

# The Demise of Investment Banking Partnerships: Theory and Evidence

ALAN D. MORRISON AND WILLIAM J. WILHELM, JR.\*

## ABSTRACT

In 1970 the New York Stock Exchange relaxed rules that prohibited the public incorporation of member firms. Investment banking concerns went public in waves, with Goldman Sachs (1999) the last of the bulge bracket banks to float. We explain the pattern of investment bank flotations. We argue that partnerships foster the formation of human capital and we use technological advances that undermine the role of human capital to explain the partnership's going-public decision. We support our theory using a new data set of investment bank partnership statistics.

---

\*Morrison is from the University of Oxford Saïd Business School and the Center for Economic Policy Research. Wilhelm is from the University of Virginia McIntire School of Commerce and the Center for Economic Policy Research. The authors are grateful to Raj Aggarwal, Ben Esty, Eric Hughson, Heski Bar-Isaac, Pete Kyle, Chris Leach, Alexander Ljungqvist, Colin Mayer, Ed Perkins, Carola Schenone and an anonymous referee for useful conversations and to seminar participants at the Cambridge Endowment for Research in Finance, the University of Western Ontario, the University of Colorado at Boulder, Tanaka Business School (Imperial College), the London School of Economics, the University of Southern Carolina, the University of Frankfurt and the American Finance Association meetings in Boston, 2006 for helpful comments. The authors thank to Stuart Glass and Steven Wheeler at the NYSE archives for their considerable patience and for assistance with the use of exchange records. Brendan Abrahms, Thomas Knoll, Mary Weiskopf and David Wilhelm provided valuable research assistance.

In 1970 the New York Stock Exchange (NYSE) relaxed its rules to permit joint stock corporate ownership among members. Existing member firms, all of which were constituted as partnerships or as closely held private corporations, did not immediately go public en masse. An initial wave of retail and brokerage firms chose to float in 1970 and 1971<sup>1</sup>; other members waited over a decade, and the last bulge bracket investment bank to float was Goldman Sachs, in 1999. That some firms chose to wait so long to float indicates that for some time after 1970 they found the partnership form preferable to the joint stock form; conversely, the early-movers clearly expected to derive advantages from flotation. In this paper we explain these observations, and we argue that the going-public decision was affected by technological innovations in both information technology and finance. We support our reasoning using a firm-level data set containing both the identity and number of partners (or key individuals) and firm capitalization.

In order to provide an economic basis for the partnership's going-public decision, we need a model that explains the economic rationale for the partnership form. Previous work focusses on the importance of profit-sharing rules in incentivizing hard work, signalling employee quality, and efficiently allocating tasks.<sup>2</sup> Our model, which extends Morrison and Wilhelm (2004), focuses on the importance of tacit human capital. Tacit human capital, first discussed explicitly by Polanyi (1966), covers forms of knowledge and skills that do not easily lend themselves to codification or to arms-length exchange. In the context of this paper, such skills include a range of talents such as advising clients, building relationships, reading market signals, and negotiating M&A deals. These skills, which are essential to investment banking, can only be learned on the job: While an MBA program can furnish a student with technical skills, it cannot teach her how to be an investment banker.

While tacit human capital is valuable to clients, by its nature it is hard to measure and virtually impossible to contract upon. This leads to a fundamental learning problem. Only a skilled agent can transfer his or her skills to a new hire, typically through a mentoring relationship. But mentoring involves costly and unobservable effort and hence is uncontractible. While contracting upon mentoring between junior and senior agents is economically desirable, it is impeded by the danger that either the senior agent will accept payment and then withhold mentoring, or that the junior agent will receive mentoring and then withhold payment for it. In this situation institutional arrangements are needed to provide the necessary mentoring incentives. We argue that the partnership is an appropriate arrangement.

Extending Morrison and Wilhelm (2004), our basic model rests upon two important distinguishing features of partnerships: namely, their opacity and the illiquidity of their shares. A partnership's opacity is manifested through relatively flat pay scales, an "up-or-out" employment policy, and an emphasis upon teamwork.<sup>3</sup> These factors prevent outsiders from observing the quality of a partnership's employees until it is revealed through a firing decision. Partnership shares are extremely illiquid; it is very costly for partners to leave the firm without the consent of their peers.<sup>4</sup> Publicly traded firms attempt to use devices such as noncompete contracts to bind employees to the firm, but these contracts are hard to enforce.

We incorporate these features in a simple model of an infinitely lived firm that deals in the human capital-intensive production of experience goods. Agents are born without human capital in our model and they have two-period careers. The firm hires some agents as unskilled "associates" and provides them mentoring. After one period a fixed fraction of the associates become skilled and in equilibrium are promoted to partner. The other associates are fired. Because the firm is assumed to be opaque, only insiders can observe an associate's after-mentoring quality; outsiders learn the associate's quality slowly by experience in the final period of his career. For this reason an associate who is fired is rewarded in the labor market as a low quality agent. In turn, partnerships can offer illiquid partnership stakes to skilled associates on a take-it-or-leave-it basis. New partners cannot sell their stake until the end of their careers, at which time their quality has been learned by their clients.

The partnership's institutional reputation provides the mentoring incentives in our model. A partnership that is regarded as trustworthy can earn high fees for its partners. A single unskilled partner is sufficient for the partnership to lose its reputation and with it, its ability to charge high fees. An unskilled associate anticipates that his type will be discovered if he accepts a partnership; this will precipitate a loss of partnership reputation and so will prevent him from cashing out upon retirement. It follows that unskilled agents refuse promotion to partnership. A newly promoted partner anticipates that there will be a market for his partnership stake only if there are sufficient skilled associates when he retires. He therefore mentors new associates in order to assure himself of an adequate return on his partnership stake.

There is a free-rider problem in mentoring that places an upper bound on the size of the partnership. This reduces the partnership's ability to make significant investments in physical capital: Very large investments will be used by a suboptimal number of partners, and some of the

capital will remain idle. Because partnerships will not make capital investments when the costs of idle capital are sufficiently large, the going-public decision therefore boils down to a trade-off between investment in human and physical capital. When the efficiency gains from large physical capital investments are sufficiently large, the partnership will float.

We examine this hypothesis from the perspective of the U.S. investment banking industry. Investment banking has traditionally rested upon human capital. The data we present indicate that the industry has always been dominated by a small number of powerful players. Historically, these individuals relied upon their skills, their personal contacts, and their reputations, rather than upon financial capital. The skills of the most important investment bankers were not codified, and could only be obtained through a lengthy, and initially not very well-paid, on-the-job apprenticeship as a clerk. The clerk's job was perceived as a valuable one, and entry-level positions were generally reserved for the family and friends of senior investment bankers. In light of our theory of partnership firms, the fact that the most important investment banking houses were constituted as partnerships should not be surprising.

The NYSE membership's decision to permit public ownership of member firms followed more than a decade of advances in transistor-based computers. Over the course of the 1960s advances in batch-processing enabled substitution of computers for human capital in routine administrative activities such as settling transactions, maintaining client balances, mailing confirmations, and so on. But computing systems remained costly and time sharing options were few. Merrill Lynch and other retail-oriented firms were early adopters, as their large transaction throughput enabled efficient, large-scale application of the new technology.<sup>5</sup> Consistent with the predictions of our theory, these firms responded to the technological shock by rapidly increasing the size of their partnerships as well as their per-partner capitalization and number of employees. The firms that were slow to adapt failed or were acquired in the midst of back-office crises. This chain of events coupled with the preponderance of retail firms among the first wave of public offerings through the mid-1970s is consistent with our prediction that a technologically driven shift in the trade-off between human and physical capital led to a staged demise of investment banking partnerships. Wholesale firms like Goldman Sachs, with their greater emphasis on big ticket market making and proprietary trading, derived little competitive advantage from advances in the batch processing capabilities of 1960s computers and thus largely were immune from the pressures that forced the first stage of reorganization.

The demise of partnership organization among wholesale houses was precipitated by the development in the late 1970s of the microcomputer and its subsequent widescale adoption in the 1980s. The microcomputer allowed real-time computations and hence facilitated the widescale adoption of the financial engineering techniques derived from the Black and Scholes (1973) model that codified previously tacit practices. This had two effects. First, it increased the relative importance in the investment banking industry of technical skills that could be learned in the classroom. Second, it significantly reduced the costs of entry into derivative and other trading markets. Our model suggests that the first of these effects reduced the importance of mentoring and in turn undermined the partnership form. The second caused a sharp decline in bid-ask spreads, which increased the minimum scale at which market making remained profitable. This resulted in a greatly increased need for financial capital and therefore generated size pressures in the partnerships. Given the declining relative importance of tacit human capital, our model suggests that the second wave of flotations beginning in the early 1980s was a rational response to the size pressures facing trading houses. By 1987 Goldman Sachs and Lazard Freres were the only prominent wholesale firms that remained in private hands but the special circumstances surrounding these firms actually lends further weight to our interpretation.

The remainder of the paper is organized as follows. We present our theory of partnerships and their going public decision in section I. Section II contains supporting evidence. Section III concludes.

## I. Theory

Our model extends Morrison and Wilhelm (2004) to incorporate investment in physical capital and the going-public decision.

### A. Model

We consider a discrete time model of an infinitely lived firm. Agents in the model are risk neutral and have two-period careers. Each agent starts his career with no personal wealth and no skills. If an agent is mentored in the first period of his career he may become skilled. There is a competitive labor market, but a firm can discover an agent's type only by employing him. The per-period risk-free interest rate is  $r$ .

The agents participate in a productive process that relies upon human capital. The human capital may be augmented by physical capital; the minimum investment in physical capital is denoted by  $M$ . Without physical capital, the per-period product of an unskilled agent is  $w_l$  and that of a skilled agent is  $w_h = w_l + \Delta w > w_l$ . The corresponding figures with the use of physical capital are  $w_l + v_l$  and  $w_h + v_h$ . Define  $W_h$  and  $W_l$  to be the respective net output of skilled and unskilled agents who have access to physical capital. The per-period cost of a unit of physical capital is  $r$  and thus

$$W_h \equiv w_h + v_h - r;$$

$$W_l \equiv w_l + v_l - r.$$

We define  $\Delta W \equiv W_h - W_l$ .

