation for clustering of IPOs through time and within industries. *Journal of Economic Literature* Classification Numbers: G24, G28, K32.

1. INTRODUCTION

Because it marks the activation of a two-way information channel, the initial public offering of equity (IPO) is perhaps the most important public information event in the life of a firm. A firm entering the public domain must provide for broad dissemination of information regarding its performance and prospects, and in return it receives feedback from investors. Negative feedback, for example, often leads to withdrawal of the stock offering and subsequent revisions to investment and production decisions.[2] Presumably, such feedback, whether positive or negative, will be particularly valuable to a firm pioneering in a nascent industry or a new technology.

But primary market feedback is costly to obtain and highly visible. As such, other firms within the industry or developing the same technology enjoy an *information externality*. If pioneering firms internalize the bulk of the costs of information production but not the benefits, they may refrain from entering the public market in the first place. In the extreme, this coordination problem can lead both potential pioneers and followers to neglect or undertake at unnecessarily high cost positive net present value (NPV) projects or even accept negative NPV projects.

If this is a serious problem, one might expect institutions capable of enforcing a more equitable distribution of the initial information-production costs to evolve in the marketplace. The question we pose in this paper is whether such institutions exist and, if they do, how they resolve the problem. We argue that the structure of the investment banking industry in the United States endows bankers with the power necessary to solve the free rider problem. Longstanding relationships with concentrated investor pools enable investment banks to act as gatekeepers, bundling the IPOs of firms subject to a common valuation factor for presentation to a common investor pool.[3] By taxing the follower firms as they attempt to go public, banks can force firms that would otherwise free-ride to share in the cost of information production.

[2] Dunbar (1998) finds that 29% of the firm-commitment offerings registered with the SEC in a sample drawn from 1979 to 1982 were terminated prior to receiving SEC approval. Benveniste and Busaba (1996) report a 14% termination rate for firm-commitment offerings registered between 1988 and 1994, and Busaba *et al*. (2001) observe a similar rate for the 1984–94 period.

[3] The suggestion that banks effectively bundle a stream of related securities offerings is analogous to Tufano's (1989) observations about the process of financial innovation. In a sample of 58 financial innovations from 1974 to 1986, he finds that pioneering banks charge lower spreads, perhaps as an inducement for issuers and investors to execute the first transaction (p. 229), but capture larger underwriting revenues by underwriting more of the subsequent deals spawned by their innovation.

Even if bundling is possible, however, enforcing a transfer from followers to the pioneering firm is nontrivial. Followers may benefit from observing the outcome of the pioneer's IPO whether or not they too attempt a public offering. The underwriter cannot force followers to attempt a public offering, but it is only when an offering is attempted that a tax can be levied against them. A threat of aggressive taxation in states where followers are expected to attempt public offerings simply increases the likelihood that a follower will avoid attempting an IPO when it otherwise would have.

By highlighting a previously unrecognized intermediary role for investment banks, our analysis sheds light on a connection, hinted at by Pagano (1993), between the institutional design of an economy's primary equity market and the organization of its financial system.[4] However, we extend the literature by identifying institutional mechanisms capable of mitigating coordination problems that may inhibit financial system development. Thus our analysis provides a bridge between recent efforts to understand the forces that influence the firm's decision to go public and the growing interest in the relative merits of alternative financial system architectures.[5]

Our work is also related to recent papers by Subrahmanyam and Titman (1999) and Persons and Warther (1997). Subrahmanyam and Titman argue that the nature and cost of investor information determine whether public or private markets are more efficient in allocating resources. When information is serendipitous and free, public markets are more efficient. When information is predominantly costly, superior resource allocation may be achieved through private markets where the benefits of information production are more fully internalized.

In contrast to Subrahmanyam and Titman (1999), we do not compare private and public equity markets. Instead, we examine the frictions that face firms in new industries when they attempt to access existing public markets. However, our analysis sheds new light on the issues discussed in Subrahmanyam and Titman. In our model of the process of going public, primary market investors benefit from costly information production when they receive large allocations in underpriced IPOs. This tilts the balance in favor of public markets. The issuing firm benefits from going public because the IPO can increase the firm's visibility, the volume of business, and the liquidity of its equity, as well as because

[4] Extreme cross-sectional and time-series variation in the size of national stock markets and the general underdevelopment of European equity markets (exceptions being the United Kingdom, Switzerland, Sweden, and the Netherlands) leads Pagano to suggest that a firm's management may be unwilling to bear the costs of going public because it is unable to fully internalize the benefits of its marginal contribution to diversification opportunities within the economy. In the absence of a solution to the coordination problem created by this diversification externality, an economy may remain in a bad equilibrium in which relatively few firms enter the public arena.

[5] See Chemmanur and Fulghieri (1999), Maksimovic and Pichler (2000), Pagano (1993), Pagano and Roell (1998), and Zingales (1995) for discussion of the going public decision. Allen and Gale (1995, 1999), Boot and Thakor (1997), Dow and Gorton (1997), and Kahn and Winton (1998) consider the relative merits of financial systems organized around stock markets and those organized around banks.

investment decisions are then conditioned on more information. Finally, social welfare is enhanced if the investment decisions of firms related by a common valuation factor benefit from the information generated by the issuing firm's IPO. The coordinating role of the investment banker in achieving these benefits suggests that there is more than serendipity underlying a vibrant primary equity market. Rather, the structure of an economy's institutions is the driving force—given sufficient market power, an investment bank can spread the costs of information production over many firms, reducing the disincentive of any one of them to go public.

Persons and Warther study the externality created by a firm pioneering the adoption of a financial innovation. The externality is enjoyed by firms that costlessly learn (with some noise) about the value of the innovation from observing the outcome of the adoption by the pioneer. Followers then decide whether to adopt the innovation themselves conditional on the pioneer's experience. In this setting, inefficiency associated with underinvestment in financial innovation is not surprising. Persons and Warther suggest that, given sufficient market power, an intermediary can diminish the underinvestment problem. In our model, followers learn not only about the cost of public equity (the analog of the financial innovation in Persons and Warther) but also about the viability of their own investment plan and business strategy. This latter benefit is realized even if the followers choose not to adopt the innovation—that is, even if they continue to rely on private finance or simply refrain from going forward on a project. This distinguishing feature of our model has rather important implications regarding the intermediary's capacity for promoting social welfare.

Our model also differs in that attempting an IPO provides useful information to the adopting firm itself. Conditional on a weak investor reception to its own offering, the issuing firm might optimally decide to cancel the offering and abandon its investment plans. This *option-to-abandon* leads the follower firm in our model to sometimes attempt an IPO even when the outcome of the pioneer's IPO is less than encouraging and to sometimes finance with private funding even when the pioneer's IPO is a success. This is in contrast to Persons and Warther's analysis in which a successful adoption of an innovation can only lead to more adoptions by the follower firms. Consideration of this added benefit to attempting an IPO provides for a richer, and we believe more realistic, characterization of the coordination problem facing the investment bank.

Our analysis provides both necessary and sufficient conditions under which an intermediary can resolve the coordination problem. We also provide some casual evidence regarding the existence of these conditions in the marketplace. Finally, we generate a set of unique hypotheses arising from the interplay between the option-like features of the decision to go public and the intermediary role of the investment bank. Tests of these hypotheses have the potential for shedding new light on both the time variation in IPO initial returns and the widely observed clustering of IPOs through time and within industries.

