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JEL classification: C73, G24

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ABSTRACT

Competition and Collusion in the IPO Market

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I. INTRODUCTION

Recent evidence presented by Chen and Ritter (2000) shows that over 90% of U.S. corporations that went public to raise proceeds of $20 million to $80 million in 1995-1998 paid exactly 7.0% of the proceeds to investment bankers. For large offerings that raised more than $80 million, average gross spreads are below 7.0% and there is little clustering on a single number. These findings have inspired a class action lawsuit against dozens of investment banks and led to the U.S. Department of Justice investigation of “the possibility of anticompetitive practices in underwriting services for initial public offerings.”

Chen and Ritter (2000) discuss several possible explanations for the seven percent clustering. The purpose of this article is to offer a game-theoretic model, as one possible explanation, for the documented pricing pattern of investment bankers. The intuition of the model is that investment bankers act strategically to avoid undercutting spreads, because they realize if one tries to win business by cutting spreads, the underwriting industry will move to an equilibrium with low spreads and lower expected profits. Anecdotally, Schroeder (2000) reports a case in which NASD Regulation Inc. censured Prudential Securities Inc. for its behavior in negotiating the gross spread for an IPO and Prudential was concerned with “setting an unfavorable precedent for future deals” according to NASD documents.

The model demonstrates that investment bankers, though competing on spreads, can still sustain profitable equilibria in a stochastic and infinite horizon setting. In the setup of the model, there are two classic benchmarks: explicit collusion and perfect competition. Under explicit collusion, investment bankers make cooperative agreements to maximize the expected profits from the perspective of the whole investment banking industry. Because investment bankers have incentives to deviate from cooperative agreements by undercutting spreads when they observe that some large firms are going public, explicit collusion does not constitute an equilibrium in this dynamic game. The perfect competition equilibrium is indeed one of the candidates of equilibria. However, the perfect competition outcome is not in the best interests of investment bankers. Investment bankers prefer outcomes with higher profits if they can find some pricing strategies that constitute profitable equilibria. In the dynamic game literature, such
pricing behavior is termed “implicit collusion” because investment bankers, while acting in their own interest, set spreads above the competitive level and earn abnormal profits without any formal agreement about how to charge in the IPO market.³

In a recent paper, Hansen (2001) presents a set of tests to distinguish between the cartel theory and the efficient contract theory, which asserts that the 7% IPOs is the survivor of competition that determines the fittest IPO contract. He concludes that the efficient contract theory is supported. Among his set of tests, Hansen (2001) interprets low concentration and new entry to the IPO market as evidence consistent with the perfect competition equilibrium.

In the most profitable non-cooperative equilibrium (called "the second-best equilibrium"), investment bankers can sustain a high spread for a wide range of offerings. However, they have to charge lower spreads for sufficiently large offerings to keep other underwriters from undercutting. The notion underlying the second-best equilibrium is similar to those of Rotemberg and Saloner (1986) and Dutta and Madhavan (1997). In an oligopolistic pricing model over the business cycle, Rotemberg and Saloner show that firms set relatively low prices during periods of high demand in equilibrium. Dutta and Madhavan offer a model to explain market dealers' pricing behavior. When expected volume is less than a critical level, dealers set prices equal to those set under overt collusion. If the volume shock is above the critical level, dealers narrow the bid-ask spreads to prevent individual dealers from defecting from the proposed equilibrium spreads. The model in this article is based on the framework of these papers.

The model suggests that investment bankers are able to sustain a high spread for offerings smaller than some critical level, and they have to charge lower spreads for sufficiently large offerings to prevent other investment bankers from undercutting. The prediction is consistent with the pattern observed in Figures 2 and 3 of Chen and Ritter (2000). Another implication of the model is that the critical offering size increases and it is easier to implicitly collude for investment bankers when more IPOs are brought to the market during a fixed calendar period (for example, a year). The cost of defecting from the "implicit collusion" equilibrium is high in the more active IPO market since investment bankers give up more expected profits during a fixed calendar period if they
undercut spreads. The implication is also consistent with the fact that 1995 through 1998 witnessed high IPO volume.

The analysis of this paper also is extended to the case of heterogeneous investment bankers. Because the smallest investment banker has the most to gain from undercutting the current spread in the IPO market and the least to lose from a collapse of an implicit collusion equilibrium, it is the smallest investment banker that determines the gross spreads in equilibrium. The higher the share of the smallest investment banker, the higher the gross spreads and the future profits for all investment bankers. This implies that implicit collusion is easier to sustain in an IPO market where investment bankers are of approximately equal market share. Thus, concentration measures such as the four-firm concentration ratio or the Herfindahl-Hirschmann index are low under the implicit collusion equilibrium and they cannot accurately differentiate between the competition equilibrium and the implicit collusion equilibrium.

In the long run, if there are no barriers to entry, investment bankers will enter as long as expected future profits are positive. When the number of investment bankers is large enough, it is harder to prevent deviation and the implicit collusion equilibrium is more difficult to sustain. In practice, the explicit costs of entering the IPO market include capital costs and costs of human resources such as security analysts with good reputations. The implicit costs of entry usually include developing underwriter prestige. These explicit and implicit costs may stand for a substantial barrier to entry. The model shows that the second-best equilibrium is sustainable with a positive entry cost when endogenous entry is considered. If investment bankers speculate that they could recoup their own entry costs in the future, the rent-seeking behavior will continue. In equilibrium, only the marginal entrants earn zero expected net profits. Thus, new entry to the IPO market without undercutting spreads could be viewed as rent-seeking behavior under the second-best equilibrium.