We think of the physical capital as a technology, such as a computerised accounting system or a client database, which increases the productivity of skilled and unskilled partners. We assume that the technology exhibits constant returns beyond its minimum scale.<sup>6</sup>

[FIGURE 1 HERE]

The career path of an agent who is hired at time 1 is illustrated in Figure 1, in which the associate and partner generations are labelled  $G_A$  and  $G_P$ , respectively. At each time there are  $N$  partners and  $n$  associates are hired per partner. An associate and the partners learn the associate's skill level at time 2, but agents outside the firm are prevented from doing so by the firm's opacity. An associate may be made a time-2 take-it-or-leave-it offer to buy a single share in the partnership, or he may be fired. Per-period wages are  $w_A$  for associates, and  $w_P$  for partners.

In line with observations in the introduction, we assume that partners cannot leave the firm before retirement. Skilled partners are able to mentor associates at a personal cost  $c$ . If  $M \leq N$  skilled partners monitor, then  $M$  associates drawn at random from the  $Nn$  associates will become skilled. If  $M$  is strictly less than  $N$  there is no way of knowing which partner shirked his responsibilities. Note that no associate is guaranteed to become skilled. When all partners perform mentoring, employment as an associate is equivalent to participation in a lottery in which the probability of success is  $\frac{1}{n}$  and the prize is a human capital augmentation in the second career period.

Clients cannot observe partner type at time 2. Rather, they learn it at time 3 through experience. At this stage it becomes common knowledge,<sup>7</sup> but it is not verifiable in a court and hence

cannot form part of the fees contract. At time 3 partners sell their shares, receive a dividend, and retire.

Contracting upon mentoring is not possible and, even if a new associate was willing at time 1 to commit to train the next generation in exchange for receiving training, such a commitment would not be time consistent. In this setting, we define a partnership equilibrium as follows:

DEFINITION 1: A partnership equilibrium consists of a share price<sup>8</sup>  $P$  at which new partners acquire a partnership stake, wages  $w_A$  and  $w_P$ , and a rule relating realised partner quality to future willingness to pay  $w$  such that:

- (PE1)  $w$  is the expected next-period productivity of partners;
- (PE2) New associates wish to join the firm;
- (PE3) Skilled associates wish to enter the partnership;
- (PE4) Unskilled associates do not wish to enter the partnership;
- (PE5) New partners elect to mentor associates.

Partnership equilibria overcome the time consistency problem in mentoring. That is, Definition 1 implies that when a new associate joins the firm he will receive mentoring but will also commit himself to providing mentoring in the future if he becomes skilled. Hence, partnerships are devices for incubating and transferring human capital that cannot be exchanged at arm's length.

Of course, partnerships are socially useful only if mentoring is optimal. The respective conditions for this to be the case with and without physical capital are given by equations (1) and (2):

$$c < \frac{\Delta w}{1+r}; \tag{1}$$

$$c < \frac{\Delta W}{1+r}. \tag{2}$$

### B. Existence of Equilibria

In this section we examine the conditions under which a partnership equilibrium exists. To do so, we define  $\pi_l$  and  $\pi_h$  to be the per-period product of skilled and unskilled agents, respectively, and assume that associates are prepared ex ante to pay for mentoring:

$$c < \frac{\Delta \pi}{1+r}. \tag{3}$$

Without physical capital we have  $\pi_l = w_l$  and  $\pi_h = w_h$ , so that condition (3) coincides with the social optimality condition (1); with physical capital we have  $\pi_l = W_l$ , but for reasons that we explain below, the value of  $\pi_h$  will depend upon both  $W_h$  and the minimum operating scale  $M$ .

The precise value of  $P$  will depend upon bargaining between outgoing and new partners, but is not important. Without loss of generality, we assume that  $P$  is the fair value of the company.

The key to the partnership equilibrium is the rule relating client willingness to pay  $w_C$  to realized partner quality. We set  $w_C$  equal to  $\pi_h$  if every previous partner was skilled, and to  $\pi_l$  otherwise. This rule reflects the importance of institutional reputation: We call a partnership *trustworthy* if  $w_C = \pi_h$  and *untrustworthy* otherwise. Fear of reputation loss incentivizes mentoring: In this sense, partnerships are repositories of collective reputations.

To show that trustworthy firms are in partnership equilibrium when clients are willing to pay  $w_C$  we first need to examine the properties of an untrustworthy firm. It is convenient, although not essential, to assume that outside firms who uncover an unskilled partner assign positive probability to the event that at least one of his peers performed mentoring. Morrison and Wilhelm (2004) show in a version of the model without physical capital that this assessment is consistent in the sense of Kreps and Wilson (1982). With this assumption, skilled agents in untrustworthy firms *strictly* prefer resignation, in which case they will earn in excess of  $\pi_l$ , to accepting a partnership, in which case they will earn  $\pi_h$ . Future hires will therefore be unmentored so that the rule  $w_C$  is time consistent. The unmentored hires will demand the whole of their per-period product  $\pi_l$  and the value of an untrustworthy firm will therefore be zero.

Now consider a trustworthy firm in which every agent in the current generation acts in accordance with rules PE3 through PE5 and all agents in future generations are expected to do likewise. To show that the economy is in a partnership equilibrium, we need only show that no agent has an incentive to deviate from this behavior. We proceed by proving a series of lemmas.

LEMMA 1: *Assume that  $w_A \geq 0$  and  $c > n\pi_l$ . Then PE2 is satisfied by setting  $w_A = 0$ .*

*Proof:* Since the share price  $P$  is a constant, each partner's total equilibrium income from salary and dividends must be the sum of net income from associates and his own marginal product, or  $n(\pi_l - w_A) + \pi_h$ . In the second period of their career new associates will receive this sum less the cost  $c$  of mentoring new associates with probability  $\frac{1}{n}$  and will otherwise earn  $\pi_l$ . Their outside option is to earn  $\pi_l$  in both periods of their life. The individual rationality (IR) constraint PE2 can therefore

be written as  $\frac{1}{n} \left( w_A + \frac{n(\pi_l - w_A) + \pi_h - c}{1+r} \right) + \left( 1 - \frac{1}{n} \right) \left( w_A + \frac{\pi_l}{1+r} \right) \geq \pi_l \frac{2+r}{1+r}$ , or  $w_A \geq \pi_l - \left( \frac{\Delta\pi - c}{nr} \right)$ . Since  $c < \frac{\Delta\pi}{1+r}$ ,  $\frac{\Delta\pi - c}{nr} > \frac{c(1+r) - c}{nr} = \frac{c}{n}$ , which is greater than  $\pi_l$  by assumption, so PE2 is satisfied at any nonnegative wage.<sup>9</sup>

LEMMA 2: *The individual rationality constraint PE3 for entering the partnership is given by equation (4):*

$$c < \frac{\Delta\pi}{1 + \frac{1}{N(n-1)}} + n\pi_l. \quad (4)$$

*Proof:* With  $w_A = 0$ , partners receive a per-period dividend equal to total production:  $(\pi_h + n\pi_l) - w_P$ . Since trustworthy firms remain trustworthy in equilibrium, the per-share ex div firm value is therefore

$$P = P_{TR} \equiv \frac{\pi_h + n\pi_l - w_P}{r}. \quad (5)$$

A skilled agent earns utility  $\pi_h + n\pi_l - c$  from accepting a partnership offer. If he refuses and is fired then the labor market knows that precisely one of the  $N(n-1) + 1$  agents returning to the workforce is skilled<sup>10</sup> and so pays each of them a wage of  $\frac{N(n-1)\pi_l + \pi_h}{N(n-1)+1}$ . Accepting promotion dominates being fired precisely when equation (4) is satisfied.

The first assumption in Lemma 1 reflects the associate's lack of wealth; we assume that  $n\pi_l \leq c \leq n\pi_l + \frac{\Delta\pi}{1 + \frac{1}{N(n-1)}}$  so that both the second condition and equation (4) are satisfied. We also assume that the outgoing partners can arrange financing for the penniless associate to purchase his partnership share.<sup>11</sup>

LEMMA 3: *Unskilled agents will accept partnerships only at prices below  $P_{USK} \equiv \frac{\Delta\pi + n\pi_l}{1+r} < P_{TR}$ . In equilibrium, retiring partners will not offer shares at this price provided  $N \geq \sqrt{1+r} (\sqrt{r} + \sqrt{1+r})$ .*

Lemma 3 implies that if a partner shirks his mentoring responsibility, the firm optimally reduces the number of partners rather than accepting an incompetent partner. Hence, at the prevailing share price no unskilled agent enters the partnership, so that PE4 is satisfied.

*Proof:* If an unskilled agent accepts a partnership stake, the firm will become untrustworthy and his share will have value zero. In the meantime, he can earn a wage  $\pi_h$ . He therefore accepts a partnership at share price  $P$  if and only if  $-P(1+r) + \pi_h + n\pi_l \geq \pi_l$ , or  $P \leq P_{USK}$ .

If a partner shirks his training responsibilities, then only  $N-1$  associates will become skilled. The partnership can either promote  $N-1$  partners at share price  $P_{TR}$  and remain trustworthy,

or it can promote  $N$  partners at share price  $P_{USK}$ , in which case the firm will, after one further period, become untrustworthy.<sup>12</sup> The income from the former strategy exceeds that from the latter precisely when  $(N - 1) \frac{\pi_h - w_P + n\pi_l}{r} \geq N \left( \frac{\Delta\pi + n\pi_l}{1+r} \right)$ , or

$$w_P \leq \frac{N(N - (1 + r))}{(N - 1)(1 + r)} (\pi_h + n\pi_l) + \pi_l \frac{Nr}{(N - 1)(1 + r)}.$$

The multiplier of  $(\pi_h + n\pi_l)$  in this expression exceeds one for

$$N \geq \sqrt{1 + r} (\sqrt{r} + \sqrt{1 + r}). \quad (6)$$

Since  $w_P < (\pi_h + n\pi_l)$ , this condition is satisfied, as required.

LEMMA 4: *Partners choose to mentor, and hence PE5 is satisfied, precisely when*

$$N \leq \frac{P_{TR}}{c(1 + r)}. \quad (7)$$

Lemma 4 places an upper bound on the partnership that rules out free-riding in mentoring. As we show below, the free-rider problem is central to the going-public decision.