2. THE MODEL

To make things concrete, it is useful to think of our model as abstracting from the market conditions facing Netscape prior to its August 1995 IPO. Although there was considerable interest in commercial applications for the Internet, there was great uncertainty surrounding both the shape that such applications might take and their potential profitability. Moreover, there were few publicly-traded firms with business strategies focused on Internet-related activities. Thus there was limited potential for information production through the secondary equity markets, but great demand for such information by both Netscape and other potential Internet startups. Faced with this highly uncertain environment, the extraordinarily positive reception for Netscape's IPO surely affirmed Netscape management's perception of its investment opportunities.[6] However, it just as surely diminished any doubts the other startups may have had about the market's perception of the viability of efforts to develop commercial applications for the Internet. Consistent with this argument, the market witnessed a wave of Internet-related IPOs following in the wake of Netscape's offering.[7]

Our model abstracts from this example by considering two privately-held firms within the same industry. We focus on the free-rider problem by assuming that the firms are identical from an *ex ante* perspective. In other words, a common technology defines the industry. We ignore the consequences of rivalry between the firms in the sense that the production decision and associated profitability of one firm do not depend on those of the other.[8] Moreover, we simply assume a natural ordering for the two firms. Firm 1 makes its financing–investment decision first. Firm 2 observes the outcome of the first firm's decision and makes its own financing–investment decision accordingly. This ordering could be a reflection of the relative maturity of the two firms or (unmodeled) strategic considerations. We abstract from the origin of this ordering and treat it as exogenous.

The value of each firm is determined by a project requiring an investment of K dollars. The realization of the market value of a firm's project depends on two factors: an industry factor common to both firms and a firm-specific (idiosyncratic) factor. We assume that each factor is normally distributed and that the two factors are distributed independent of one another. The common industry factor, represented by i, has a prior distribution that is normal with mean I_1 and variance τ_1^2.

[6] Netscape's first-day closing price of \$58.25 yielded a one-day return in excess of 100% for those purchasing shares at the offer price of \$28.00. The large implied discount in association with a strong positive reception for the offering is consistent with the use of discounts in the acquisition of private information. See Benveniste and Wilhelm (1997) for a review of the relevant literature.

[7] Casual observation suggests that such clustering is common. For example, of the 15 trucking-industry (SIC code: 4200 – 4210) IPOs completed between 1990 and 1994, 10 were completed in the 14-month period running from September 1993 through November 1994.

[8] In contrast, Maksimovic and Pichler (2000) allow firms to choose between two technologies and focus on the interaction between competitive conditions within the industry and the timing of individual firm decisions to go public.

Firm j's ($j = 1, 2$) idiosyncratic factor, represented by f_j, has an expected value of zero and a known variance σ_f^2. The realization of firm j's market value, V_j, is just the sum of the industry factor and the firm's idiosyncratic factor, or

$$V_j = i + f_j. \tag{1}$$

Thus, the unconditional expected value for each firm is normally distributed with mean I_1 and variance $\sigma_1^2 = (\tau_1^2 + \sigma_f^2)$.

Each firm has two, mutually exclusive, alternative sources of financing for its project: a firm may sell its entire equity stake to the public or it may finance its assets through private sources (and remain privately held). We envision private financing as a combination of privately placed equity or debt, bank debt, and/or venture capital. Alternative financing is a reality for most firms and within our model it accounts for many of the subtle but important distinctions between our conclusions about information externalities and those of Persons and Warther (1997).

Going public confers a variety of benefits on the firm. We capture this by assuming that the opportunity cost of remaining private is a linear function of the value of the firm's assets so that the value of firm j as a private entity is $(1 - \alpha)V_j,\ 0 \leq \alpha \leq 1$.[9] The widely acknowledged liquidity and diversification benefits of being public are clearly increasing in firm size. For our purposes, however, we contend that there are perhaps more important benefits that lend themselves to this functional form. Specifically, we might think of α as reflecting the benefits of increased visibility and/or the ability to scale up production more rapidly than a competitor. The latter benefit might be particularly important to a firm in an industry, such as the computer software industry, where establishing an industry standard can lead to a virtually insurmountable competitive advantage. One might also imagine consumer products firms or restaurant chains, for example, deriving benefits from increased visibility. In either case, if a pioneering firm gains a competitive edge from entering the public arena first, we would expect α to vary within as well as across industries. We consider the empirical implications of cross-sectional variation in α in Section 6.

If the firm opts for public financing, it either completes its public offering and finances its project or, conditional on information revealed during the course of the marketing effort, terminates its offering and declines the project. In either case, the firm bears a fixed cost, $F > 0$, reflecting the various due diligence and legal costs associated with registration and preparation of the prospectus as well as the opportunity cost of diverting management attention from day-to-day operations. (Characterizing F as being the same for the pioneer and the follower firms simplifies the notation without sacrificing the generality of the results.)

[9] We considered the case when there is also a fixed component to the opportunity cost of staying private, that is, when the cost is $\alpha V_j + b$. None of our results changed, however.

We assume that for the first firm in the industry to attempt a public offering, investors, in aggregate, must bear a fixed cost, C, to participate.[10] The participation cost reflects investor opportunity cost and the cost of producing information about both the firm and the industry. The marginal cost of participating in the second firm's offering is less than C, reflecting the fact that some information about the common industry factor is already available at that time. (The information cost can in general be modeled as an increasing function of the uncertainty about the value of a firm, which is less for the second firm, as we demonstrate below, once the first firm attempts an IPO.) For simplicity and without loss of generality, we assume that investors' marginal cost of participating in the second firm's IPO is zero.

If the first firm attempts a public offering (whether it is completed or terminated), the realization of V_1 becomes public information.[11] The second firm can then condition its investment decision and whether it goes public on this information. Under these circumstances, the investment–financing decision of the second firm is conditioned on superior information to that of the first firm. Specifically, upon observation of V_1, the prior distribution of i is revised such that the second firm observes a posterior distribution that is normal with mean I_2 and variance τ_2^2 where

$$I_2 = I_1 + (V_1 - I_1)\left[\tau_1^2 / \left(\tau_1^2 + \sigma_f^2\right)\right],$$

and

$$1/\tau_2^2 = 1/\tau_1^2 + 1/\sigma_f^2.$$

It follows that the conditional distribution of V_2, $(\tilde{V}_2 \mid V_1)$, is normal with mean I_2, and variance σ_2^2, where $\sigma_2^2 = \tau_2^2 + \sigma_f^2$. (Note that $\sigma_2^2 < \sigma_1^2$ since $\tau_2^2 < \tau_1^2$.)

Three courses of action can be adopted by the second firm conditional on V_1. The firm may simply choose not to finance its project, in which case its value is zero, or the firm may choose to finance its project as a private entity, in which case its expected value is

$$E(\mathrm{NPV}_2 \mid V_1; \text{private}) = (1 - \alpha)E(V_2 \mid V_1) - K,$$

where $E(V_2 \mid V_1) = I_2$. And finally, the firm may choose to attempt a public offering, in which case its expected value is

[10] We gain much clarity and sacrifice little generality by abstracting from the incentive problems analyzed by Benveniste and Spindt (1989), Benveniste and Wilhelm (1990), Benveniste *et al.* (1996), and Benveniste and Busaba (1997) that make the acquisition of information from potential investors costly. We provide a more complete description of the implications of costly information acquisition in Section 5. Busaba (2000) provides a theoretical analysis of the connection between a firm's option to cancel an IPO and the cost of information acquisition, and Busaba *et al.* (2001) provide empirical analysis.

[11] Assuming that V_1 becomes public simplifies the exposition but is not necessary for the results. All that is needed is that the second firm learns something from the outcome of the first firm's IPO.

$$E(\mathrm{NPV}_2 \mid V_1; \text{public}) = \int_K^{+\infty} [V_2 - K] n(V_2 \mid V_1)\, dV_2 - F,$$

where $n(V_2 \mid V_1)$ is the normal probability density function of V_2 conditional on V_1, and the lower limit of the integral reflects the fact that the firm will terminate its offering if it infers from investor feedback that $V_2 < K$. One benefit to attempting an IPO is that the firm learns the market value of its project prior to undertaking investment. This allows the firm to avoid negative conditional expected NPV investments in assets that appeared profitable *ex ante* or to undertake positive conditional expected NPV projects that appeared unprofitable *ex ante*.