The paper proceeds as follows. Section II presents the model and analyzes the second-best strategy and related implications for the IPO market. Some caveats about the model are also given. Section III concludes the paper. Proofs of propositions are delegated to the appendix.
II. An Implicit Collusion Model for the IPO Market

A. Basic Setup

Consider $M$ symmetric investment bankers providing underwriting service in an infinite-horizon setting. At the start of each period, one firm needs the underwriting service of one investment banker to help it to go public. The issuing firm is characterized by the gross proceeds that the firm receives before the fee charged by its underwriter. Let $P_t$ be the gross proceeds (or offering size) received by the firm at time $t$. We assume the amount of gross proceeds for issuing firms is independent and identically distributed from period to period and regard it as the random variable $P$ that has domain $[P, \bar{P}]$ and has a distribution $F(P)$. After observing the size of one issuing firm in each period, $M$ investment bankers simultaneously quote their spread levels at which they are willing to provide underwriting service. Since the offering size of issuing firms may be different from period to period, this game is a dynamic game rather than a repeated game in which the proceeds or economic environment is constant in each period. There is no private information, so we have a dynamic game with complete information.

We assume the expected profit function of investment bankers as a group is $\pi(S; P_t)$ and the function is strictly concave in the gross spread $S$ (measured as a proportion, such as 0.07) and increasing in the proceeds $P_t$. Formally, the monopoly spread is

$$S^m = \arg \max_s \pi(S; P_t).$$

When investment bankers form a cartel and charge a monopoly spread $S^m$ that is independent of the amount of gross proceeds, they are able to earn the maximal profit from the perspective of the whole investment banking industry. For analytic simplicity, we assume that there are no fixed costs of underwriting. Instead, the underwriting technology has constant returns to scale as represented by total costs on a deal that are proportional to proceeds, total costs = $cP$.

When investment bankers set the spread equal to the marginal cost $c$, they earn no economic profits. It is easy to see that when each investment banker charges an underwriting spread at the marginal cost $c$ in each period no matter what spreads other investment bankers charge, this pricing behavior constitutes a subgame-perfect Nash
equilibrium. First, investment bankers will not charge below \( c \) since they are going to make losses and will be better off by choosing not to participate in the game or simply charging \( c \). Second, when all investment bankers charge above \( c \), one investment banker can make more profits by undercutting the prevailing spread. Finally, after any previous history of play, the strategy requires each investment banking firm to set its spread equal to \( c \) in every future period regardless of its rivals’ behavior. Since each investment banker earns at most zero when its opponents set their spreads equal to \( c \), and it earns exactly this amount by setting its spread equal to \( c \) in each future period, the strategy of "pricing at marginal cost" in all periods is a subgame perfect Nash equilibrium.

Although "pricing at marginal cost" is a sustainable equilibrium of the pricing game played by investment bankers, the competitive outcome does not coincide with the best interests of investment bankers as a whole group. Investment bankers may prefer to form a cartel to capture the monopoly rent. But they cannot reach such cooperative agreements easily for two reasons. First, explicit price fixing agreements violate the antitrust law. Second, investment bankers have incentives to deviate from cooperative agreements by undercutting spreads when they observe some large firms are going to go public. Therefore, explicit collusion cannot be sustained for all periods, even if investment bankers understand it is beneficial for them to cooperate in the long run.

In the dynamic context, we still can find some equilibria in which investment bankers act non-cooperatively and make positive profits. We are especially interested in looking for the "second-best" equilibrium, which is defined as a non-cooperative equilibrium that has the highest possible profit for the whole investment banking industry among non-cooperative equilibria.\(^5\) We call this the implicit collusion equilibrium.

**B. The Second-best Equilibrium**

Assume the current realization of the IPO proceeds is \( P' \). Let \( J(P) \) denote the total expected present value of future profits to the whole investment banking industry under the second-best strategy and \( \pi(S'; P') \) be the current profits to investment bankers as a group from charging the spread \( S' \). Similar to the argument of dynamic programming, the value function \( J(P') \) for the second-best strategy can be expressed in terms of current-period profits plus the present value of future expected profits, as

\[
J(P') = \max_S \left[ \pi(S'; P') + \rho E(J(P)) \right]
\] (1)
for all $S \leq S'$, where $\rho$ ($\rho = 1/(1+r)$ and $r$ is the discount rate for one period) is the one-period discount factor for all $M$ investment bankers.

Equation (1) is known as the Bellman equation. Constraint (2) is the incentive compatibility condition. It means that the expected profits from following the second-best strategy are greater than one-shot profits from deviating from the strategy and charging a lower spread. Specifically, an investment banker sets spreads equal to the suggested spreads according to the second-best strategy and expects the tacit pricing to continue through the future. From the assumption of symmetric investment bankers, the investment banker's expected profits are decomposed as follows: he receives an immediate expected profit of $\frac{1}{M} \pi(S'; P')$ and he also receives the expected discounted continuation payoff of $\frac{1}{M} \rho E(J(P))$. For the R.H.S. of (2), if the investment banker undercuts the spread to capture the market, the investment banker earns $\pi(S; P')$ for the current period and no profits for future periods, expecting other investment bankers thereafter to price at the marginal cost, which is the worst possible punishment. The optimization problem (1) means that investment bankers maximize their aggregate intertemporal profits subject to the incentive compatibility constraint (2). This is simply due to the definition of the second-best equilibrium.