*Proof:* Mentoring is subject to a free-rider problem among partners. A partner who shirks mentoring retains the entire associated utility gain  $c$  while the losses associated with his behavior are shared equally among the partners. If the number of partners is reduced from  $N$  to  $N - 1$ , the per partner share value declines by  $P_{TR} - \frac{N-1}{N}P_{TR} = \frac{P_{TR}}{N}$ . This loss is experienced at the end of the partner's career, while the mentoring cost is incurred immediately. Thus, partners mentor associates rather than suffer this loss if and only if  $c \leq \frac{P_{TR}}{N(1+r)}$ : this reduces to condition (7).

The preceding discussion is summarized in proposition 1.

PROPOSITION 1 (Existence of Partnership Equilibria): *Suppose that conditions (3), (4), (6), and (7) are satisfied. Then wages  $w_A = 0$  and  $w_P < \pi_h$  with the client payment rule  $w_C$  together constitute a partnership equilibrium.*

*Proof:* We have shown that no mentoring occurs in untrustworthy partnerships, and that in trustworthy partnerships it does occur, so that PE1 is satisfied. Conditions PE2 to PE5 follow from Lemmas 1 to 4.

### C. Physical Capital and the Free-Rider Problem

Lemma 4 demonstrates that a free-riding problem in monitoring constrains the partnership size. When the partnership relies upon physical capital this may introduce inefficiencies by preventing capital use at the minimum efficient scale. It is for this reason that the per-period product  $\pi_h$  of a partner may drop below  $W_h$ . In this section we examine this effect and demonstrate that in some situations it may render a partnership equilibrium unsustainable.

A partnership of size  $N$  will use  $N(n+1)$  units of physical capital. If this is below the minimum operating scale  $M$ , then  $(M - N(n+1))$  units of capital will remain idle. The cost of any idle capital must be shared equally among the partners. In a partnership firm with capital the output of a partner *net of the cost of idle capital* is therefore

$$\pi_h = W_h - \max \left\{ r \left( \frac{M}{N} - (n+1) \right), 0 \right\}. \quad (8)$$

For a sufficiently high minimum operating scale  $M$  the idle capital problem reduces each partner's productivity because he has to bear more than his marginal capital costs. This reduces the cost of reputation loss and hence exacerbates the free-rider problem. It is not clear in this situation that the no free-riding condition (7) can be satisfied: Lemma 5 establishes when it can be, and also the corresponding maximum partnership size.

LEMMA 5: *The no free-riding condition (7) can be satisfied in a partnership with physical capital if and only if*

$$M \leq M_h \equiv \frac{1}{4cr^2(1+r)} (W_h + nW_l + r(1+n))^2. \quad (9)$$

When condition (9) is satisfied, the maximum partnership size for which free-riding will not occur is  $\bar{N}$ :

$$\bar{N} \equiv \begin{cases} \text{int } N_{NIC}, & \text{if } M \leq M_l; \\ \text{int } N_{IC}, & \text{if } M_h \geq M > M_l, \end{cases} \quad (10)$$

where  $\text{int } X$  denotes the integer part of  $X$ , and

$$\begin{aligned} N_{NIC} &\equiv \frac{W_h + nW_l}{cr(1+r)}; \\ N_{IC} &\equiv \frac{1}{2} \left\{ N_{NIC} + \frac{1+n}{c(1+r)} + \sqrt{\left( N_{NIC} + \frac{1+n}{c(1+r)} \right)^2 - \frac{4M}{c(1+r)}} \right\}; \\ M_l &\equiv (n+1) \text{int } N_{NIC}. \end{aligned}$$

*Proof:* The no free-riding condition (7) can be satisfied if and only if there exist  $N$  and  $w_P$  such that  $N \leq \frac{\pi_h + n\pi_l - w_P}{cr(1+r)}$ . Since  $w_P \geq 0$ , this is the case if and only if there exists  $N \leq \frac{\pi_h + n\pi_l}{cr(1+r)}$ . Using the definition of  $\pi_h$  (8), this is true if and only if

$$(\exists N \text{ s.t. } [N \leq N_{NIC} \text{ and } M \leq N(n+1)]) \text{ or } (\exists N \text{ s.t. } N \leq f(N)), \quad (11)$$

where

$$f(N) \equiv N_{NIC} - \frac{M/N - (n+1)}{c(1+r)}. \quad (12)$$

The first of the conditions in equation (11) is satisfied if and only if  $M \leq M_l$ , in which case  $N = \text{int } N_{NIC}$ . For the second condition, note that the equation  $N = f(N)$  is quadratic in  $N$ , that  $\lim_{N \downarrow 0} f(N) = -\infty$ , and that  $\lim_{N \uparrow \infty} f(N)$  is finite. It follows that there exists  $N$  with  $N \leq f(N)$  if and only if  $N = f(N)$  has a real solution: This holds if and only if  $M \leq M_h$ , in which case the higher of the two solutions is  $N_{IC}$ . The result follows immediately from the observation that  $M_h > M_l$ .

To understand Lemma 5, note that the no free-riding condition (7) reduces to  $N \leq N_{NIC}$  if and only if  $\pi_h = W_h$ . This is the case provided there is no idle capital, which can be accomplished at the maximum partnership size  $\text{int } N_{NIC}$  if and only if the minimum efficient operating scale  $M$  is less than  $M_l$ . For higher values of  $M$  some idle capital is inevitable at  $\text{int } N_{NIC}$ , which has the effect of reducing the cost of free-riding. Free-riding can then be prevented if  $N$  is below  $f(N) < N_{NIC}$ , where  $f(N)$  is defined in equation (12). The highest  $N$  that accomplishes this is  $N_{IC}$ .

Since idle capital reduces the value of a partnership, it will render associates less willing to pay for mentoring. Lemma 6 establishes when a partnership equilibrium exists in which they will be prepared to do so.

LEMMA 6: *A partnership exists that satisfies condition (3) for associates to pay for mentoring if and only if  $c \leq \bar{c}$ , where*

$$\bar{c} \equiv \begin{cases} \frac{\Delta W}{1+r}, & M \leq M_l; \\ \frac{\Delta W}{1+r} - \frac{r}{1+r} \left( \frac{M}{\text{int } N_{IC}} - (1+n) \right), & M > M_l. \end{cases} \quad (13)$$

*The size of the corresponding partnership will be  $\bar{N}$ , as defined in equation (10).*

*Proof:* Immediate from manipulation of equations (7) and (8).

Equation (13) is the condition for a partnership equilibrium to exist in which associates are prepared to pay for mentoring. It is instructive to compare it to condition (2) for mentoring to be socially optimal. The two coincide only when  $M \leq M_l$  and there is no idle capital. For higher minimum efficient operating scales, the impossibility of contracting upon mentoring raises the effective cost of mentoring by  $\frac{r}{1+r} \left( \frac{M}{\text{int } \bar{N}_{IC}} - (1+n) \right)$ . This renders mentoring unsustainable in a partnership equilibrium even in some circumstances in which, with perfect contracts, it would be desirable.

We know from Proposition 1 that a partnership equilibrium exists provided conditions (3), (4), and (7) are satisfied. Condition (4) is unaffected by the presence of physical capital. Lemmas 5 and 6 show how the other two conditions are altered, so for partnerships with physical capital, Proposition 1 reduces to the following.

**PROPOSITION 2 (Partnership Equilibria with Physical Capital):** *A partnership with physical capital exists precisely when condition (4) is satisfied,  $M \leq M_h$ , and  $c \leq \bar{c}$ . When these conditions are satisfied, a partnership of size  $\bar{N}$  exists.*

#### D. The Going-Public Decision

In this section we show how a technological shock may cause a partnership to go public. We consider a partnership operating without physical technology: that is, such that the optimality condition (1) for mentoring is satisfied. Suppose that some innovation gives the partnership access to a physical technology that has minimum operating scale  $M$  and unit per-period cost  $r$ , and that increases the per-period product of skilled and unskilled agents to  $W_h$  and  $W_l$ , respectively.

The partnership could respond to the innovation in three ways. First, it could continue to operate without the use of the new technology, in which case its per employee output would be  $\frac{w_h + nw_l - c}{n+1}$ . Second, it could adopt the new technology and continue to function as a partnership. In this case, as in Proposition 2, its size would be  $\bar{N}$  and its per-employee output would be  $\frac{\pi_h + nW_l - c}{n+1}$ . Third, it could adopt the new technology and cease to function as a partnership. In this case mentoring would cease to be incentive compatible and the per employee output would therefore be  $W_l$ . The partnership will go public precisely when the third option is preferred to the first two.

This observation implies two conditions. For going public to dominate nonadoption of the technology, the technology must substitute for human capital:  $W_l \geq \frac{w_h + nw_l - c}{n+1}$ . This reduces to the

following condition on the efficiency gain for low skill employees:

$$v_l - r > \frac{\Delta w - c}{n + 1}. \quad (14)$$

Condition (14) is satisfied for high enough  $n$  or for high enough  $v_l$ . We can think of  $n$  as a measure of the number of associates required to support each partner.<sup>13</sup> Since in our model the benefits of monitoring accrue to only one of these associates, the increase in associate productivity required to justify folding the partnership is a diminishing function of  $n$ .

The second condition requires the new technology to render mentoring either inefficient or impossible in a partnership. Training is inefficient, in which case a partnership will be impossible, when condition (2) is violated: that is, when

$$c > \frac{\Delta W}{1 + r}. \quad (15)$$

Condition (15) will be satisfied when the technology renders human skill obsolete. A classic example of such an innovation is the assembly line. In investment banking, the special ability to maintain large client databases was rendered largely irrelevant by the introduction of the personal computer.