The expected value of the second firm conditional on observing the first firm's attempted public offering is therefore:

$$\int_{-\infty}^{+\infty} \max\left\{0, (1-\alpha)E(V_2 \mid V_1) - K, \int_K^{+\infty} [V_2 - K] n(V_2 \mid V_1)\, dV_2 - F\right\} n(V_1)\, dV_1. \tag{2}$$

Were the second firm to ignore or not observe V_1, its investment–financing decisions would depend only on the prior distribution of the industry factor. With private financing, its expected NPV would be

$$(1 - \alpha) I_1 - K, \tag{3}$$

where I_1 represents $E(V_2)$ *a priori*. Similarly, attempting a public offering without the benefit of observing the first firm's offering attempt yields an expected value of

$$\int_K^{+\infty} [V_2 - K] n(V_2)\, dV_2 - F, \tag{4}$$

where $n(\cdot)$ denotes the prior normal probability density function with mean I_1 and variance σ_1^2. (When it is optimal for firm 2 to attempt an IPO *a priori*, it would have been optimal for the identical firm 1 to do the same; the information cost, C, would already be sunk at the time firm 2 attempts an IPO.) Finally, if the second firm abandons its investment opportunity, its value is zero. Therefore, the second firm's expected value is max{0, (3), (4)} when it does not condition its investment–financing decisions on V_1.

3. A STATE-CONTINGENT CHARACTERIZATION OF THE INFORMATION EXTERNALITY

Thus it is obvious that an attempt by firm 1 to go public provides an information externality to the second firm. The externality is valuable when firm 2 alters its behavior conditional on the outcome of the first firm's IPO. In this section, we provide a detailed characterization of expression (2) by studying how firm 2 conditions its investment and financing decisions on its knowledge of V_1. This characterization is necessary for understanding the conditions for an intermediary to resolve the coordination problem facing the two firms. Moreover, it provides the foundation for many of the empirical predictions that we discuss later. (The decisions of the first firm and the related discussion of the coordination problem are presented in Section 4.)

We start by characterizing the values of $E(\text{NPV}_2 \mid V_1;\ \text{private})$ and $E(\text{NPV}_2 \mid V_1;\ \text{public})$ as functions of V_1.

LEMMA 1.

- *$E(NPV_2 \mid V_1; private)$ is linear and increasing in V_1.*
- *$E(NPV_2 \mid V_1; public)$ is increasing and convex in V_1.*[12] *The function approaches a minimum of –F as V_1 approaches $-\infty$.*

Proof. See the Appendix.

Figure 1 depicts the functions $E(\text{NPV}_2 \mid V_1; \text{private})$ and $E(\text{NPV}_2 \mid V_1; \text{public})$ and therefore expression (2). We illustrate the widest range of possible outcomes by considering the case where $E(\text{NPV}_2 \mid V_1; \text{public})$ crosses $E(\text{NPV}_2 \mid V_1; \text{private})$ at values of V_1 greater than V_1' (where $E(\text{NPV}_2 \mid V_1';\ \text{private}) = 0$) and define the lower and upper crossover points as V_L and V_U.[13]

Expression (2) is reflected in the envelope established by the horizontal axis in region I, $E(\text{NPV}_2 \mid V_1; \text{public})$ in regions II, III, and V and $E(\text{NPV}_2 \mid V_1; \text{private})]$ in region IV. In region I, $E(\text{NPV}_2 \mid V_1; \text{private})$ is negative and the second firm will not fund its investment privately. Moreover, the response to the first firm's

[12] Ignoring the constant F, $E(\text{NPV}_2 \mid V_1; \text{public})$ is quite similar to an ordinary call option. The primary differences are that we assume that V_2 is normally rather than lognormally distributed and the fact that we have ignored the time value of money.

[13] Figure 1 represents one set of assumptions regarding the relative magnitudes of F and α. An increase in F produces a downward shift in $E(\text{NPV}_2 \mid V_1; \text{public})$. A decrease in α causes $E(\text{NPV}_2 \mid V_1; \text{private})$ to shift to the left and exhibit a steeper slope. Thus, increasing F and/or decreasing α widens the range over which private finance dominates public finance. In extreme cases, V_L drops below V_1' and $E(\text{NPV}_2 \mid V_1; \text{public})$ becomes negative for all realizations of V_1 below V_L. Similarly, as α approaches zero, V_U approaches infinity and it will no longer be optimal to bear the fixed cost F of a public offering even when V_1 is large. Under such circumstances the second firm will either not invest or it will fund its project privately. In contrast, as F diminishes and/or α increases, the likelihood that the second firm will attempt a public offering, conditional on V_1, increases. In the extreme, $E(V_2 \mid V_1; \text{public})$ will be greater than $E(V_2 \mid V_1; \text{private})$ for all realizations of V_1. In this case, if the second firm funds its project, it will only do so with public funding.

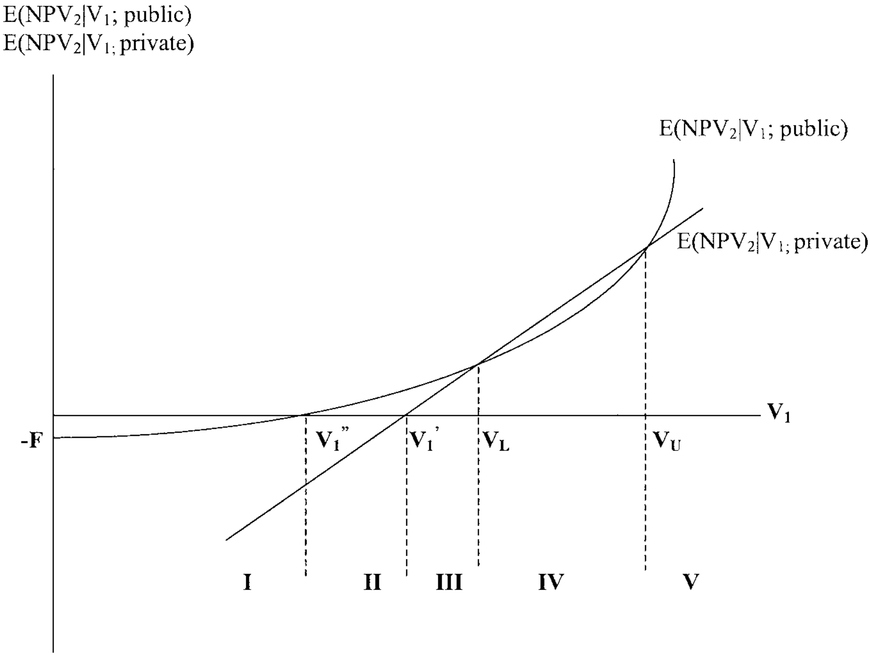

FIG. 1. Expected NPV of firm 2 as a function of the outcome of firm 1's IPO. $E(\mathrm{NPV}_2 \mid V_1; \text{public})$ represents the expected value function if firm 2 chooses to finance with public equity. $E(\mathrm{NPV}_2 \mid V_1; \text{private})$ is the expected value under private financing.

IPO is sufficiently weak to deter the second firm from bearing the fixed cost F of collecting additional information through its own IPO. Thus, in this region the second firm simply will not invest and its expected value is zero.

The second firm will attempt a public offering if V_1 falls in regions II and III. The difference between these two regions lies in the fact that investment would not be undertaken with private funding in region II, but would be in region III. The dominance of public finance in these regions results from the ability to discover the value of a project via an IPO prior to undertaking investment. Though V_1 is still low in region II, the conditional likelihood that V_2 exceeds K is high enough to justify paying F to explore the value of the project. Attempting an IPO in region III is a lower-risk strategy than financing the project privately, since the firm can abandon investment if the project is discovered to have a negative NPV (i.e., if $V_2 < K$), which remains a distinct possibility in this region.