From our assumptions, the expected value of future profit to the whole investment banking industry can be expressed as a perpetuity and simplified to

$$E(J(P)) = \left( \frac{1}{1-\rho} \right) \int P \pi(S(P); P) dF(P).$$

If investment bankers expect future profits to be zero whether they cooperate at time $t$ or not, the pricing game at time $t$ will essentially be a one-shot game in which the well-known equilibrium is the competitive equilibrium. Lemma 1 characterizes the competitive equilibrium via the expected continuation payoffs in the second-best equilibrium.
Lemma 1: The unique non-cooperative equilibrium is the competitive equilibrium if and only if the expected continuation payoffs in the second-best equilibrium are zero, i.e., \( E(J(P)) = 0 \).

Lemma 1 implies that if there exists a second-best equilibrium other than the competitive equilibrium, the expected continuation payoffs must be strictly positive. Since the time horizon of the pricing game is infinite, the extent of patience for investment bankers will affect the magnitude of the expected continuation payoffs. We now focus on the expected continuation payoff.

Note that the monopoly spread \( S^m \) maximizes the profit function, and at worst investment bankers get zero profits when they charge at \( c \). The per-period payoff for each underwriter is nonnegative and bounded by \( \pi(S^m; P) \) and hence \( E(J(P)) \) is also nonnegative and bounded above. When investment bankers are more patient, i.e., the discount factor \( \rho \) is larger and the future is appreciated more, investment bankers are less willing to undercut gross spreads to give up future profits. Intuitively, the expected discounted continuation payoff \( K = \rho E(J(P)) \) under any strategy will increase in the discount factor.

The following lemma, which is a variant of lemma 4 in Dutta (1995), captures the above intuition and facilitates the proofs of the later main propositions.

Lemma 2: Consider any strategy \( \sigma \) and its associated outcome. Suppose, at a fixed discount factor \( \rho_1 \), the expected continuation payoff \( E(J(P; \rho_1)) \) is nonnegative after each finite history and suppose further that the per-period payoff for each underwriter is bounded. Then, the expected discounted continuation payoff under \( \sigma \), after each finite history, is non-decreasing in the discount factor, i.e., \( K_2 = \rho_2 E(J(P; \rho_2)) \), \( K_1 = \rho_1 E(J(P; \rho_1)) \), \( K_2 \geq K_1 \) whenever \( \rho_2 \geq \rho_1 \).

Since we are interested in the non-cooperative equilibrium with the highest possible profits for the whole investment banking industry, it is beneficial to examine the extent to which the collusive spread is sustainable. When the collusive spread \( S^m \) is sustainable given current offering size \( P \), it follows from (2) that

\[
\frac{K}{M} \geq (1 - \frac{1}{M}) \pi(S^m; P).
\]  

(4)
The L.H.S. of (4) is the expected continuation profits to an investment banker given that no other investment bankers deviate from the second-best strategy. $\frac{K}{M}$ thwarts an individual investment banker from charging a lower spread to capture the whole IPO market since it is the expected profits forgone in the future if someone defects. However, $\pi(S^m;P)$ is increasing in $P$ and as a result, inequality (4) may not hold for a large offering size. This means the collusive spread can no longer be sustainable for large offerings since any investment banker has an incentive to undercut the spread to grasp the business of large offerings. Therefore, investment bankers will set spreads lower for larger offerings to keep an individual investment banker from cheating. It follows that investment bankers will sustain the collusive spread for small offerings and charge less for sufficiently large IPO firms.

On the other hand, Lemma 2 states that the expected continuation payoff $K$ is higher when investment bankers are more patient. This makes (4) hold more easily and collusive pricing is sustainable in a wide range of offering size. In contrast, if investment bankers are impatient, they undercut spreads more easily and act more competitively. Then, constraint (2) may not hold and the competition equilibrium arises.

With the help of Lemma 1 and Lemma 2, Proposition 1 characterizes the second-best equilibrium.

**Proposition 1:** There exists a constant $\rho_0 \in [1-1/M, 1)$ such that when $\rho > \rho_0$, the second-best strategy for any investment banker is as follows: 1) if the offering size is below a unique critical proceeds $P_C(\rho)$, where $P \leq P_C(\rho) \leq \bar{P}$, charge the collusive spread $S^m$; 2) if the offering size is above the critical proceeds ($P > P_C(\rho)$), charge an underwriting spread $S^*(P)$, where $S^*(P) < S^m$; 3) if any investment banker deviates from this strategy, set the underwriting spread at $c$ in each period onwards.

When $\rho \leq \rho_0$, the unique equilibrium is the competitive equilibrium and charge the underwriting spread at $c$ in each period.

Proposition 1 shows that if investment bankers are sufficiently impatient (with low discount factor), the competitive equilibrium is the only equilibrium. If investment bankers are patient enough, their pricing behavior is like “implicit collusion” for
offerings below some critical level of offering size by charging the same monopoly spread. However, they will charge lower spreads depending on the amount of proceeds to prevent defection of individual investment banker for issues beyond the critical level. The characterization for patient underwriters in Proposition 1 is consistent with the pattern of clustering at the same gross spread of 7.0% over a range of offering sizes and lower spreads for larger offerings as shown in Figures 2 and 3 of Chen and Ritter (2000). Note that “implicit collusion” in the second-best equilibrium is distinct from “overt collusion”. For overt collusion, investment bankers charge a unique profit-maximizing spread for all new issues (this assumes that no economies of scale exist). However, in the second-best equilibrium, investment bankers recognize their dynamic interdependence of their respective pricing behavior and charge different spreads for different size of IPOs.