When  $c < \frac{\Delta W}{1+r}$ , mentoring is socially efficient. However, it will be impossible in a partnership if

$$M > M_h, \quad (16)$$

and a partnership with mentoring will be dominated by a joint stock corporation in which mentoring does not occur if  $M \leq M_h$  and  $W_l \geq \frac{\pi_h + nW_l - c}{n+1}$ . The latter condition is equivalent to

$$[\Delta W < c \text{ and } M \leq M_l] \text{ or } \left[ \Delta W < c + r \left( \frac{M}{\text{int } N_{IC}} - (n + 1) \right) \text{ and } M_h \geq M \geq M_l \right],$$

which, because  $c < \frac{\Delta W}{1+r}$ , reduces to

$$\Delta W < c + r \left( \frac{M}{\text{int } N_{IC}} - (n + 1) \right) \text{ and } M_h \geq M \geq M_l. \quad (17)$$

Condition (17) is satisfied when the free-rider problem constrains the firm size to such an extent that it is no longer worth bearing the costs of idle capital. When this happens the firm will elect to go public and to cease to mentor even though mentoring remains socially desirable. Since  $N_{IC}$  is increasing in  $M$ , the likelihood that this will occur is an increasing function of  $M$ .

We summarize the discussion of this section in Proposition 3.

**PROPOSITION 3 (Going Public Decision):** *A partnership firm faced with a new technology will respond by going public if:*

1. *Condition (14) is satisfied: that is, the technology substitutes for human capital;*
2. *One of the following is true:*
  - (a) *Condition (15): skill is rendered obsolete by the new technology;*
  - (b) *Condition (16): idle capital renders mentoring impossible in a partnership;*
  - (c) *Condition (17): idle capital costs in partnerships are higher than the value of human capital.*

## II. Evidence

Proposition 3 predicts that partnership firms will go public in response to technological shocks that substitute for human capital if their minimum operating scales are unattainable within the partnership and the consequential idle capital costs are unsustainable. In this section we present evidence that shocks of this nature hit the U.S. investment banking industry in the second half of the twentieth century.

Our empirical analysis rests on industry data from 1955 to 2000. The starting date is the approximate starting point from which we can reliably gather capitalization measures for U.S. investment banks.<sup>14</sup> Figure 2 provides a summary of three data series central to our analysis of the theory.

[Figure 2 here]

In the first series, we plot the total capitalization of the top ten investment banks (ranked by capitalization). In 1955 investment bank capitalization was still low: The ten most heavily capitalized banks maintained about \$821 million dollars of equity and subordinated debt. By 2000, this number had grown to about \$194 billion. The industry has long been highly concentrated in most dimensions. The second series, the capitalization of the next 15 most-heavily capitalized firms as a percentage of the top ten, illustrates a massive increase in the concentration of capital within the industry. In 1955, this second tier of banks maintained capital greater than 80% of the capital maintained by the top ten banks. By 2000, this ratio had declined to around 10%.

The final series reflects the capitalization of the top ten banks relative to an important activity measure: the dollar value of underwritten corporate securities. Technological advances have reduced the time required for distribution of securities offerings from days to a matter of hours. Presumably,

underwriting risk has declined as a consequence and yet capitalization per dollar underwritten has nearly doubled. This change in the industry, which was concentrated in the post-1975 period, corresponds with the rise of the over-the-counter derivatives markets, proprietary trading, and merchant banking activities in which banks increasingly invested their own capital in transactions for which they previously would have provided only advisory services.<sup>15</sup>

The substantial increases in industry capitalization illustrated in Figure 2 are consistent with an increase in the minimum operating scale for industry participants. In the remainder of this section we present firm-level data that bear on our capital-based theory of the partnership's going-public decision.

### *A. Sample Banks*

Private banking partnerships were, and remain, subject to few reporting requirements. Our theory suggests that opacity is a choice variable for such firms as they seek to protect their investments in human capital.<sup>16</sup> Thus, it should not come as a surprise that data for individual banks are sparse. In light of this problem, and given the traditionally high and rising concentration of activity within the industry, we track the evolution of 23 banks. The sample presented in Table I is a cross-section of prominent banking partnerships as of 1955.

[Table I here]

Until fairly recently, investment-banking firms could be characterized roughly as either retail or wholesale oriented. Retail firms tended to specialize in securities distribution and retail brokerage. Wholesale firms tended to emphasize one or more of advisory services, deal origination, proprietary trading, institutional distribution, and clearing. Even at mid-century, however, this distinction was starting to blur as firms such as Merrill Lynch successfully began to leverage their retail distribution channels to gain access to more lucrative deal-origination opportunities.

Recognizing the difficulty in drawing sharp distinctions between firm types, in Table I we classify the 23 sample firms as either retail or wholesale operations. Our classification reflects characterizations of the firms in the financial press, their standing in the hierarchy of securities underwriters (see Hayes (1971)), and their number of branch offices and corporate clients as of 1970 (reported in Table I).

Each of the 12 banks in the retail category had at least 30 branch offices in 1970. As early as 1949, Merrill Lynch maintained 100 branch offices to serve a large and diffuse retail clientele (Perkins (1999), p.194). By 1970, the firm maintained 275 branch offices, of which 48 were outside the United States. A more representative member of the retail group, Hayden Stone, maintained 9 branch offices in 1959 (New York Times, December 23, 1970, p.35) and 82 in 1970. In contrast, only one of the 11 wholesale banks (Salomon Brothers) had more than 20 branches in 1970 and three (Kidder Peabody, Kuhn Loeb, and Morgan Stanley) maintained no branch offices.<sup>17</sup>

In spite of their large branch networks, among the retail banks only Merrill Lynch maintained a banking relationship with at least 20 Fortune 500 firms. In contrast, Morgan Stanley and Goldman Sachs each had 49 clients among the Fortune 500 and only four banks maintained fewer banking relationships than Merrill Lynch's closest competitor among retail banks (Eastman Dillon with 14 clients). Two of these banks, Bear Stearns and Salomon Brothers, focused primarily upon trading and institutional distribution, while Lazard, Frères (along with its partner firm in Paris) was perhaps the most influential global mergers and acquisition advisor at the time (New York Times, May 28, 1972, F1).

Table I also provides the year in which the partnership reorganized as either a private or public corporation, failed, or was acquired by another public corporation. Although NYSE member firms were prohibited from going public prior to 1970, a number of firms reorganized as private corporations both before and after 1971, often as a prelude to a public offering. For the purposes of our analysis, the private corporations do not differ in any significant respect from partnership organizations since our theory does not depend in any way on limited liability.<sup>18</sup>

Among the 12 retail firms, five carried out IPOs in 1971 or 1972. Two more, Eastman Dillon and Paine Webber, went public via merger with a publicly traded firm or its subsidiary in 1972. Four of the remaining six either failed or were acquired in the aftermath of operational crises arising in the late 1960s.<sup>19</sup> Only Hornblower & Weeks and Shearson Hammill remained private, independent operations past 1974.

Wholesale firms dominated the next wave of activity between 1978 and 1986. With the exception of Bear Stearns and Morgan Stanley, these firms were acquired by public corporations. Out of our 24 sample firms, by 1987, only Goldman Sachs and Lazard, Frères remained private partnerships.

## *B. The First Wave of Flotations*

### *B.1. Technological Change*

We argue that changes from partnership to joint stock form are precipitated by technological shocks that drive new physical capital investment in the production process. Part (1) of Proposition 3 characterizes “physical capital” as nonhuman investment that increases the productivity of human capital: In the investment banking industry, physical capital refers to both investments in communications and data-processing technology and the financial (risk) capital necessary for sustaining contingent obligations at arm’s length. The latter substitutes for tacit human capital embodied in a reputation for fair dealing (see Boot, Greenbaum, and Thakor (1993)).

[Figure 3 here]

Advances in data-processing technology are illustrated in Figure 3. Nordhaus (2001, Appendix 2) provides statistics on computer advances between 1950 and 2001: We use these statistics to compute a time series of the most powerful machines to date as measured by a standardized information-theoretic measure, millions of standardised instructions per second, or MSOPS. We exclude supercomputers from our data because they were intended for the scientific analysis of large nonlinear dynamic systems and hence seem of minimal importance to the investment banking industry, at least in the period that we analyze.<sup>20</sup>

The decade before the first investment bank flotation witnessed substantial advances in computer architecture. First, 1959 saw the production of the first computers that used transistor rather than valve technology. Moreover, 1959 was something of a watershed year for the investment banking industry. Although some large firms such as Merrill Lynch had maintained their own computer systems “for some time” (New York Times, May 15, 1961), in 1959 both RCA and IBM announced plans to open computer service centers targeted at the Wall Street financial district that would enable time sharing of data-processing capacity as an alternative to exclusive-use, leased or purchased equipment. This move appears to have substantially lowered the minimum scale of computerized securities transaction processing. For example, in October 1959, RCA introduced new computers for both small- and large-scale data processing.<sup>21</sup> E.F. Hutton announced it would be the first customer of the RCA service center, “shifting about 1/5 of its clerical load to RCA” including “trade confirmations, stock records, margin records and monthly statements” (New York Times, July 26,

1959).<sup>22</sup> Later in the 1960s the Digital Equipment Corporation produced the first minicomputers, which allowed smaller scale computing than the previously ubiquitous IBM mainframe.

As a result of the technological and organisational advances identified above, in the 1960s computers became able to perform many routine tasks that were formerly the preserve of human agents. Notwithstanding, Wall Street firms were slow to computerize back-office operations and many suffered as trading volume grew rapidly during the mid-1960s. In the first half of the decade, NYSE share volume hovered between 3 and 4.5 million shares per day. In 1965, the average daily share volume exceeded 6 million and then more than doubled to nearly 13 million in 1968. The NYSE responded first by shortening the trading day and then began closing on Wednesdays to allow member firms to process backlogged transactions. During this period failures to complete a transaction through the delivery of stock certificates, or “fails,” became the standard measure of operational (in)efficiency.

[Table II here]

Table II illustrates the experience of our sample firms. Goodbody, for example, suffered fails in excess of 30 days of nearly \$26 million – equivalent to about 52% of the firm’s capitalization. Similarly, Hayden Stone and Glore Forgan suffered fails equal to about 28% and 49% of their capitalization.<sup>23</sup> In contrast, Merrill Lynch and Bache suffered modest levels of fails relative to their peers, and relative to 1969 levels, by which time trading volume had begun to subside. On average, the experience of wholesale firms appears similar but this masks important differences among firms within this category. High fail rates in this group were concentrated among firms like Bear Stearns and Goldman Sachs that were engaged in large-scale, institutional trading activities.<sup>24</sup> During the slower markets of 1969, fails as a percentage of capital among wholesale firms were about one-third of the levels suffered by retail firms.