In general, $E(\mathrm{NPV}_2 \mid V_1; \text{public}) - E(\mathrm{NPV}_2 \mid V_1; \text{private})$ can be stated as

$$\int_{-\infty}^{K} [K - V_2] n(V_2 \mid V_1)\, dV_2 + \int_{-\infty}^{+\infty} \alpha V_2 n(V_2 \mid V_1)\, dV_2 - F,$$

illustrating the two advantages of attempting an IPO relative to private financing

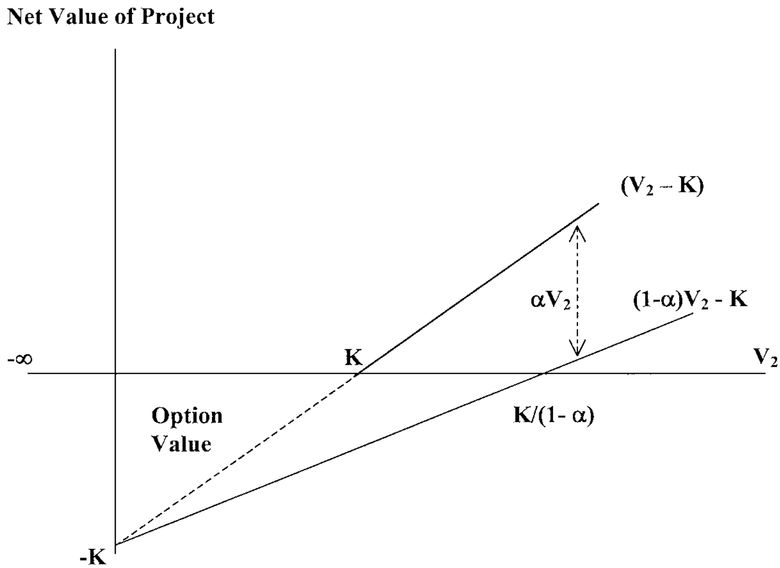

FIG. 2. The advantages of attempting an IPO relative to investing with private financing, as a function of the market value of the assets. The function $\max(V_2 - K, 0)$, depicted by the horizontal axis to the left of K and the line $(V_2 - K)$ to the right, is the net value of the project under public financing. The straight line with equation $(1 - \alpha)V_2 - K$ depicts the net value under private financing.

(see Fig. 2). The first term reflects the value of the option to abandon negative NPV projects, while the second term represents the reduction in the cost of equity capital when equity is publicly traded. (The fixed cost of attempting an IPO is F.) Region IV in Fig. 1 represents realizations of V_1 based on which private financing dominates public financing for the second firm. As the likelihood of the firm discovering a negative NPV project is smaller for larger values of V_1, the option to abandon loses value in region IV and so does the relative advantage of attempting an IPO. Moreover, the benefits of publicly traded equity are still not high enough in this region to justify incurring the cost F of attempting a public offering. Realizations of V_1 in region V, on the other hand, imply tremendous benefits associated with having equity publicly traded. Dominance returns to public finance in this region.

The fact that no single financing–investment policy dominates for every realization of V_1 suggests that firm 2 benefits from conditioning its decisions on information revealed through firm 1's IPO. The optimal unconditional financing–investment policy—characterized by max{0, (3), (4)}—is suboptimal conditional on some realizations of V_1. The following theorem formalizes this result.

THEOREM 1. *The second firm benefits from observing the first firm's IPO. The second firm's expected value conditional on observing the first firm's IPO is higher than its expected value if it makes financing–investment decisions unconditionally. That is*, (2) $>$ max{0, (3), (4)}.

4. THE COORDINATION PROBLEM

The preceding analysis illustrates that followers can reap benefits from observing the outcome of a pioneering firm's IPO. Thus, even if the private benefits associated with the first firm attempting an IPO are nonpositive, social welfare may be best served by having it do so. Unfortunately, investors will participate only if they are compensated for bearing the cost of information production, C. If the firms approach the market independently, the first firm will therefore be forced to bear the entire burden of information production. As a result, the firm will attempt a public offering if and only if the incremental benefit of doing so outweighs the cost of information production. Noting that the first firm makes its investment–financing decisions based on the prior information about the industry factor, the firm's condition to attempt an IPO can be written as

$$(4) - \max\{(3), 0\} - C > 0. \tag{5}$$

If condition (5) is violated, firm 1 refrains from attempting an IPO and firm 2 loses the related information externality. Since firms 1 and 2 are identical *ex ante*, going public will not be a viable option for firm 2 when (5) is violated (because firm 2 will have to pay for investor participation in this case). Hence, the expected value of the firm will be max{(3), 0} and the lost externality is characterized in the following lemma.

LEMMA 2. *The externality that will be lost when firm* 1 *fails to attempt an IPO is the difference between the second firm's conditional expected value and the firm's expected value if it chooses a priori between abandoning the project or investing with private finance. Formally, the lost externality is* (2) − max{(3), 0} *where for* (3) > 0 (*i.e., when private finance dominates a priori*), *the lost externality is given by*

$$\begin{aligned}
&\int_{-\infty}^{V_1''} \{-(1-\alpha)E(V_2 \mid V_1) + K\} n(V_1)\, dV_1 \\
&+ \int_{V_1''}^{V_L} \left\{ \int_K^{+\infty} [V_2 - K] n(V_2 \mid V_1)\, dV_2 - F - [(1-\alpha)E(V_2 \mid V_1) - K] \right\} n(V_1)\, dV_1 \\
&+ \int_{V_U}^{+\infty} \left\{ \int_K^{+\infty} [V_2 - K] n(V_2 \mid V_1)\, dV_2 - F - [(1-\alpha)E(V_2 \mid V_1) - K] \right\} n(V_1)\, dV_1,
\end{aligned} \tag{6}$$

where V_1'' *is such that* $E(\mathrm{NPV}_2 \mid V_1 = V_1''; \textit{public}) = 0$. (*See Fig.* 1.)

When, based on prior information, the second firm would have refrained from funding its project (i.e., when (3) < 0), the information produced by the first firm's

IPO will cause there to be states in which the second firm will either attempt an IPO or (conditionally) fund its project privately. The magnitude of this benefit is given by (2).

When, based on prior information, the second firm would have funded its project privately (i.e., when (3) > 0), the information externality that will be lost if firm 1 fails to attempt an IPO is given by expression (6). The first line of the expression represents the lost ability (in region I of Fig. 1) to avoid investment in negative conditional expected NPV projects that unconditionally appeared to have positive NPV. The second and third lines indicate the lost benefits when public financing conditional on V_1 dominates private finance (which happens in regions II, III, and V).

Since firm 2 loses when firm 1 fails to attempt an IPO, it is possible in theory to put in place a mechanism through which firm 2 subsidizes the attempt to go public by firm 1. In this respect, consider a central planner who is capable of fully internalizing both the costs and the benefits of information production and who then acts on behalf of the two firms to maximize social welfare.[14] Since the two firms are identical *a priori*, the planner weighs the social welfare associated with taking firm 1 public against that associated with having both firms rely on private financing or simply not investing. Social welfare associated with taking firm 1 public is the sum of firm 1's expected value when it attempts a public offering (expression (4)) plus firm 2's expected value conditional on firm 1 attempting a public offering (expression (2)), less the information-production cost, C. If the planner elects not to take firm 1 public, both firms have the same expected value of max{(3), 0}. Thus, the planner will take firm 1 public if and only if

$$\{(4) - \max[(3), 0]\} + \{(2) - \max[(3), 0]\} - C > 0. \tag{7}$$

In contrast to firm 1's individual decision rule, the planner's takes into consideration the information externality that will be lost if firm 1 fails to attempt an IPO, given by (2) $-$ max{(3), 0}. If the value of the externality is large enough, there may be circumstances in which a planner would take firm 1 public (as (7) is satisfied) but in which the firm itself would be unwilling to attempt a public offering (as (5) is violated). The value of the externality in these circumstances would dominate expected net losses to firm 1 that stem from the firm's need to pay the information cost, C, or sometimes from (4) being less than max{(3), 0}. (Note that since (2) $>$ (4), it is possible for (2) to exceed max{(3), 0} when (4) does not.) Absent a central planner that internalizes the externality captured by firm 2, social welfare is diminished since firm 1 will attempt to go public in fewer circumstances than is socially optimal. Theorem 2 provides a formal statement of this result.