We define “the start of each period” as when one issuing firm needs underwriting services and will go public. That is, each period represents one transaction. To address empirical questions, it is interesting to analyze the effect of changes in the frequency of going public during a fixed calendar period. When more IPOs are brought to the market in a fixed calendar period because of a permanent and unexpected shock, the discount factor used between transactions becomes larger (the discount rate becomes smaller because it is for a shorter time period) assuming that the discount rate used during a fixed calendar period is unchanged. Hence, investment bankers act as if they are more patient in the “hot” market (high issue volumes) than in the “cold” market (low issue volumes). By Lemma 2, the expected discounted continuation payoffs will increase. Intuitively, as investment bankers recognize relatively more profitable opportunities in the “hot” market, they are less willing to undercut spreads to give up future profits. Thus, it is easier for investment bankers to implicitly collude in the hot IPO market. (This may seem counter to the Rotemberg-Saloner (1986) result that it is more difficult to collude during booms. The difference in results is because Rotemberg and Saloner are defining a boom as high current volume relative to the present value of future volume. Here, the present value of future volume increases relative to the current transaction in a hot market.) The following Proposition characterizes the nature of changes in the frequency of going public.
Proposition 2: Given the second-best strategy, if there is a permanent shock that brings more IPOs to the market during a fixed calendar period, it is easier to implicitly collude for investment bankers, i.e., the amount of critical proceeds $P_C$ increases.

Table I of Chen and Ritter (2000) shows that there were roughly 360 IPOs with proceeds of at least $20$ million per year during 1995-1998. This average number of IPOs is far greater than that for the period 1991-1994, which was about 260 IPOs per year. Thus, the period 1995-1998 has seen a relatively hot IPO market though it is not clear whether high issue volumes result from a permanent shock. Consistent with the prediction of Proposition 2, $90\%$ of moderate size IPOs have paid the same gross spread of $7.0\%$ and this partly reflects the reluctance of investment bankers to undercut spreads during the relatively hot period.

C. Heterogeneous Investment Bankers

We have assumed that $M$ investment bankers are symmetric and they win the underwriting business with equal probability, which appears in the incentive compatibility condition (2). To reflect differences in underwriters’ size, reputation, analyst coverage, or industry specialization, we investigate heterogeneous investment bankers in this section. These differences may impact the probability of winning a deal and affect the ability of investment bankers to implicitly collude.

Let $h_i > 0$ denote the probability of winning a deal by investment banker $i$ when all investment bankers charge identical gross spreads and $\sum_{i=1}^{M} h_i = 1$. In the previous analysis we assume that $h_i = 1/M$ for all $i$, but now we allow differences, which are characterized by $h_i$, among investment bankers. Alternatively, $h_i$ could be interpreted as the market share of investment banker $i$. Let $H=(h_1, h_2, ..., h_M)$ denote the probability distribution of winning the underwriting business among investment bankers, and let $J_i(P; H)$ be the expected future profits of investment banker $i$ in the second-best equilibrium. Since we investigate the impact of heterogeneous underwriters on the implicit collusion equilibrium, we restrict the analysis to equilibria in which all underwriters charge the same spread and no underwriter has an incentive to deviate from the spread prevalent in the IPO market. Thus, the structure $H$ remains unchanged and it follows that
$$J_i(P; H) = h_i E\left[\sum_{m=1}^{M} J_m(P; H)\right].$$

Let $K(H)$ denote the aggregate expected discounted continuation payoff to all investment bankers where $K(H) = \rho E\left[\sum_{i=1}^{M} J_i(P; H)\right]$. It follows that the expected present value of future profits of investment banker $i$ is $h_i K(H)$.

Now, investment bankers are heterogeneous with the structure $H$. To characterize the effect of heterogeneity among investment bankers on the second-best equilibrium, we need to consider the relevant change in the incentive compatibility condition (2). The following lemma demonstrates that the “smallest” investment banker (in terms of probability or market share when all investment bankers choose identical spreads) is the one most likely to undercut the gross spread.

**Lemma 3:** If the investment banker with the smallest probability of winning a deal (or the smallest market share) chooses not to undercut the gross spread prevalent in the market, then no other investment banker will charge a lower gross spread.

The intuition of Lemma 3 is that the smallest investment banker has the most to gain from marginally undercutting the current spread and the least to lose from a collapse of the implicit collusion equilibrium. Lemma 3 implies that it is the smallest investment banker that determines the equilibrium gross spreads in the setup of heterogeneous underwriters. Thus, we index investment bankers so that investment banker $M$ is the smallest investment banker and define $h_M = \text{min}(h_1, h_2, ..., h_M)$. Lemma 3 facilitates the comparison of the aggregate expected future profits under two different structures and we have the following proposition.

**Proposition 3:** For two different structures $H$ and $H'$ in the second-best equilibrium, if $h_M > h_{M'}$ (that is, the smallest investment banker under the structure $H$ has a higher probability of winning a deal or a larger market share than the smallest investment banker under the structure $H'$), then the aggregate expected future profits under $H$ are not less than those under $H'$, i.e., $K(H) \geq K(H')$. Further, the critical proceeds and the gross spreads under $H$ are larger than under $H'$, i.e., $P_c(H) \geq P_c(H')$ and $S^*(P; H) \geq S^*(P; H')$ for all proceeds $P > 0$.

For the second-best equilibrium with heterogeneous underwriters, the smallest investment banker plays an important role to determine expected future profits and the
gross spreads, as demonstrated in Proposition 3. The higher the share of the smallest investment banker, the higher the gross spreads and the future profits for all investment bankers. The important implication of Proposition 3 is that implicit collusion is easier to sustain in an IPO market where investment bankers are of approximately equal market share because of the larger critical proceeds. Thus, the Herfindahl-Hirschmann index is low under the implicit collusion equilibrium with some specific structure.

Hansen (2001) presents evidence of low concentration measures in the IPO market during recent years and asserts that “the concentration findings argues against collusion.” However, an alternative interpretation is that findings of low concentration could be consistent with the outcome of an implicit collusion equilibrium, as implied by Proposition 3.