To summarize, the 1960s saw significant advances in computer technology. These changes were of most importance in retail-oriented firms with large branch networks (see Section II.A), where traditional back-office tasks such as transaction processing and record-keeping were amenable to batch processing. The “back-office crisis” of 1968 was evidence of severe competitive pressures to adopt this technology. We therefore argue that by the end of the 1960s, condition (1) of the going public proposition was satisfied for retail investment banks.

## B.2. The Human/Physical Capital Tradeoff

Condition (2) of the going-public proposition examines the trade-off between physical and human capital. Flotation is optimal either when skill is rendered obsolete by the new technology, or when the idle capital costs of adopting a new technology within a partnership firm outweigh the value of the tacit human capital that the partnership maintains. In this section, we analyze the tradeoff between human and physical capital.

The introduction of mainframe computing into the back office during the 1960s greatly reduced the unit cost of transactions processing, provided the processing volumes were sufficiently high. With a constant (tacit) transaction origination technology in the front office, the increased minimum scale for back-office processing could only be met by increasing the number of experienced transaction originators: in other words, by expanding the partnership.

Thus, the upper bound on partnership firm size attributed by our theory to the free-rider problem in mentoring requires that partnership firms to trade off the efficiency gains that the new technology could bring to their back offices against the value of tacit front-office skills.<sup>25</sup> We argue that retail firms with high trading volumes chose to respond by jettisoning the partnership form and expanding to the point at which investment in the new back office technologies was efficient. Moreover, any increases in the codification of the origination skills of account executives would have further undermined partnership organization.

It is difficult to measure the free-rider problem among partners and its bearing on the development and preservation of human capital. The problem increases in both the difficulty of peer-group monitoring among the partners and in the costs of mentoring.

The problems of peer-group mentoring are increasing in the size of a *mentoring unit*, which we define to be the smallest group of people within the partnership whose mentoring efforts can be separated from the rest of the firm. A crude proxy for the size of the mentoring unit is the number of partners. The number of partners for New York Stock Exchange member firms can be assembled from annual NYSE membership directories. Most, but not all, of the major investment banks during the sample period were NYSE member firms.

The cost of mentoring should rise with the number of people for which an individual partner is responsible. There are no systematic records enabling direct annual measurement of this variable at the firm level, but it is possible to assemble proxies such as the total number of employees

or the number of registered representatives (certified sales people) at key times, including the years immediately preceding a partnership firm’s public offering. Table III provides a summary of capitalization and the number of partners for each sample firm at five-year intervals between 1955 and 1970, when NYSE members agreed to permit public ownership of their firms. In addition, as a proxy for the cost of mentoring at the end of the period, we report the number of employees per partner.<sup>26</sup>

[Table III here]

Throughout the 1955 to 1970 period, Merrill Lynch was by far the largest and most heavily capitalized securities firm. In 1955, Merrill had 73 partners, 4,600 employees (63 per partner), and capitalization of \$31.5 million (\$432 thousand per partner). By 1970, Merrill had about 18,000 employees and \$305 million in capital. Treating the firm’s 217 officers and directors as the private corporation’s analog to partners, both the number of “partners” and the firm’s capital per partner more than tripled (in the latter case, to about \$1.4 million).

In contrast, in 1955 Morgan Stanley was a 20-man partnership with capitalization of \$5.1 million (\$255 thousand per partner) and no retail operations. The firm remained a partnership (with 29 partners in 1969) until 1970 when it reorganized as a private corporation. As of 1970, the firm remained strictly a wholesale operation with 34 directors or managing directors holding equity stakes in the firm, about 260 additional employees (in 1971) and capitalization of \$9.4 million (\$276 thousand per “partner”).

[Figure 4 here]

Figure 4 illustrates the sharp differences in partnership growth patterns for Merrill Lynch and Morgan Stanley. The retail orientation of Merrill Lynch was associated with a larger partnership prior to the firm’s IPO but the relative growth patterns are similar. Each firm exhibited sharp growth in the partnership during the decade prior to its IPO. The primary difference in growth patterns is in their timing. Thus, in the case of retail-oriented Merrill Lynch, both the scale of the mentoring unit and the cost of mentoring rose sharply, as did the level of financial capital per unit of human capital during the decade preceding the first wave of IPOs. During the 1960s, the operational structure of wholesale-oriented Morgan Stanley changed relatively little by comparison.

The data reported in Table III for the remaining sample banks suggest a fairly consistent distinction between the two classes of firms along these dimensions. On average, the number of

partners in retail firms nearly quadrupled between 1955 and 1970. Wholesale partnerships grew at about half this rate on average. In spite of their more rapid growth, the average number of employees per partner among retail firms in 1970 was almost twice that among wholesale firms. Finally, the mean capital per partner grew by about 50% among retail firms but less than 30% among wholesale firms.

The capital growth among retail firms is particularly noteworthy in light of the substantial losses stemming from operational failures at several of the sample banks during the late 1960s discussed in Section II.B.1. Among wholesale firms, there is perhaps greater variation in the nature of operations across firms than exists within the retail sample. We noted earlier that Salomon Brothers and Bear Stearns, in particular, stood apart from banks like Morgan Stanley, Lazard, and Kuhn Loeb, which focused primarily on advisory services and deal origination. Capitalization per partner declined among the dealmakers, where operations arguably were more heavily dependent on tacit human capital.<sup>27</sup>

In addition to the above indirect evidence that technology-induced increases in minimum efficient scale aggravated free-riding among partners, there is a good deal of casual evidence of increasing codification of the substantial body of human capital that resided within the account executives of retail firms. Footnote 16 documents effort as early as 1945 by Merrill Lynch to codify this element of the firm's human capital. By 1961, the *New York Times* (May 28, 1961, F1) reported that 12 firms had "formal, full-time, classroom-type training programs. Three years ago, only three concerns had them." The article goes on to claim that "scores of brokerage houses in recent years have instituted less formal programs for salesmen." If such efforts substituted for informal training, they diminished the value of mentoring as envisioned in our model.

Additional, albeit indirect, evidence of increased knowledge codification within retail investment banks can be obtained by examining partnership tenure in major investment banks. As important information about partner quality was codified, it became easier for clients to measure the quality of their bankers, and it therefore became harder to maintain the opacity that we argue was an important feature of the traditional partnership. The consequence of increased investment bank transparency was a steady increase in investment banker mobility, as competitors started to hire one another's star performers, and the tradition that experienced bankers would spend their entire career with one firm was eroded.

These effects are hard to document because of difficulties in the systematic identification and

tracking of the careers of prominent bankers, but several data sources provide evidence that is consistent with our theory's predictions. The NYSE's annual membership directories record partnership rolls for member firms, so that admission and departure for investment banking partnerships can be tracked for these firms before their flotations. As banks began to incorporate privately in the late 1950s, there was almost a one-to-one mapping from partnership rolls into rolls reporting the holders of voting stocks.

[Table IV here]

Table IV uses these data to report the average tenure of the 1952 and 1960 partner (or voting shareholder) cohorts reported by 17 prominent investment banks. The banks are reported in increasing order of the average tenure for the 1952 cohort. Average tenure ranges from 16 years for Paine Webber's 1952 cohort to 28 years for Alex. Brown's cohort. Retail banks had a smaller reliance upon tacit skills and hence they had the lowest tenure.

Computerization started to take hold on Wall Street in the 1960s. Hence, any effect that computers had upon the career paths of the partners should be more manifest for the 1960 partner cohort than for the 1952 cohort. We argue earlier that, as computerization and codification broke down partnership opacity, it should have resulted in an increase in investment banker labor mobility. Consistent with this conjecture, in Table IV we see a drop in average partner tenure between 1952 and 1960. Moreover, the decrease is most pronounced among the retail firms for which batch processing technology was most important. Goodbody, Dean Witter, and Hornblower, all of which were retail brokerage firms, saw sharp declines in their partner tenure, which brought them into line with their peers within the retail segment of the industry. In contrast, there is little change in partnership tenure for the wholesale banks (Brown, William Blair, Kidder, Goldman, Cowen, Morgan Stanley, and White Weld) from the 1952 to the 1960 cohort.

In summary, the retail segment of the investment banking industry was especially exposed to the following shocks during the 1960s:

1. Significant advances in data-processing technology that substituted for human skills and also increased the minimum efficient scale of back-office operations;
2. Rising costs of mentoring as firms responded by increasing both the number of mentors and the size of the mentoring unit;
3. Capital demands that outstripped the increased number of partners;

4. An apparent decline in the relative value of tacit human capital as firms developed formal training programs for account executives and, in some cases (such as back-office functions), new technology obviated the need for human skills altogether. This, coupled with increased partnership transparency, caused an increase in labor mobility in wholesale investment banking partnerships.

Our going-public Proposition 3 predicts that partnerships will choose to float when a technological innovation substitutes for capital and serves either to render skill obsolete or to increase the costs of mentoring within a partnership to uneconomic levels. The first shock above satisfies the first of these conditions; the second, third, and fourth together satisfy the second. These shocks therefore provide considerable, albeit descriptive, evidence consistent with our theory. The virtual exclusivity of retail firm participation in the initial wave of investment bank flotations lends further weight to the argument.

### *C. The Second Wave of Flotations*

The first wave of technological change gave most banks computerized data-processing capacity and connectivity with the major securities exchanges, but had little impact on the practice of investment banking and the traditional institutions of Wall Street. The second wave of technological change included continued advances in computing and information technology that worked hand-in-glove with advances in financial economic theory. Perhaps most important among the latter was the development of the Black-Scholes-Merton framework for valuing options. Operational efficiency considerations continued to loom large with the 1975 elimination of fixed commission rates. Against this background the second wave of technological change began to influence strategy and promoted the development of new trading venues.

Table I suggests identifying the onset of the second wave of flotations with the acquisitions of White, Weld and Loeb Rhoades by Merrill Lynch and Shearson, respectively.<sup>28</sup> Salomon was then acquired in 1981 by Phibro (a public commodities trading operation) and Shearson acquired Lehman in 1984. By 1985, when Bear Stearns went public, capitalization per employee among the five most heavily capitalized investment banks had nearly quadrupled to \$258,677. The second wave of private banks entering the public domain leveled off with Morgan Stanley's 1986 IPO, GE Financial's 1986 acquisition of Kidder Peabody, and Primerica's 1987 acquisition of Smith Barney.