THEOREM 2. *When the first firm is free to maximize its private welfare*, *social welfare is diminished by virtue of the fact that satisfying a planner's condition for*

[14] We define social welfare as the sum of the net present values of the two firms less the information-production costs that arise if at least one firm goes public.

taking firm 1 *public*, (7), *is not sufficient to satisfy the firm's condition*, (5), *for going public.*

5. NECESSARY AND SUFFICIENT CONDITIONS FOR RESOLUTION OF THE COORDINATION PROBLEM

Inefficiency associated with an (information) externality is neither surprising nor a novel observation. What we are interested in is the conditions under which an intermediary might enhance efficiency, whether these conditions exist in the market place, and whether the behavior necessary for resolving the coordination problem is related to unexplained characteristics of the marketplace. It is to these issues that we now turn.

Theorem 2 simply establishes that the coordination problem between pioneers and followers results in diminished social welfare. It also suggests that a central planner, perhaps an intermediary with enough market power, might be able to solve the coordination problem.[15] Although we will argue that market power is only a necessary condition for resolving the coordination problem, it is worth considering precisely the nature of the power necessary and whether it appears to exist in the marketplace.

In the context of the primary equity markets, it must be the case that investors are accessible only through the intermediary. Although there are no legal constraints on firms approaching investors directly, there is reason to believe that they cannot or will not as a practical matter. For example, Beatty and Ritter (1986) and Chemmanur and Fulghieri (1994) argue that investment banks have an advantage in certifying the quality of an issue because their repeated participation in the market places a premium on the development and maintenance of reputation capital. Benveniste and Wilhelm (1990) suggest that an investment bank can further diminish the indirect costs of a public offering because its investor network serves as both a distribution channel and a channel for collecting information. Network membership carries the expectation that an investor will participate repeatedly and relatively indiscriminately in the bank's deals. In exchange for this commitment, institutional investors enjoy allocation priority in discounted securities offerings (see Hanley and Wilhelm, 1995).[16] Since there are fixed costs to maintaining such networks (see Eccles and Crane (1988) for examples), it is unlikely that an issuing

[15] Solving the coordination problem is in the interest of an intermediary such as an underwriter because it results in increased underwriting business and hence commissions.

[16] Calomiris and Ramirez (1996) provide insight into the historical contribution of investor networks to the welfare of public securities markets. Prior to the (Glass–Steagall) Banking Act of 1933, investment banks relied heavily on commercial banks for placing blocks of securities. However, the prohibition on commercial bank ownership of corporate securities destroyed these relationships and foreshadowed a 20-year period during which private placements and bank loans played a more important role in financing U.S. corporations. With the increasing prominence of institutional investors during the 1960s, similarly strong relationships were established and the cost of public issuance declined sharply (see Calomiris and Raff (1995)).

firm will be able to overcome the investment bank's comparative advantage arising from regular participation in the public capital markets.

In addition to investment banks controlling access to the investor networks, one must also believe that there are sufficient barriers to entry that one or a few banks can act as gatekeepers to public finance for a group of firms subject to a common valuation factor. Several features of the securities underwriting industry suggest that this is approximated in practice. First, the industry is highly concentrated. Between 1989 and 1996, the top five lead managers of IPOs (measured by share of total proceeds reported by Securities Data Company (SDC)) accounted for 35% of total proceeds while the top ten lead managers accounted for 55% of total proceeds. More recently, three banks, Goldman Sachs, Morgan Stanley, and Merrill Lynch, managed 55% of the IPOs completed during the first half of 1999. This measure is only partially revealing of the degree of concentration within the industry. As Table I indicates, the top lead managers also frequently co-manage with one another.[17] Thus, a relatively large fraction of IPO proceeds are raised through a relatively narrow set of investor networks.

There is also casual evidence that banks develop unique underwriting capacity that is not replicable in the short run. For example, in 1986 Microsoft chose a co-manager for its IPO from among four banks recognized as *technology boutiques* (Alex. Brown, L. F. Rothschild, Hambrecht & Quist, and Robertson Colman & Stephens) in an attempt to appeal to investors who specialize in technology stocks (Uttal, 1986). Apparently the existence or perception of such unique capacity is common. Of the 15 trucking-industry (SIC code: 4200-4210) IPOs completed between 1990 and 1994 and reported by SDC, 9 were lead managed by one bank (Alex. Brown). Similarly, one bank lead managed 7 of the 27 restaurant IPOs (SIC code: 5810-5812) brought to market during the period while the remaining members of the top five lead managers accounted for another 11 deals. In the larger and more diverse software category (SIC code: 7370), the top five lead managers still accounted for 42 of the 87 completed offerings. Many observers attribute unique capacity to a bank maintaining access to a unique pool of investors and employing a particularly reputable industry analyst capable of generating secondary market interest in the issuing firm. In either case, one would expect that because it is relationship and reputation intensive, such capacity makes it difficult to replicate in the short run.

On the other hand, such capacity is expropriable. Anand and Galetovic (1996) argue that the threat of expropriation can inhibit private investment in such assets in the first place. Therefore, in equilibrium the market structure must be such that rents are sufficient to support production of the expropriable assets but insufficient to induce hit-and-run entry by those who would free ride on the efforts of incumbents. This leads Anand and Galetovic to interpret various features of the investment banking industry as being reflective of an equilibrium degree of cooperation among incumbent firms. A recent study by Chen and Ritter (2000)

[17] Eccles and Crane (1988) provide similar evidence for the 1984–1986 period.

TABLE I
Lead Banks and Co-Manager Banks, 1989–1996

Number of IPOs lead-managed	Goldman	Morgan	Lehman	Merrill	Alex-Brown	DLJ	Montgomery	Robertson	H&Q	SBI
	73	61	68	29	120	50	83	74	73	32
Co-manager banks	Percentage (%) co-managed by bank									
Goldman Sachs	—	1.20%	2.08%	0.00%	0.00%	1.39%	0.00%	0.00%	0.00%	4.44%
Morgan Stanley	2.94%	—	1.04	6.98	1.23	0.00	0.94	0.00	0.00	4.44
Lehman	3.92	3.61	—	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Merrill	5.88	2.41	1.04	—	0.00	4.17	0.00	1.08	2.25	0.00
Alex-Brown	10.78	10.84	8.33	6.98	—	6.94	10.38	9.68	3.37	4.44
Donaldson Lufkin	12.75	8.43	5.21	11.63	2.45	—	1.89	6.45	2.25	0.00
Montgomery	6.86	6.02	2.08	2.33	8.59	11.11	—	5.38	5.62	15.56
Robertson Stevens	4.90	10.84	2.08	2.33	7.36	1.39	2.83	—	8.99	0.00
Hambrecht &Quist	7.84	15.66	6.25	0.00	9.20	1.39	6.60	10.75	—	0.00
SBI	1.96	1.20	2.08	6.98	0.61	4.17	1.89	0.00	0.00	—
Total[a]	57.84%	60.24%	30.21%	37.21%	29.45%	30.56%	24.53%	33.33%	22.47%	28.89%

Example. Morgan Stanley was (one of) the co-manager(s) in 2.94% of the deals that Goldman Sachs managed as the lead bank and for which there was at least one co-manager bank.

[a] Totals give the percentage of the co-manager positions that were filled by the nine banks for each lead manager.

reports that, between 1995 and 1998, in over 96% of IPOs raising between \$20 and \$80 million, the issuing firm paid a gross spread of exactly 7.0%. Although it is unclear whether banks compete in other dimensions, this coordination on gross spreads, tacit or otherwise, is consistent with the form of cooperation imagined by Anand and Galetovic to arise when production depends on expropriable assets.

Thus, both theory and evidence suggest that access to the distribution channels sought by firms within a particular industry will be controlled by a relatively small number of banks. We abstract from this characterization of the marketplace by assuming that firms subject to a common valuation factor approach investors through a single intermediary. Consequently, the intermediary is in a position to bundle the offerings of pioneers and followers and thereby force the firms to share the cost of the information externality produced by the first firm's IPO. Furthermore, we assume that the cost of ensuring investor participation arises from providing investors with allocations of shares priced at a discount from their full-information value.