D. Endogenous Entry

So far, we have fixed the number of investment bankers. In the long run, if there are no barriers to entry, investment bankers will enter as long as expected future profits are positive. When the number of investment bankers $M$ grows large enough, it is clear that the incentive compatibility condition (2) no longer holds. Thus, under free entry, the implicit collusion equilibrium discussed in previous sections does not arise.

In reality, the explicit costs of entering the IPO market include capital costs and costs of human resources such as analysts with good reputations. The implicit costs of entry typically include developing underwriter prestige. These explicit and implicit costs may represent a significant barrier to entry. As Sherman (2000) points out, one potential barrier to entry is that the incumbent underwriters that are expected to handle book-building IPOs more frequently can greatly reduce expected underpricing for the current offering. The long-term relationships between the incumbent underwriters and their pools of regular uninformed investors allow underwriters to lower average underpricing.

To investigate the issue of endogenous entry, we assume investment bankers incur a fixed entry cost $e > 0$ to enter the IPO market. The following proposition demonstrates that the number of investment bankers $M$ can be endogenously determined by

\[
\sqrt{\frac{1}{M}} K \left( \frac{1}{\sqrt{M}} \right) = e. \tag{5}
\]
**Proposition 4:** If the cost of entry $e > 0$, then the number of investment banker is finite and the implicit collusion equilibrium is sustainable with endogenous entry.

Proposition 4 presents the symmetric case. If investment bankers differ in their cost of entry, then the marginal entrant would make zero expected net profits but established investment bankers with lower entry costs would make strictly positive net profits. Alternatively, if investment bankers conjecture that they could recover their own entry costs in the future, the rent-seeking behavior does not stop. In equilibrium, only the marginal entrants earn zero expected net profits.

New entrants to the IPO underwriting market, such as Deutsche Bank Securities (formerly Deutsche Morgan Grenfell), Friedman Billings Ramsey, and commercial banks like Nationsbank, Bankers Trust, BankAmerica and BancBoston, almost charge the same spread of 7% for offerings between $20 million and $80 million (see Chen and Ritter (2000); Dunbar (2000); Hansen (2001)). In contrast, Gande, Puri, and Saunders (1999) find that underwriter spreads in the corporate debt underwriting market have declined significantly with commercial bank entry. Hansen (2001) argues that the new entry observed in the IPO market is evidence against collusion. Still, Proposition 4 points out that the second-best equilibrium is sustainable with endogenous entry. New entry to the IPO market with almost demanding the same spread could be viewed as rent-seeking behavior under the second-best equilibrium.

From the proof of Proposition 4, we know that $K(1/M)$ decreases in $M$, i.e., the more the number of investment banking firms in the IPO market, the less the expected future profits are. Equation (5) also offers an insight about the entry strategy of commercial banks. To enter the IPO market, commercial banks chose to buy out established investment banking firms rather than set up new subsidiaries or directly jump into the IPO underwriting business themselves. The buyout strategy will not increase the number of investment banking firms in the IPO market. Thus, the expected future profits indicated by the L.H.S. of (5) under the second-best equilibrium are larger than it otherwise would be.

**III. Discussion**

The above dynamic game-theoretic model is based upon certain assumptions that deviate from the institutional framework of the IPO underwriting business. First, it
assumes that there are constant returns to scale (the marginal cost of underwriting is $c$) rather than being characterized by a fixed cost and declining average costs. Second, the model assumes no capacity constraints: a given underwriter can capture all of the underwriting business in a period if it charges the lowest spread, no matter how large the deal. In reality, for all but the largest underwriters, either lowering the offer price or forming a syndicate to share the risks and market a large deal would be required. Furthermore, there are constraints on grabbing numerous deals in an active market because writing a prospectus in a manner that will be approved by the S.E.C. takes time, as does scheduling and conducting a road show. In other words, there are increasing marginal costs of underwriting in the short run for any given underwriter.

Third, the model assumes, as is typical in models of dynamic games with complete information, that in the second-best equilibrium a potential price-cutter assumes that other underwriters will respond by setting spreads equal to marginal cost for all future deals. This threat, with its maximum penalty to a price-cutter, achieves maximal deterrence. It is not at all clear how time-consistent this threat is, however. If the deterrence fails, and one underwriter cuts its spreads, it is not obvious that *ex post* the best response is to cut all future spreads to marginal cost, rather than earn some economic profits on a smaller market share with spreads still above marginal cost. This time-consistency problem is not unique to the model, but is instead a generic problem in game theory.

Fourth, the model assumes that penalties occur entirely in the price dimension; future spreads are set equal to marginal cost. In reality, other underwriters have an opportunity to impose a quantity penalty by excluding a price-cutter from future syndicates.

We conjecture that the effect of all of these deviations from the formal model above is to have an equilibrium where the sustainable spread is above marginal cost, but below the monopoly spread. In other words, the qualitative results from the non-cooperative dynamic game that we have modeled above are likely to hold. Investment bankers realize that they don’t want to turn IPO underwriting into a “commodity business.”
The analysis presented in this paper demonstrates that profitable equilibria can exist even though underwriters directly compete on the price dimension only. On the other hand, Shaked and Sutton (1982) show that product differentiation can relax price competition. If investment bankers can find some other ways to attract deals successfully, they may reduce head-on competition on the gross spread. Thus, the implicit collusion equilibrium will be reinforced. In practice, underwriters of IPOs are able to direct the focus of issuers to other dimensions such as underwriter prestige and analyst coverage (see Carter, Dark, and Singh (1998), Chen and Ritter (2000), Dunbar(2000), Krigman, Shaw, and Womack (2001), among others). There are some merits of analyst coverage. First, more analyst followings in the aftermarket will expand the breadth of investor cognizance and increase the size of the investor base about the IPO firm. Merton (1987) argues that the size of the investor base for a particular firm is positively associated with the value of the firm in the setting of incomplete information among investors. The cost of capital is thus reduced if the IPO firm makes follow-on offerings. Second, the shareholders of the IPO firm will benefit from the enhanced liquidity that results from the analyst coverage and buy recommendation.