Among our sample firms only Goldman and Lazard remained partnerships by year-end 1987. In the remainder of this section we describe the timing and the magnitude of technological change, and how it worked its way through several important functional areas of the industry.

### *C.1. Technological Change*

Our going-public proposition predicts that flotation is preceded by a technological change that substitutes for physical capital. Unlike the first wave of flotations, the second was not triggered by an increase in raw processing power. Indeed, Figure 3 shows that between the late 1960s and the advent in the 1980s of the personal microcomputer, there was no advance outside the supercomputer realm in computational speed. The advances in this period focussed instead on reductions in the capital costs of computers. The further development in the 1970s of mini computers and the introduction of the microcomputer allowed for a greater degree of real-time computation.

This trend is illustrated in Figure 5. Using data from Nordhaus (2001, Appendix 2), the figure depicts the lowest computing costs achieved at each year between 1950 and 2001. Computing costs started to drop rapidly in the 1970s and continued to do so throughout the remainder of the twentieth century.

[Figure 5 here]

The decline in computing costs and the ability to perform real-time calculations at the desk led to a new shift in the business use of computers. For example, the invention of the computer spreadsheet revolutionized business practices, not least in dealing rooms. Cheaper computers substituted for tasks traditionally performed by wholesale account managers as major trading houses (e.g., Salomon, Merrill Lynch, and Goldman Sachs) used computers to track the positions and preferences of institutional investors.<sup>29</sup> Real-time computer processing allowed the creation of new markets in which human agency was of less importance. For example, the early 1980s saw the emergence of batch order submission systems and program trading of stock baskets. Similarly, the spectacular advances in derivatives trading, both on exchanges and over-the-counter, could not have happened without the advances that occurred at this time in distributed real-time processing.

In summary, the late 1970s and early 1980s were characterized by advances in small-scale computing. Real-time monitoring of markets and rapid calculation of risk management figures reduced the importance of tacit human capital in the wholesale investment banking industry. This trend

was evidenced by the emergence of new markets, and also by the increasing ability of computers to outperform humans in responding to price movements. We therefore argue that by 1980, technological advances were displacing human capital within *wholesale* investment banks, and thus condition (1) of the going-public proposition was satisfied.

### *C.2. Codification of Human Capital*

The impact of distributed real-time computing upon the trade-off in wholesale investment banks between human and physical capital can be understood only against a backdrop of the contemporaneous advances in financial economics. The Black-Scholes-Merton framework for options valuation became widely used by options traders only when desktop valuation of options portfolios became possible, and this in turn led to further advances in the theory. In the 1980s a basic understanding of financial economics was increasingly regarded as essential for trading room personnel.

As we discuss in Section II.C.1, the increasing emphasis within wholesale investment banks upon financial engineering increased the codifiability of relevant human capital. This trend was amplified by changes in hiring practices that had started in the 1960s, when, in addition to facing technological forces favoring growth, a number of investment banks were under pressure to replace a generation of retiring partners for whom relatively few successors were groomed during the post-World War II era (Hayes (1971)). This led to a sharp increase in hiring from top MBA programs and, as knowledge became more codifiable, business schools were increasingly regarded as an important tool for disseminating new theoretical knowledge.<sup>30</sup>

Although human capital was being codified at a rapid rate during the period, not all functional areas of investment banking were equally susceptible to the process. We contend that differences among banks in their emphasis on various banking functions explains, at least in part, the timing of firm reorganization within this second wave of industry reorganization. Toward that end, we now examine the time paths of several functional areas of wholesale investment banking that cut across a wide range of susceptibility to codification in both timing and magnitude.

### *C.3. Market Making*

Basic market making and trading functions were especially susceptible to displacement of human agency. Unfortunately, we cannot observe directly the market-making functions of individual

investment banks. However, there are several broad patterns in the organization of independent market-making operations that bear out our argument. First, Jones (2002) provides broad systematic evidence of declining bid-ask spreads in Dow Jones Industrial Average stocks. The pattern is especially noteworthy in light of considerable monopoly power exercised by the NYSE in the provision of liquidity for these stocks.

Although we cannot document the pattern systematically, numerous references in the financial press leave little doubt that spreads in both exchange-traded and over-the-counter derivatives markets also narrowed as knowledge of financial engineering techniques diffused throughout the industry. Until well into the 1980s, the derivatives markets were the province of highly specialized firms organized as private partnerships. Perhaps the three most prominent among these firms were O'Connor & Associates, CRT, and Cooper Neff. By the late 1980s rising economies of scale in marketing and risk management coupled with narrowing spreads led to the acquisition of each by a large commercial bank (Swiss Bank, Nations Bank, and BNP, respectively).

Changes in market making at the NYSE, manifested in reorganization among specialist firms, were more complex owing much to the Exchange's dominant status in U.S. capital markets. But as both technological advances and regulatory changes eroded the exchange's market power, the structure of specialist firms also changed. By 1970, specialist firms were facing pressures similar to those bearing on the large brokerage firms that dominated the first wave of transition from partnership to public ownership. The New York Times reported on March 11, 1970 (p.82) that Bear Stearns became the first investment bank to establish a "financial relationship" with a NYSE specialist firm as the latter struggled with "the increasing dominance of the market by large institutions dealing in big blocks of stock." The financial arrangement involved formation of a "joint account" with (rather than purchasing a stake in) John E. Barrett & Co., which provided the specialist firm an estimated 30% of its capitalization. Two years after the NYSE permitted other member firms to go public, the 577 member firms provided the remaining 75 specialist firms with the option of public ownership "in a move to obtain access to greater capital and thereby accommodate growing institutional volume."<sup>31</sup> With the number of listings standing at 1,478, the specialist firms were now responsible for an average of 20 stocks.<sup>32</sup>

The number of specialist firms remained fairly stable through the 1970s and by 1981 stood at about 67 firms. From this point forward, consolidation took place at a rapid pace. By 1986, there were 57 specialist firms and between October 1987 and June 1992, 21 specialist firms were acquired

(New York Times, October 9, 1986, and Wall Street Journal, July 2, 1992). Amidst competitive pressure from over-the-counter market makers, electronic commerce networks (ECNs), and debate over whether the Exchange itself should go public, the specialist firm community collapsed to the seven listed in Table V (as of October 31, 2004). Of these seven firms, five are dominant when measured by the number of listed stocks for which they are responsible. All five are publicly owned or affiliated with a publicly owned firm. Two, Spear Leeds and Fleet, are wholly owned by banks among the top ten by capitalization while Bear Stearns holds about a 50% stake in Bear Wagner.

[Table V here]

#### *C.4. Securities Underwriting*

Systematic variation in informational frictions across types of securities are such that the securities underwriting function provides a useful setting for indirect evaluation of our theory. In broad terms, adverse selection theories of capital structure suggest that equity offerings suffer more under the burden of asymmetric information than debt offerings. If, as a consequence, equity underwriting depends more heavily on tacit behavior embodied in bank reputation and relationships with both issuers and investors, we expect the consequences of technological advances for securities underwriting functions to be most evident in the debt markets.

The relative behavior of debt and equity underwriting spreads since 1970 bears out this prediction. Between 1970 and 2000, underwriting spreads for nonconvertible debt offerings reported by the Securities Data Corporation (SDC) declined sharply. Ranking offerings by gross proceeds, the smallest quartile of offerings carried spreads of about 2% of gross proceeds in 1970 but only 0.34 % in 2000. For the largest quartile of offerings, spreads were 0.9% in 1970 and 0.32% in 2000. Kim, Palia, and Saunders (2003) provide a year-by-year account for all debt offerings (as well as for IPOs and seasoned equity offerings (SEOs), separately) at both the mean and median as well as means and medians by decade. During the 1970s, the mean (median) underwriting spread was 1.56% (0.88%) of gross proceeds. During the 1990s, the mean (median) declined to 0.84% (0.65%) of gross proceeds. The difference in both the mean and median is statistically significant at the 1% level. Equity underwriting spreads were more volatile, in large part due to extreme variation in high fee IPO activity, but subject to a similar but less steep decline between 1970 and 2000. The smallest (largest) quartile of equity offerings in 1970 carried an average spread of about 9.4% (6%)

of gross proceeds. By 2000, the smallest and largest quartile average spreads stood at 6.75% and 4.6%. The evidence from Kim et al. suggests that declines in both SEO and IPO spreads were statistically significant across the three decades.

### *C.5. Increasing Dependence on Financial Capital*

If a decline in the cost of computers coupled with the effects of product market competition served to increase the minimum efficient operating scale for wholesale investment banks, minimum operating scale could only be achieved by increasing the transaction volume, which would require a greater number of front-office staff and also a greater level of financial capital.

Figure 6 illustrates both patterns arising during the second wave of reorganization. We regard the 1979 acquisition by American Express of Shearson Hammill as the culmination of the first wave of flotations and consolidations by retail investment banks. The figure shows the subsequent expansion in the capitalization of the five most heavily capitalized investment banks relative to their total number of employees. In 1979, mean capitalization per employee stood at about \$65,000 and ranged from \$27,076 at Paine Webber to \$113,499 at Salomon Brothers. In 2000, the five most heavily capitalized investment banks averaged about \$1 million per employee (down from about \$1.2 million in 1995) and ranged from \$874,588 at Salomon Smith Barney (now a subsidiary of Citicorp) to about \$3.6 million at Lehman Brothers.<sup>33</sup>

[Figure 6 here]

### *C.6. Significant Holdouts and the Rise of Advisory Boutiques*

By 1987, only Goldman Sachs and Lazard among our sample banks remained private partnerships. Each stands as an exception that proves the rule. The corporate advisory function, most prominently surrounding mergers and acquisitions (M&A), is perhaps the investment banking function least susceptible to the sort of codification our theory envisions driving reorganization. As we note earlier, Lazard was perhaps the most prominent M&A advisor during the 1970s and remains prominent and highly specialized in this capacity. As such, Lazard is precisely the type of firm that our theory suggests would have little exposure to the forces underlying industry reorganization. As of November 2004, Lazard still had only 2,500 employees worldwide and only recently gave serious

consideration to a public offering. The fractious negotiations led by Bruce Wasserstein on the one hand and Michel David-Weill (a descendent of the founding families with a 20% ownership stake) on the other almost surely reflect a battle of wills among strong personalities within the firm and suggest that the broader economic forces envisioned in our model are not bearing heavily on the decision at this stage of the firm's development.