If the IPOs of both firms are sold to the same investor pool, there are two opportunities for "taxing" the second firm. First, the underwriter can underprice the public offerings of both firms such that investors expect to recoup the information cost C.[18] In this case, the second firm directly bears a share of the cost of information production if it chooses to go public. Alternatively, the underwriter can discount the shares of the first firm by enough to ensure investor participation, but then assess the firm an underwriting commission that is less than the marginal cost of bringing the firm to market. (Underwriting costs include among other things the cost of developing an industry-specific marketing strategy and distribution channel.) The tax is then levied by assessing the second firm an underwriting commission that exceeds the marginal cost of marketing the firm. Obviously, these two approaches to taxing the second firm are not mutually exclusive and therefore can be used in conjunction with one another. The fact that there is little variation in the underwriting commission across earlier versus later offerings (Chen and Ritter, 2000) is consistent with this conjecture.

We should note here that the taxing of the second firm under both approaches takes place only when the firm goes public. We rule out the possibility of imposing a fee up front—that is, before the first firm attempts an IPO—on the grounds that, in reality, the second firm might not exist, or be identifiable, at that stage. Furthermore, even if the firm existed then, it might not have the money to pay the fee. This view is consistent with the observation that underwriters are compensated only out of the proceeds of an IPO (usually at the 7% rate) and the fact that there is no up-front payment for investors who participate in IPOs.

[18] We place emphasis on investor expectations because conditional on the first firm attempting a public offering, and therefore investors having borne the fixed cost of participation, it is neither certain that the first firm will complete its offering nor that the second firm will follow with a public offering. We address this issue in greater detail below.

The taxation problem is nontrivial because the underwriter cannot force the second firm to attempt a public offering, and it is only when the second firm completes an offering that a tax can be levied. An overly aggressive redistribution effort simply will cause the second firm to avoid attempting an IPO when it otherwise would have. Thus, the taxation can happen only in regions II, III, and V, and the maximum expected feasible transfer (or "tax") is equal to the second firm's expected benefits associated with attempting an IPO net of the expected benefits from remaining private (or simply not investing). This amount is given by the following expression (see Fig. 1):

$$\int_{V_1''}^{V_L} \left\{ \int_{K}^{+\infty} [V_2 - K] n(V_2 \mid V_1)\, dV_2 - F - \max[(1-\alpha)E(V_2 \mid V_1) - K, 0] \right\} n(V_1)\, dV_1$$
$$+ \int_{V_U}^{+\infty} \left\{ \int_{K}^{+\infty} [V_2 - K] n(V_2 \mid V_1)\, dV_2 - F - [(1-\alpha)E(V_2 \mid V_1) - K] \right\} n(V_1)\, dV_1. \tag{8}$$

Expression (8) suggests that in general it will be impossible for the underwriter to capture the entire surplus associated with the second firm's ability to observe the first firm's IPO. In other words, it will be impossible for the first firm to fully internalize the benefits of information production. Once again, this is simply a consequence of the fact that under some circumstances, the second firm will optimally finance privately or abandon the project yet it will have had the opportunity to condition its decision on the outcome of the first firm's IPO. This point is formalized in Theorem 3:

THEOREM 3. *The maximum expected feasible transfer*, (8), *is less than the externality that will be lost by the second firm when the first firm fails to attempt an IPO*, (2) − max{(3), 0}.

The intuition behind the theorem is simple. When the second firm would not have funded its investment privately *a priori*, realizations of V_1 in region IV would make the firm optimally fund the investment privately. Conversely, when the second firm would have been willing to fund its investment privately *a priori*, observing V_1 in region I would lead the firm to abandon investment. In each case, the second firm is better off for having observed the outcome of the first firm's IPO, but in neither case, because the firm does not attempt to go public, is it possible for the underwriter to capture the surplus associated with this benefit. Furthermore, when the second firm would have invested with private funds *a priori*, the benefit it derives if V_1 falls in region II cannot be taxed entirely. Although the firm would conditionally seek a public offering in this region, an attempt by the underwriter to extract the entire net benefit relative to investing with private funds leads the firm to simply abandon investment altogether. (This limitation is reflected in the max operator in the first line of (8).)

Although it may be impossible for the first firm to fully internalize the benefits of information production, the underwriter may be able to achieve a level of social welfare identical to that produced by a central planner. Given market power of the type described earlier, Theorem 4 identifies a necessary and sufficient condition for an intermediated resolution to the coordination problem:

THEOREM 4. *An intermediated resolution to the coordination problem requires that the maximum expected feasible transfer*, (8), *be greater than the first firm's expected private loss from attempting a public offering. That is, an underwriter with market power can solve the coordination problem if and only if*

$$\{(4) - \max[(3), 0]\} - C + (8) > 0.$$

The ability to solve the coordination problem will always be restricted, as demonstrated by Theorems 3 and 4, as long as nonpioneering firms have a fallback position in which they benefit from the information externality while remaining beyond the reach of the intermediary. The generality of this condition therefore suggests qualification of the Persons and Warther (1997) characterization of Drexel Burnham Lambert as a dominant intermediary in the junk bond market of the 1980s, able to promote innovation by subsidizing early adopters with rents expected to be captured from future adopters. Specifically, Benveniste *et al.* (1993) provide evidence of substitution between bank loans and junk bonds. Thus any transfer Drexel might have enforced could have been constrained by its ability to "tax" firms that conducted their sub-investment-grade borrowing through commercial banks, but nevertheless enjoyed benefits from the development of the junk bond market.

Although we are not aware of any scientific evidence supporting this conjecture, we think it is plausible that the creation of public markets for sub-investment-grade debt created information externalities for both future participants in the market and sub-investment-grade credits that continued to borrow from commercial banks. Aside from any benefits that may have arisen from greater competition, information-production costs for commercial banks (and therefore the cost of bank loans) should have been diminished by their ability to free-ride on information production in the public (junk-bond) markets. Thus if market power was important to the junk-bond boom in the 1980s, as Persons and Warther suggest, our analysis suggests that it was only because the innovation produced surplus well beyond that which was captured by the nonissuing sub-investment-grade credits over which investment banks would have had little power.[19] Assuming that externalities are

[19] Persons and Warther also suggest that the market power wielded by Salomon Brothers in the early stages of the mortgage-backed securities markets was an important factor in their success. Once again, it is likely that there were substantial externalities generated by pioneers that an intermediary could not have expected to internalize. Presumably, those that could be captured were substantial relative to the private costs facing pioneers.

a central feature of financial innovations, successful innovations are thus likely to exhibit either a total surplus that is simply very large relative to the private costs of pioneers or a more modest surplus of which a relatively large fraction can be recaptured by the pioneer.

Our analysis of IPOs highlights a potentially important source of social welfare in addition to those associated with the actual adoption of an innovation. In an IPO, even firms that attempt but do not complete a public offering can produce valuable information for themselves and their peers. The value of the option to terminate an offering following information production suggests that only a fraction of the social benefits associated with active primary markets arise from the more easily observed completed offerings. Similarly, although Persons and Warther focus on the adoption of an innovation as the source of information externalities, our model suggests that those innovations that are not widely adopted may produce substantial information externalities associated with the innovating bank's research, design, and marketing efforts. The findings of both Eccles and Crane (1988) and Tufano (1989) appear to support this claim.

Finally, our results, summarized in Theorems 1 through 4, hold in a more general framework that explicitly models the process through which investor information is solicited during the marketing of an IPO (see footnote 10). In such a framework, investors must be offered an incentive to truthfully reveal the private information they hold as a consequence of bearing the participation cost, C. Since investors anticipate the second firm's IPO, satisfying their participation constraint for the first firm's IPO requires that their profits exceed C less the expected underpricing required of the second firm to elicit information from investors in the event that it too attempts a public offering. Either the participation constraint or the incentive-compatibility constraint, depending on which is binding, therefore determines underpricing of the first firm's IPO. In either case, the cost of going public is higher for the first firm (since the second firm faces only a weaker incentive-compatibility constraint) and the firm is unable to fully internalize the externality its attempted IPO produces. As a consequence, social welfare will be increased when it is possible for an intermediary to enforce a transfer between the two firms, and this will be possible under circumstances similar to those we have just described.