**IV. Conclusion**

This article presents a game theoretic model to explain the pattern of “clustering” spreads for a wide range of offerings and lower spreads for large offerings in the IPO market. In a stochastic and infinite horizon setting, investment bankers while acting non-cooperatively may charge underwriting spreads above competitive levels in equilibrium. The model implies that investment bankers are able to sustain a high spread for offerings smaller than some critical level and they have to charge lower spreads for sufficiently large offerings to prevent other investment bankers from undercutting. Another implication of the model is that when more IPOs are brought to the market during a fixed calendar period, it is easier to implicitly collude for investment bankers. The cost of defecting from the “implicit collusion” equilibrium is high in the more active IPO market since investment bankers give up more expected profits during a fixed calendar period if they undercut spreads.
The model also shows that implicit collusion is easier to sustain in an IPO market where investment bankers are of roughly equal market share. This implies that concentration measures that are usually used will be low under the implicit collusion equilibrium, and they cannot precisely distinguish between the competition equilibrium and the implicit collusion equilibrium.

When endogenous entry is considered, the model shows that the second-best equilibrium is sustainable with a barrier to entry. If investment bankers conjecture that they could recoup their own entry costs in the future, the rent-seeking activity will never stop. In equilibrium, only the marginal entrants earn zero expected net profits. Thus, new entry to the IPO market without undercutting spreads could be viewed as rent-seeking behavior under the second-best equilibrium, rather than evidence that perfect competition exists.

The evidence of IPO gross spreads from the 1990s is consistent with the implications of the implicit collusion model.
REFERENCES


APPENDIX

Proof of Lemma 1: The part of necessity is obvious. To prove sufficiency, suppose that there exists one equilibrium other than the competitive equilibrium. There must be some pricing rule that specifies the underwriting spread above the competitive level as the part of the equilibrium strategy other than the competitive equilibrium strategy. From (1), this will yield positive expected continuation payoffs to investment bankers as a group, a contradiction. Q.E.D.

Proof of Proposition 1: Step 1: Based on the work of Abreu (1988), we know that the equilibrium strategy can be specified as two parts: (1) the initial path and (2) the punishment paths, one for each investment banker.

The initial path is followed in the event that no player deviates from this path in the past. And some punishment is imposed in the event that some player deviates from the initial path or from any punishment path. Further, the optimal punishment is the pricing rule that yields the lowest expected profit. Obviously, we can take the optimal punishment to be "pricing at marginal cost in each period." Now, we need to construct the initial path. Let \( K = \rho E(J(P)) \) be the present value of expected continuation payoffs to investment bankers as a group under the initial path. Suppose that the current size of the IPO is \( P \) and \( K \) is greater than zero. From the incentive compatibility condition (2), the collusive price is sustainable if and only if

\[
\frac{K}{M} \geq (1 - \frac{1}{M}) \pi(S^n; P)
\]

Since \( \pi(S^n; P) \) is strictly increasing in \( P \), the above inequality may not always hold. Define critical offering size \( P_C \) as the solution to

\[
\frac{K}{M} = (1 - \frac{1}{M}) \pi(S^n; P), \quad \text{(A1)}
\]

if a solution exists. Note that \( P_C \) depends on \( \rho \) since \( K = \rho E(J(P)) \). If

\[
\frac{K}{M} < (1 - \frac{1}{M}) \pi(S^n; P),
\]

then define \( P_C = P \). On the other hand, if

\[
\frac{K}{M} > (1 - \frac{1}{M}) \pi(S^n; P),
\]

then define \( P_C = \bar{P} \).
Construct the initial path as follows: (1) For $P \leq P^C$, price at the collusive spread $S^m$.
(2) For $P > P^C$, price at $S^*$ which solves

$$\frac{K}{M} = (1 - \frac{1}{M}) \pi(S^*; P).$$

(A2)

Note that $S^* < S^m$ because we restrict $S^* \leq S^m$ and $S^*$ can not be equal to $S^m$ from (A2).

The construction of the initial path and the punishments gives the second-best strategy. To make this clear, observe that the incentive compatibility condition is always satisfied and the pricing strategy is deviation-proof, if investment bankers follow this second-best strategy from the next period onward. Furthermore, the strategy achieves the highest profit among the sustainable set of prices. From the second-best strategy and (1), it follows that

$$J(P) = \begin{cases} \pi(S^m; P) + K & \text{for } P \leq P^C \\ \frac{K}{M-1} + K & \text{for } P > P^C \end{cases}$$

(A3)

Combination of (4) and (A3) implies

$$E( J(P) ) \leq \frac{MK}{M-1} \text{ for all } P.$$  

(A4)

Substituting $K = \rho E(J(P))$ into (A4), we have the inequality $\rho \geq (1 - 1/M)$ since we assume $K > 0$ at this point. Therefore, if $\rho < (1 - 1/M)$, then $K = 0$ and the unique equilibrium is the competitive equilibrium from Lemma 1.