Goldman's top ranking in the 1986 league tables for both equity underwriting and M&A advising suggests that it too remained a predominately human capital-intensive operation toward the end of the second wave of reorganization. Moreover, the firm's simultaneous rise in trading functions benefitted from partnership capital of around \$1 billion in 1986 – about twice that of perhaps its closest competitor, Morgan Stanley (pre-IPO capitalization). In spite of the partnership's relative wealth of capital and dominant position in human capital-intensive production, Goldman gave serious consideration to a public offering in 1986 and ultimately accepted a \$500 million private equity investment from Sumitomo bank in exchange for 12.5% of the firm's annual profits and appreciation in equity value. (The Bank Holding Act of 1956 precluded Sumitomo from having voting rights or any influence over the firm's operations.) Thus, Goldman was able to sustain growth in financial capital-intensive trading operations without visibly compromising its partnership structure through at least the early 1990s.

On the other hand, casual evidence suggests that many Goldman partners, especially those outside the firm's trading operations, viewed the firm as a partnership in name only as bonuses paid to nonpartner traders rose sharply. Consistent with this argument, about 30% of the partnership declined to reenter a new partnership agreement (that closed December 1, 1994) in the aftermath of massive trading losses in the firm's London office. The group responsible for these losses was also influential the previous year in forcing the firm to alter its compensation policy to pay some nonpartner traders more than the firm's junior partners.<sup>34</sup>

One noteworthy defection from the Goldman partnership involved the 1991 retirement of Geoffrey Boisi. The youngest-ever partner at Goldman, Boisi led investment banking operations and was widely viewed as a key "culture carrier" within the firm. In 1993, Boisi and three other former Goldman partners formed a small private equity partnership which was then acquired in 2000 by Chase Manhattan bank for an estimated \$500 million. Boisi was appointed head of investment banking for what soon became JP Morgan Chase but left soon thereafter in disagreement with senior management regarding the direction of investment banking operations.

A similar example of a prominent “human capitalist” leaving a bank that had gone through the second wave of reorganization involves Robert Greenhill. After serving as President of Morgan Stanley and CEO of Smith Barney, Greenhill established Greenhill & Co. in 1996 to advise on “significant” mergers, acquisitions, restructuring, and similar corporate finance matters.”<sup>35</sup> Greenhill & Co. is noteworthy for having been the first such investment banking boutique to go public with its summer 2004 IPO. With 107 employees, of which 22 were managing directors, the firm’s size and low ratio of employees per managing director would pose a challenge to our model were it not unique and perhaps something of a test case in contracting to protect the human assets in which public shareholders have invested. Alternatively, perhaps this example is an early indication of (or, at least, experiment in) the codification of advisory functions.

To summarize, an important consequence of cheap distributed computing was a greatly increased emphasis upon financial engineering and substitution of electronic data analysis for human agency. This served to reduce the value of tacit human capital, and also to unleash competitive forces that reduced trading spreads and increased the minimum financial scale at which wholesale investment banks could operate. There was therefore a clear relative shift away from tacit human capital and towards financial and physical capital. Thus, the second wave of investment bank flotations follows the pattern suggested by our theory.

The primary holdouts among investment banking functions include corporate advisory services and to a lesser extent equity underwriting and complex financial engineering and trading functions (including hedge funds). Over the same period, the markets have witnessed the rise of prominent boutique firms focused typically in one of these areas. Our theory suggests that such functions, assuming they remain heavily dependent on tacit knowledge, are not optimally managed within large publicly traded corporations. Where boutiques have not provided an organizational alternative, as in equity underwriting, we believe this has much to do with the present difficulty in separating underwriting (and certification) from the information production and distribution function that benefit from large-scale networks maintained by the largest banks. On the other hand, it is noteworthy that in instances in which a distribution network appears to limit the human capitalist’s outside options, markets have witnessed several prominent defections of entire banking teams (e.g., Frank Quattrone’s technology banking team).

### III. Conclusion

In this paper we provide a theory of the partnership that yields a technological explanation of the going-public decision, and we present supporting evidence from the U.S. investment banking industry. We argue that partnership firms provide an institutional framework that supports the transfer of tacit human capital. The partnership contract accomplishes this by giving partners an illiquid stake in the reputation of their firm. They mentor incoming partners in order to maintain this reputation, and hence ensure that there is a market for their shares. Hence, we would expect to see partnership firms in human capital industries in which corporate reputation is important: this is indeed true of law, consulting, and of financial services.

While legal and consulting firms have for the most part remained partnerships, the U.S. investment banking industry has jettisoned the partnership form. Since the New York Stock Exchange amended its rules in 1970 to admit publicly quoted members, every major investment bank has elected to float. We provide a technological explanation for this decision. As a result of a free-rider problem among partners, there is an upper limit to the size of a partnership firm. As a result, it may be hard for firms to adopt new technologies at an efficient scale. New capital-intensive technologies therefore force firms to choose between the human capital that a partnership generates, and the efficient operating scale that is possible in a joint stock corporation. When the latter is more valuable than the former, partnerships will choose to go public.

The evidence in this paper provides a strong indication that the late twentieth-century explosion in computer power transformed the way that investment banks do their business. It increased the competitiveness of the investment banking business and significantly raised the minimum capital requirements for investment banking. At the same time, it lowered the importance of human agency in financial markets. One could argue that these advances would have revolutionized the organization of the investment bank irrespective of the importance that we place in our formal analysis upon tacit human capital. For example, if partnerships were simply a device for incentivizing cross-monitoring within teams, then they could similarly have been superseded by new technologies that increased minimum operating scale past the point at which such monitoring was feasible.<sup>36</sup> Nevertheless, we believe that the historical evidence points strongly to the importance of tacit human capital in the pre-1970 investment bank. The empirical part of the paper provides evidence and an argument in support of a later erosion in the importance of tacit skill to investment

bankers.

We document two waves during which U.S. investment banking partnerships went public. The first, beginning in 1970, was dominated by retail-oriented firms and was precipitated by the introduction of transistor-based computers and advances in batch processing beginning in the late 1950s. These advances had their largest impact on retail firms for two reasons. First, their responsibility for settling transactions for many small accounts managed through dispersed branch networks made the back-office operations of these firms particularly susceptible to advances in batch data processing. Evidence of general expansion in the scale of operations and widespread back-office failures in the late 1960s suggests that early adopters such as Merrill Lynch gained significant competitive advantage by achieving the new minimum efficient operating scale ahead of their peers.

In the presence of competitive pressure to expand, our model implies that partnerships ultimately are constrained in their ability to sustain investment in tacit human capital. We argue that tacit human capital was less central to production in retail firms and that, in any event, these firms were systematically codifying key elements of their human capital. Thus, the pressing need for the mentoring that we envision as the primary advantage of partnership organizations was obviated. We believe that it is no coincidence that among NYSE member firms, retail-oriented investment banks were among the most vocal proponents for permitting flotation and also the first to take advantage of the subsequent opportunity.

There is little evidence that wholesale firms suffered similar pressures during the 1960s and 1970s. Advances in batch processing technology would not displace human judgment in advisory services and their proprietary trading, market making, and big ticket customer trading functions awaited further advances before they could achieve the massive scale of operation that would come about in the 1980s. Consistent with this argument, the scale of operations among wholesale firms changed relatively little and the partnership structure was preserved.

The second wave of flotations involving wholesale firms followed the introduction of the microcomputer in the 1980s, which facilitated the adoption of new financial engineering techniques. These served both to diminish the value of tacit human capital, and also to lower the cost of entry into lucrative trading markets. As a result, bid-ask spreads declined and the minimum scale at which it was possible to make an adequate return on trading increased accordingly. The second wave of flotations involving primarily wholesale firms is therefore consistent with the trade-off between human capital and financial capital predicted by our model.

While our empirical evidence is entirely based upon the U.S. experience, we believe that our story has wider relevance. Financial institutions throughout the world were exposed to the same technological shocks and one would therefore expect a similar response, particularly in the face of financial globalization, which, throughout the period we study, exposed domestic institutions to an increasing degree of competition from optimally constituted foreign investment houses. For example, Michie's (1999) history of the London Stock Exchange documents the increasing importance in the 1960s of computerisation and the pressure that this put on the limited capital resources of the partnership member firms.<sup>37</sup> By 1969 the pressing need for capital forced the Exchange to allow member firms to incorporate themselves as limited liability firms. Some restrictions upon ownership remained, however.<sup>38</sup> These were finally lifted in the 1985 "Big Bang" in response to the increasing competitive pressures that precipitated the second wave of flotations in the United States.

We believe that our theory can explain many of the institutional changes that have engulfed the financial services industry since 1960 in terms of technological change. We conjecture that more recent changes, in particular financial conglomeration and the flotation of advisory businesses, are equally susceptible to explanations based on advances in information technology and the codification of tacit human capital.

Our explanation of the move from partnership to joint stock corporation may be applicable to industries other than investment banking. For example, recent years have witnessed a decline in workplace training for lawyers in the United States. Hillman (2001, p. 1078) states of U.S. law firms that "Mentoring is haphazard, if it exists at all. Firms point to the new economies of law practice and ask law firms to do more." He also documents a sharp rise in lawyer mobility. Both observations may be indicative of a reduced need in law firms for tacit skill. One might expect these changes to affect the governance of law firms. Indeed, the U.K. government is introducing legislation to allow British law firms to seek outside finance for the first time. Although we believe that this evidence suggests that our theory has wider implications, a detailed analysis of other industries is outside the scope of this paper, and is therefore left for further research.

## NOTES

<sup>1</sup>The 1970 Donaldson, Lufkin & Jenrette IPO was the first; Merrill Lynch, Reynolds Securities, and Bache & Co. followed in 1971.