6. EMPIRICAL IMPLICATIONS

Our model also sheds light on the fact that IPOs tend to be clustered in time and within industries. In our model, a hot market occurs when both firms attempt a public offering. Followers are more likely to attempt public offerings when there is a high probability of realizing the states associated with regions II, III, or V in Fig. 1. Pioneering firms are more likely to jump start the process when the potential exists for mitigating the ability of followers to free-ride on the pioneer's costly information production effort. To the extent that investment banks can fulfill this intermediary role, their leverage is also greatest in regions II, III, and V, since these are the states in which an implicit tax can be levied against the second firm's surplus from observing the outcome of the first firm's IPO. Thus, our model predicts that hot markets reflect the realization of states associated with regions II, III, and V.[20]

Obviously, region V states are more likely to occur when the pioneering firm's IPO is well received by the market (high V_1). We have also shown that, holding the fixed cost (F) of going public constant, states associated with regions II, III, and V are more likely to occur when the benefits of being publicly traded, α, are relatively large.

The implications for the hot-market phenomenon associated with the option-like feature of a public offering (exhibited in regions II and III) are more subtle. Recall first that uncertainty about a firm's market value arises at both the industry and the firm level (a firm's unconditional expected value has a variance $\sigma_1^2 = (\tau_1^2 + \sigma_f^2)$). What the second firm learns about the industry factor is then given by

$$I_2 = I_1 + (V_1 - I_1)\left[\tau_1^2 / \left(\tau_1^2 + \sigma_f^2\right)\right],$$

where $[\tau_1^2/\sigma_1^2]$ determines the degree and $(V_1 - I_1)$ the direction of learning.

If we were to hold learning $[\tau_1^2/\sigma_1^2]$ constant but increase total uncertainty (σ_1^2 and therefore σ_2^2), the second firm's option value in going public increases. Therefore $E(\text{NPV}_2 \mid V_1;\text{public})$ in Fig. 1 shifts up for all values of V_1. In contrast, the location of $E(\text{NPV}_2 \mid V_1;\text{private})$ in Fig. 1 depends only on what the second firm learns from the first firm's IPO. Therefore, the net effect of holding learning constant while increasing total uncertainty is to widen the range of realizations of V_1 over which public finance dominates (or over which a hot market will occur).[21] In other words, if there is sufficiently high option value in attempting a public offering, it would not be surprising to observe a flurry of offerings even in the aftermath of one or more poorly received offerings by firms in the same industry.

In summary, our model draws attention to two potentially distinct types of hot markets: those arising as a consequence of a strong positive market response to the efforts of pioneering firms and those associated with high option value. As

[20] Our analysis is complementary to Stein's (1997) explanation for waves of innovative activity. In Stein's model, firms compete on both technological (high-spillover) and distributional (zero-spillover) dimensions. Firms are more likely to gain competitive advantage by being strong in the zero-spillover dimension, but in doing so they may inhibit innovation by raising barriers to entry. Successful entrants overcome the incumbent's command of the distribution network and consequently produce a shakeup externality by opening the market to other technologically-strong entrants. By solving the coordination problem we describe and thereby increasing the availability of public financing for new technologies, the institutional structure of the primary equity market may contribute to the production of the shakeup externalities that promote innovative activity.

[21] In other words, $E(\text{NPV}_2 \mid V_1;\text{public})$ is a function of the mean and variance of the conditional distribution of V_2 whereas $E(\text{NPV}_2 \mid V_1;\text{private})$ is a function of the mean only. Both the mean and the variance are functions of τ_1^2 and σ_f^2. Thus, failing to hold learning constant, it will not be possible in general to determine the net effect of a volatility shock. However, we have identified several cases in which the net effect can be determined. Further details are available upon request.

such, our explanation for clustering provides a complementary supply side to the more common demand side argument that primary market activity is driven by the flow of funds into mutual and pension funds and the general level of the secondary market. Although technological advances arrive randomly, in the presence of information externalities produced by pioneering firms, the timing with which firms in a developing industry turn to the public equity markets may not be random.

One way of assessing the contribution of information externalities to IPO clustering is to recognize that this perspective implies learning across a sequence of IPOs by firms related by a common valuation factor. Evidence reported by Benveniste *et al.* (2000) is consistent with this hypothesis. Holding other things constant, our model also predicts that if information externalities are substantial, learning will diminish as one moves through a series of offerings related by a common valuation factor.

Because learning will diminish over a series of related IPOs, our model suggests a distinct pattern of underpricing across these IPOs. If the offerings were not bundled together, the first firm to go public would underprice by enough to pay for the information cost C, while the subsequent firms would not need to offer a discount. But if, as we suggest, underwriters spread the information cost over a series of IPOs in a new industry, where information production tends to be particularly costly, then underpricing should not be less for the later offerings, holding all else equal.

Our model also suggests an explanation for the time variation in IPO initial returns observed by, among others, Ibbotson and Ritter (1996). In our model, two factors influence the level of initial returns in hot markets. In the more general form of the model described in the previous section, the underpricing needed to elicit strong indications of interest will be concentrated in states when investor demand is strong (for example, see Benveniste and Spindt (1989)). Thus, region V hot markets will be characterized by larger initial returns, other things equal.

On the other hand, to this point we have considered only the case where there is a single follower and a single pioneer. If there are multiple firms that would benefit from the information externality produced by the pioneering firm's IPO, follower surplus is increased. Assuming that the information-production costs facing the pioneering firm are independent of the number of firms in the industry, it is therefore more likely that the critical mass of follower surplus necessary to offset these costs will be achieved. Moreover, any single firm's share of the information-production cost will be smaller. This effect has the impact of reducing initial returns in hot markets. Likewise, cold markets can arise for two reasons. In region I, realizations of V_1 are sufficiently low that only the pioneering firm will attempt an IPO. In such states, the Benveniste and Spindt (1989) framework suggests that initial returns will be minimal. In region IV, there will be few IPOs (only the pioneering firm's IPO in our model), but larger initial returns.

The identity of the dominant effect is an empirical question. Figures 1 and 2 in Ibbotson and Ritter (1996) suggest a negative correlation between activity and initial returns consistent with the interpretation that firms share information production costs in hot markets. However, regardless of which effect dominates, our model predicts that region V hot markets will be characterized by larger initial returns than region II or III hot markets.

Finally, our assumption that α is constant across firms within an industry deserves further attention. Setting aside the obvious fact that α will vary randomly across firms in practice, there seem to be two plausible arguments for systematic variation in α. First, pioneers may gain a competitive advantage by being able to scale up production sooner than competitors (see Maksimovic and Pichler (1996)). This seems particularly likely in winner-take-all industries where firms race to establish standards that can effectively create insurmountable barriers to entry for potential entrants. In such cases, α may be smaller for followers.

On the other hand, if we broaden our definition of the industry to include producers of complementary goods, α might actually be larger for many followers. For example, Netscape's ability to scale up production following its IPO may have increased the likelihood of the firm establishing a standard for Internet search engines and thereby created opportunities for producers of complementary products and services (increasing α for these firms). If complementary firms approach public investors through the same channels as the pioneer, the net effect could be to increase the potential for effecting the transfer necessary to induce the pioneer to go public in the first place.

7. CONCLUSION

Our model is designed to illustrate how an intermediary can promote social welfare by spurring primary equity markets into action in the presence of information externalities. Pioneering firms, particularly those in nascent industries, may be slow to enter the market if the costs of entry are high and the benefits cannot be fully internalized. However, if the investment banking industry is sufficiently concentrated and the relationships between banks and investors are sufficiently strong, banks can resolve the coordination problem between pioneers and followers by enforcing a transfer of follower surplus such that the relatively high entry costs facing potential pioneers are at least partially offset. Thus, private institutions can serve as catalysts for public investment in circumstances where previous authors have suggested government intervention might be appropriate.[22]

It remains an empirical question whether such benefits outweigh any costs associated with a concentration of market power within the investment banking industry. Nevertheless, our analysis draws into sharp focus the importance of a vibrant primary equity market. Specifically, we have shown that there can be

[22] Subrahmanyam and Titman (1999) suggest that firms ignore the positive externality associated with having additional firms trading on an exchange. Subsidizing the development of a stock market may therefore increase social welfare by inducing firms that would otherwise find it rational to remain private, to enter the public market.

circumstances under which conditionally positive expected NPV investments will be forgone in the absence of a primary equity market (region II in Fig. 1). In these cases, given the option to collect additional information by attempting a public offering, firms will optimally choose to do so. Conditional on such information, some investments with negative unconditional expected NPVs will be undertaken.