Step 2: In step 1, we suppose $K > 0$. Here, we show that the expected discounted continuation payoffs are positive for sufficiently large discount factors. In fact, there exists $\rho_0 < 1$ such that $K > 0$ for $\rho \geq \rho_0$. To show this, we construct another equilibrium for an appropriate discount factor: choose any $P_0 > P$ and for $P \leq P_0$, charge the underwriting spread according to the collusive pricing strategy while for $P > P_0$, price at the marginal cost. Lemma 1 tells us the underwriting spread for $P > P_0$ is the equilibrium price. Let $K_0$ be the expected lifetime payoff to this strategy. We have

$$K_0 = \frac{\rho}{1 - \rho} \int_{P}^{P_0} \pi(S^m; P) dF(P).$$

(A5)

The strategy is incentive compatible for $P \leq P_0$ if and only if

$$\frac{K_0}{M} \geq (1 - \frac{1}{M}) \pi(S^m; P),$$

(A6)
for $P \leq P_0$. From (A5), there exists an appropriate discount factor $\rho_0 < 1$ such that (A6) holds. Since the profits to this strategy are strictly positive from the right hand side of (A6), it follows that the second-best profits are strictly positive for $\rho = \rho_0$. Hence, Lemma 2 implies that $K > 0$ for $\rho \geq \rho_0$.

Using step 1 and step 2, we have established that there exists a discount factor $\rho_0 \in [1-1/M, 1)$ such that: (1) for $\rho < \rho_0$, the unique equilibrium is the competitive equilibrium and $K = 0$; (2) for $\rho \geq \rho_0$, the second-best pricing strategy exists and is described as in step 1 and $K > 0$. Q.E.D.

**Proof of Proposition 2:** Let $R$ denote the discount rate over a fixed calendar period (e.g., one year) with $n$ IPOs brought to the market. Therefore, in the model, there are $n$ periods during the fixed calendar period and the discount factor between any two IPOs will become

$$\rho_n = \left(\frac{1}{1 + R}\right)^n,$$

and we have

$$\frac{d\rho_n}{dn} = \frac{\rho_n}{n^2} \ln(1 + R) > 0.$$

When the frequency of going public increases during a fixed calendar period, the discount factor applied to the next IPO, $\rho_n$, increases monotonically. From Lemma 2, $K$ increases as $\rho_n$ increases and in turn $P_c$ increases, this follows directly from the definition of $P_c$. Hence, as $n$ increases, it is easier to implicitly collude among investment bankers and the second-best profits also increase. Q.E.D.

**Proof of Lemma 3:** We consider equilibria in which all investment bankers charge identical gross spreads on the equilibrium path. A slight modification in the incentive compatibility condition (2) reveals that the spread $S'$ is sustainable if

$$h_1[\pi(S'; P') + K(H)] \geq \pi(S'; P')$$

(A7)
for all \( i = 1, 2, \ldots, M \). The maximal profits for undercutting is given by the R.H.S. of (A7) since investment banker \( i \) can capture the entire deal by marginally undercutting the current spread. The incentive compatibility constraint (A7) is then reduced to

\[
K(H) \geq \left( 1 - \frac{h_i}{h_M} \right) \pi(S'; P') \tag{A8}
\]

Without loss of generality, we index investment banker so that underwriter \( M \) is the smallest underwriter, that is, \( h_M = \min(h_1, h_2, \ldots, h_M) \). It is easy to see that the R.H.S. of (A8) is maximized when \( h_i = h_M = \min(h_1, h_2, \ldots, h_M) \). It implies that if investment banker \( M \) does not undercut the gross spread, neither do any of the other investment bankers. Q.E.D.

**Proof of Proposition 3:** The approach here is based on the iterative algorithm developed by Dutta and Madhavan (1997) to construct the second-best value function. Then, the algorithm is employed to compare the aggregate expected future profits under different structures.

**Step 1:** Consider the first-best value function for a given structure \( H \) when investment bankers act as a cartel. Denote these payoffs \( J_0(P; H) \), where

\[
J_0(P; H) = \pi(S^\text{m}; P) + \rho E[J_0(P; H)] \tag{A9}
\]

Note that \( J_0(P; H) \) is independent of the structure \( H \) from the assumption of bankers acting as a cartel. To use the iterative algorithm, we consider the value function \( J_1(P; H) \) which is defined by the mapping \( TJ_0(P; H) \), where

\[
J_1(P; H) = TJ_0(P; H) = \max_{S} \left\{ \pi(S; P) + \rho E[J_0(P; H)] \right\} \tag{A10}
\]

subject to \( \rho E[J_0(P; H)] \geq \left( 1 - \frac{h_M}{h_M} \right) \pi(S; P) \). \tag{A11}

Equations (A10) and (A11) can be interpreted as the following “one-shot” game: If all investment bankers charge the same spread \( S \), investment banker \( i \) obtains a payoff \( h_i \left[ \pi(S; P) + \rho E[J_0(P; H)] \right] \), where the first-best value \( J_0(P; H) \) can be interpreted as the payoff investment bankers anticipate for not undercutting the spread \( S \). If one investment banker marginally undercut the current spread, this investment banker receives expected
profits $\pi(S; P)$. The highest equilibrium payoff to this game is then defined by the mapping $T$.

Now we consider to continue the iteration one more step and define the value function $J_2(P; H)$ to be

$$J_2(P; H) = TJ_1(P; H) = \max_3 \{\pi(S; P) + \rho E[J_1(P; H)]\}$$

subject to $\rho E[J_1(P; H)] \geq \left(1 - \frac{h_\ell}{h_M}\right)\pi(S; P)$.  