APPENDIX

Proof of Lemma 1.

- Part 1: The partial derivative of $E(\mathrm{NPV}_2 \mid V_1;\ \text{private})$ with respect to V_1 is the positive constant $(1-\alpha)(\partial I_2/\partial V_1) = (1-\alpha)[\tau_1^2/(\tau_1^2+\sigma_f^2)]$.
- Part 2:

a. The partial derivative of $E(\mathrm{NPV}_2 \mid V_1;\ \text{public})$ with respect to V_1 can be shown to be

$$[1 - N(V_2 = K \mid V_1)][\partial I_2/\partial V_1] > 0,$$

where $N(V_2 = K \mid V_1)$ is the normal cumulative distribution function of V_2 conditional on V_1, evaluated at K. (The derivation is available upon request.)

b. The convexity of $E(\mathrm{NPV}_2 \mid V_1;\ \text{public})$ stems from the fact that the second derivative of the function with respect to V_1 is positive (proof available upon request). Notice the resemblance between this function and that of a call option prior to maturity. V_2 resembles the value of the underlying asset at maturity, V_1 resembles the value of the asset prior to maturity, and K the strike price.

c. As V_1 approaches $-\infty$, the probability of $V_2 > K$ approaches zero and

$$\int_K^\infty [V_2 - K]n(V_2 \mid V_1)\, dV_2 \to 0.$$

REFERENCES

Allen, F., and Gale, D. (1995). A welfare comparison of the German and U.S. financial systems, *Eur. Econ. Rev.* **39**, 179–209.

Allen, F., and Gale, D. (1999). Diversity of opinion and financing new technologies, *J. Finan. Intermediation* **8**, 68–89.

Anand, B. N., and Galetovic, A. (1996). "A Theory of Financial Market Structure," working paper, Universidad de Chile, Santiago, Chile.

Beatty, R. P., and Ritter, J. R. (1986). Investment banking, reputation, and the underpricing of initial public offerings, *J. Finan. Econ.* **15**, 213–232.

Benveniste, L. M., and Busaba, W. Y. (1996). "Price Discovery and the Option Value in Going Public," working paper, University of Arizona, Tucson, AZ.

Benveniste, L. M., and Busaba, W. Y. (1997). Bookbuilding vs. fixed price: An analysis of competing strategies for marketing IPOs, *J. Finan. Quant. Anal.* **32**, 383–403.

Benveniste, L. M., Busaba, W. Y., and Wilhelm, W. J. (1996). Price stabilization as a bonding mechanism in new equity issues, *J. Finan. Econ.* **42**, 223–255.

Benveniste, L. M., Singh, M., and Wilhelm, W. J. (1993). The failure of Drexel Burnham Lambert: Evidence on the implications for commercial banks, *J. Finan. Intermediation* **3**, 104–137.

Benveniste, L. M., and Spindt, P. A. (1989). How investment bankers determine the offer price and allocation of initial public offerings, *J. Finan. Econ.* **24**, 343–362.

Benveniste, L. M., and Wilhelm, W. J. (1990). A comparative analysis of IPO proceeds under alternative regulatory environments, *J. Finan. Econ.* **28**, 173–207.

Benveniste, L. M., and Wilhelm, W. J. (1997). Initial public offerings: Going by the book, *J. App. Corp. Finance* **10**, 98–108.

Benveniste, L. M., Wilhelm, W. J., and Yu, X. (2000). "Evidence of Information Spillovers in the Production of Investment Banking Services," working paper, Boston College, Chestnut Hill, MA.

Boot, A. W. A., and Thakor, A. V. (1997). Financial system architecture, *Rev. Finan. Stud.* **10**, 693–733.

Busaba, W. Y. (2000). "Bookbuilding, the Option to Withdraw, and the Timing of IPOs," working paper, University of Arizona, Tucson, AZ.

Busaba, W. Y., Benveniste, L. M., and Guo, R. (2001). The option to withdraw IPOs during the premarket: Empirical analysis, *J. Finan. Econ.* **60**, 73–102.

Calomiris, C. W., and Raff, D. M. G. (1995). The evolution of market structure, information, and spreads in American investment banking, *in* "Anglo-American Finance: Financial Markets and Institutions in 20th-Century North America and the U.K." (R. Sylla and M. Bordo, Eds.), Business One-Irwin, Homewood, II.

Calomiris, C. W., and Ramirez, C. D. (1996). The role of financial relationships in the history of American corporate finance, *J. App. Corp. Finance* **9**, 52–73.

Chemmanur, T. J., and Fulghieri, P. (1994). Investment bank reputation, information production, and financial intermediation, *J. Finance* **49**, 57–79.

Chemmanur, T. J., and Fulghieri, P. (1999). A theory of the going-public decision, *Rev. Finan. Stud.* **12**, 249–279.

Chen, H., and Ritter, J. (2000). The seven percent solution, *J. Finance* **55**, 1105–1131.

Dow, J., and Gorton, G. (1997). Stock market efficiency and economic efficiency: Is there a connection?, *J. Finance* **52**, 1087–1129.

Dunbar, C. (1998). The effect of withdrawals on contract choice in initial public offerings, *J. Finan. Intermediation* **7**, 60–90.

Eccles, R. G., and Crane, D. B. (1988). "Doing Deals: Investment Banks at Work," Harvard Business School Press, Boston, MA.

Hanley, K. W., and Wilhelm, W. J. (1995). Evidence on the strategic allocation of initial public offerings, *J. Finan. Econ.* **37**, 239–257.

Ibbotson, R. G., and Ritter, J. R. (1995). Initial Public Offerings, *in* "Handbooks of Operations Research and Management Science: Finance," (R. Jarrow, V. Maksimovic, and W. Ziemba, Eds.), Chap. 30, pp. 993–1016, North-Holland, Amsterdam.

Kahn, C., and Winton, A. (1998). Ownership structure, speculation and shareholder Information, *J. Finance* **53**, 99–130.

Lee, I., Lochhead, S., Ritter, J., and Zhao, Q. (1996). The costs of raising capital, *J. Finan. Research* **19**, 59–74.

Maksimovic, V., and Pichler, P. (2000). Technological innovation and initial public offerings, *Rev. Finan. Stud.*, in press.

Pagano, M. (1993). The flotation of companies on the stock market: A coordination failure model, *Eur. Econ. Rev.* **37**, 1101–1125.

Pagano, M., and Roell, A. (1998). The choice of stock ownership structure: Agency costs, monitoring and the decision to go public, *Quart. J. Econ.* **113**, 187–225.

Persons, J. C., and Warther, V. A. (1997). Boom and bust patterns in the adoption of financial innovations, *Rev. Finan. Stud.* **10**, 939–968.

Stein, J. C. (1997). Waves of creative destruction: Firm–specific learning-by-doing and the dynamics of innovation, *Rev. Econ. Stud.* **64**, 265–288.

Subrahmanyam, A., and Titman, S. (1999). The going public decision and the development of financial markets, *J. Finance* **54**, 1045–1082.

Tufano, P. (1989). Financial innovation and first-mover advantages, *J. Finan. Econ.* **25**, 213–240.

Uttal, B. (1986). Inside the deal that made Bill Gates 350,000,000, *Fortune* **114**, 23–32.

Zingales, L. (1995). Insider ownership and the decision to go public, *Rev. Econ. Stud.* **62**, 425–448.