(A12) Similarly, both (A12) and (A13) are interpreted as another “one-shot” game: if investment bankers set the spread $S$, investment banker $i$ receives a payoff $h_i[\pi(S; P) + \rho E[J_1(P; H)]]$. However, if the investment banker deviates, he or she receives expected profits $\pi(S; P)$. Equivalently, $J_2(P; H)$ can be interpreted as the highest sustainable profits in a game of three periods, where the game proceeds to higher rounds if and only if no investment banker has undercut the spread in the previous round and the round-three payoff is the first-best value $J_0(P; H)$.

Proceeding in this way, we can define $J_{n+1}(P; H) = TJ_n(P; H)$. Note that $J_0(P; H) \geq J_1(P; H)$ because $J_0$ solves the maximization problem (A10) without the incentive compatibility condition imposed by (A11). Therefore, the set of spread $S$ that is feasible in (A13) must also satisfy the incentive compatibility condition (A11). On the other hand, the maximand in (A12) is smaller than that in (A10). These facts imply that $J_1(P; H) \geq J_2(P; H)$. By the same argument, if follows that $J_n(P; H) \geq J_{n+1}(P; H)$.

Since we have a monotonic and bounded sequence with an upper bound $J_0(P; H)$ and a lower bound 0, we can define the limit $J(P; H) = \lim_{n \to \infty} J_n(P; H)$ for every $P$. Thus, by continuity, $J(P; H) = TJ(P; H)$. The mapping $TJ$ gives the maximal payoffs from incentive-compatible spreads with $J$ as the continuation payoffs. From the interpretation of (A10) through (A13), the fixed point of the mapping, $J(P; H)$, must be the second-best value function.

**Step 2:** Now we can compare the second-best values under the structure $H$ and $H'$. From Lemma 3, we only focus on the smallest investment banker. Assume that $h_\ell > h_{M'}$, and note that $J_0(P; H) = J_0(P; H')$. It follows from equation (A11) that the set of spreads
that are sustainable in equilibrium is smaller under the structure $H'$. Hence, $J_1(P; H) \geq J_1(P; H')$. The same argument yields $J_n(P; H) \geq J_n(P; H')$ for all $n$ and $P$. Therefore, in the limit, $J(P; H) \geq J(P; H')$ for all $P$ and $K(H) \equiv \rho E[J(P; H)] \geq \rho E[J(P; H')] \equiv K(H')$.

Similar to (A1), we can define the critical offering size (gross proceeds) $P_c(H)$ under the structure $H$ as the solution to $h_m K(H) = (1 - h_m)\pi(S^m; P)$. Since $\pi$ is increasing in $P$, it is clear that $P_c(H) \geq P_c(H')$.

To compare the gross spreads, there are three case to consider: (i) $P \leq P_c(H')$, the monopoly spread is incentive compatible for both $H$ and $H'$. (ii) $P_c(H') < P \leq P_c(H)$, the monopoly spread is incentive compatible for $H$ but not for $H'$. (iii) $P_c(H) < P$, the monopoly spread is not sustainable under either $H$ or $H'$.

In case (ii) and (iii), the sustainable spread must be lower than the monopoly spread. From the incentive compatibility condition, it follows that any spread that is incentive compatible under $H'$ will also be incentive compatible under $H$. Therefore, the spread under $H$ is higher than under $H'$. Q.E.D.

**Proof of Proposition 4:** The expected discounted continuation payoff is $K(H) = \rho E(J(P; H))$. Proposition 3 implies that the second-best profit level is a function of the minimum share alone. Thus, when investment bankers are symmetric, we have $K(H) = K(1/M)$. From the last step of the proof of Proposition 3, assuming $h_m = 1/M > h_m' = 1/N$, similar arguments show that $K(1/M)$ decreases in $M$. If we ignore the integer constraint, the equilibrium number of investment bankers with endogenous entry solves the following equation:

$$\frac{1}{M} K\left(\frac{1}{M}\right) = e.$$ 

Since $1/M$ and $K(1/M)$ all decrease in $M$, it immediately follows that $M$ is finite when $e > 0$. Therefore, the implicit collusion equilibrium is sustainable with endogenous entry. Q.E.D.
ENDNOTES:


3 In the same spirit, Andrew D. Klein has the following comment: "Out of mutual self-interest, most bankers have lived by a not-needed-to-discuss code that they wouldn't cut spreads." See Business Week, November 9, 1998. Also, an anonymous head of underwriting for an investment bank says of the gross spread, "The fact is, we'd been cutting our own throats to compete on price." See Wall Street Journal, page C1, April 10, 1997.

4 One example of expected profit function is \( \pi(S; P_t) = \phi(S) \cdot (S \cdot P_t - c \cdot P_t) \), where \( \phi(S) \) is the probability that the issuing firm will accept the deal under the spread of \( S \). Assuming that the function \( \phi(S) \) is strictly decreasing and \( \phi(S) \cdot \phi'(S) < 2(\phi(S))^2 \) can assure the existence of the monopoly spread which is independent of the amount of gross proceeds.

5 As described in Dutta and Madhavan (1997), the "first-best" equilibrium refers to overt collusion since it yields the highest profits for the investment banking industry. Note that overt collusion is not an equilibrium of the non-cooperative pricing game discussed in this paper.

6 The cooperative bargaining feature of the underwriting syndicate is not pursued here. While investment bankers share revenues through the underwriting syndicate, in practice the lead manager grabs the lion’s share of revenues. Table V of Chen and Ritter (2000) shows how the gross spread is split in a typical syndicate. Therefore, assuming that each investment banker acts independently to try to lead the deal would be appropriate.

Pichler and Wilhelm (2001) model the underwriting syndicate from the perspective of the information production role of investment bankers and the potential for free riding within the syndicate.