<sup>2</sup>Bar-Isaac (2003) shows how an agent of established reputation can commit to work hard by forming a partnership with a junior agent of unproven quality. Farrell and Scotchmer (1988) show that equal-sharing rules may cause inefficiencies. Levin and Tadelis (2005) argue that profit redistribution rules raise the quality hurdle for new hires and hence act as a signal of quality when firm quality is hard to observe. Garicano and Santos (2004) argue that the profit sharing rules imposed by partnerships can improve incentives for agents to redirect jobs to those most able to perform them.

<sup>3</sup>Endlich (1999, p. 21) provides a striking example of the cultural tendency within the Goldman Sachs investment banking partnership toward downplaying individual accomplishment. Gilson and Mnookin (1985, p. 365, fn 89) observe that the holdup threat presented by marketing the firm through the writing and lecturing of individual lawyers "... may account for the recent development of seminars for existing and potential clients put on by a single law firm. These seminars are designed to provide direct information concerning quality to potential clients, but unlike writing and lecturing by individual lawyers, this approach features a number of the firm's lawyers as opposed to a single star..."

<sup>4</sup>For several decades following James McKinsey's death in 1939, new partners bought out old partners at the book value of their shares to make cashing out less attractive (*The Economist*, March 22, 1997, Management Consultancy Survey, p.19). Similarly, until 1996 Goldman Sachs forced retiring partners to cash out over several years, and the management committee could extend the payout schedule (Wilhelm and Downing (2001), chapter 7). Leslie D. Corwin, a specialist in partnership law, suggested in 1997 that "If a firm is unwilling to cash out a partner, which often happens when a partner is moving to a competitor, the only recourse may be to sue." (*New York Times*, June 8, 1997, F9.)

<sup>5</sup>A similar argument is made by Chandler (1990), who posits that only large corporations could support the capital-intensive production technologies of the second industrial revolution. For this

reason these technologies were employed, and the modern corporation was born, only when improved communications networks generated sufficiently large markets.

<sup>6</sup>This is in contrast to Levin and Tadelis' (2005) model of partnerships with physical capital. Levin and Tadelis assume an exogenous outside wage from which they compute the optimum firm size given an exogenous distribution of agent abilities. Our model hinges upon the endogeneity of the outside option, which is determined jointly with skill levels by an endogenous monitoring decision. With a more general technology than ours an agent's outside option would depend upon the effectiveness of the capital he used. This would depend upon the firm's size, which would depend in turn upon the wage level. Joint determination of wage levels and firm size is impossible in a partial equilibrium model. Our discussion of technology should therefore be regarded as an example. We believe, however, that our intuition would carry over with other technologies to a general equilibrium framework.

<sup>7</sup>It is reasonable to assume that performance information would become common knowledge over several generations. In the interest of tractability we assume that it is shared immediately.

<sup>8</sup>Constraining  $P$  to be a constant as in Definition 1 is without loss of generality. This condition simply implies that each generation of partners extracts from the partnership in salary and dividends precisely what is added during its tenure by the associates and partners.

<sup>9</sup>Consistent with our model, Wilhelm and Downing (2001, chapter 7) suggest that a Goldman Sachs associate would bid (accept negative wages) for employment (and training) were it not for informational friction.

<sup>10</sup>This is an off-equilibrium path belief: It is again consistent in the Kreps and Wilson sense.

<sup>11</sup>This assumption is crucial, as if the associate could signal his quality to the labor market through raising finance he would simply leave the firm and sell himself for his marginal product without mentoring. In a richer model with career paths exceeding two periods, the least-cost financing alternative would be for junior partners to borrow from active senior partners who are best positioned to assess the borrower's quality and to monitor the loan.

<sup>12</sup>We assume that all partnership shares must be equally priced. Since differing prices would signal the presence of an unskilled new partner, this seems reasonable.

<sup>13</sup>Although we do not explicitly model the support role of associates, it seems reasonable to assume that it exists.

<sup>14</sup>Capitalization figures are collected from annual rankings reported by Finance magazine through 1977. Roughly speaking, they reflect equity capital and subordinated liabilities as reported by broker-dealer firms to the Securities Exchange Commission (SEC). Friend, Hess, Mendelson, and Longstreet (1967, p. 548) outline the precise calculations used in 1962 for data taken from SEC form X-17-A. Finance stopped publishing annual capitalization rankings after 1977. Capitalization figures for subsequent years are collected from similar rankings reported by the Securities Industry Association or from the annual reports of public firms. These figures reflect equity capital and long-term debt. In cases in which broker-dealer operations are carried out by a subsidiary of a parent firm, the parent's capitalization is the number reported.

<sup>15</sup>Wilhelm and Downing (2001) suggest that this trend may have followed naturally from the weakening in the 1980s of exclusive relationships between investment banks and their customers. Investing their financial capital in deals reduced the danger that investment bankers' ideas would be usurped by competitors and hence allowed them to retain a claim upon the human capital that they invested in designing transaction structures.

<sup>16</sup>Merrill Lynch was a noteworthy early counterexample. In 1940, the firm began publishing an annual report for public dissemination and, initially, was the only NYSE member to do so (Perkins (1999), p.164). At the time Merrill Lynch maintained the largest network of retail branch offices and was setting the stage for trading access to its distribution network for securities underwriting participations. The firm's annual reports gained considerable attention from the financial press and appealed to a prospective retail clientele questioning the trustworthiness of Wall Street firms in the aftermath of the market crash. Some competitors eventually followed suit. This early example of promoting transparency is not particularly challenging to our theory in the sense that key features of the firm's human capital were well codified by this time. In fact, Merrill was among the first companies in the U.S. to institute (in 1945) a formal training program for its employees (Perkins (1999) p. 195). Competitors benefited from the firm's efforts as evidenced by the defection of about 25% of the graduates of its training programs during its first two decades. The firm tempered at the margin the incentive to defect among non-partners by refusing to rehire employees who left the

firm for other brokerages and with a delayed-withdrawal profit-sharing program (Perkins (1999) pp. 198-200).

<sup>17</sup>Among wholesale banks, First Boston and Dillon Read are perhaps noteworthy for their absence. First Boston is excluded because it was publicly incorporated from its founding in 1934 in the aftermath of the Glass-Steagall Act. Similarly, Dillon Read, which had only one office located in New York City, was incorporated prior to 1955.

<sup>18</sup>A mild qualification is perhaps in order. A common reason given for the private incorporation of investment banks was that it reduced tax obligations on the firm's profits and thereby promoted accumulation of capital within the firm. A partner's profits typically were subject to a higher marginal tax rate than was borne by corporate profits. Incorporation also diminished the threat of large capital withdrawals resulting from estate settlement in the event of a partner's death. When Loeb, Rhoades incorporated in 1977, John Loeb identified such issues as the only reason for the firm's incorporation (New York Times, July 10, 1977, p.85).

<sup>19</sup>Hayden Stone merged with Cogan, Berlind, Weill & Levitt, Inc. in 1970 and was acquired by Shearson Hammill in 1974.

<sup>20</sup>Specifically, we exclude the following computers: Atlas, CDC 6600, CDC 7600, Cray-1, Cray-2, IBM 360/75, and IBM 360/195.

<sup>21</sup>Small scale computers could be leased for as little as \$7,000 per month while larger computers started at \$25,000 per month. Each could be purchased for about 50 times its monthly lease rate (Wall Street Journal October 9, 1959). By contrast, IBM planned a minimum scale of 15 hours computing time (at less than \$300 per hour) for use in its financial district service center (New York Times, August 4, 1959).

<sup>22</sup>In the same article, Ronello Lewis, a Hutton partner, claimed that the \$300,000 Hutton expected to pay RCA was about equal to its own costs at the time for carrying out this portion of its clerical business. Lewis had recently joined Hutton after having worked at RCA and Olin Mathieson. Lewis claimed to have found Wall Street "about thirty years behind the times in office procedure" upon his arrival, and suggested it had improved little since his arrival. He also noted that back-office operations and broker compensation each accounted for about 25 % of commission

dollars, and he derided fears that outsourcing of data processing would expose customer lists or secrets to competitors.

<sup>23</sup>Descriptions of back office operations at these firms (e.g., New York Times, December 23, 1970, p. 35) paint a picture of mass confusion during this period. Coupled with the subsequent decline in economic activity, these operational problems led to large-scale withdrawals of capital by subordinated lenders. Fearing a run on all brokerage firms, in 1970 NYSE member firms coordinated the acquisition of Goodbody by Merrill Lynch, the merging of Hayden, Stone with CBWL, and the rescue of F.I. DuPont, Glore Forgan by a group led by H. Ross Perot. Perot admitted at the time that his motive for backing DuPont was not to enter the brokerage business but to build an EDS data center on the back of operational shortcomings still prevalent on Wall Street (Institutional Investor, March 3, 1971, p.155).

<sup>24</sup>Although gaining note for its strong corporate relationships, Goldman was in the midst of large-scale growth in its trading operations. Over the course of a “few” years, Goldman had risen by July 1971 from 33rd to third in brokerage commissions (behind only Merrill and Bache) and was especially gaining market share in block trading and arbitrage, where Salomon was its primary competitor among sample firms. (New York Times, July 11, 1971).

<sup>25</sup>Although we note in section II.B.1 that investment banks could share or rent computer time, a substantial management literature suggests that there is a limit to the relevance of this technique, since it undermines the ability of the bank’s management to identify the commercial uses of new technologies (see for example Wilcocks, Feeny, and Islei (1997)). Our data, which show evidence of operating scale bottlenecks, suggests that banks attempted to retain a significant degree of computing power in-house and hence is supportive of this hypothesis.

<sup>26</sup>In cases in which the bank had reorganized as a private corporation by 1970, numbers reported in the “partners” column reflect the number of key individuals listed in the NYSE annual directory. In some instances, holders of voting and nonvoting stock are listed separately, in which case we count only the voting stockholders. Limited partners are not included in these counts on the grounds that they are unlikely to influence firm policy. In many instances, although limited partners are unable to withdraw their capital immediately, their (voting) equity stakes are converted to debt claims. On the same grounds, individuals identified exclusively as subordinated debt holders are

excluded from the counts for private corporations.

<sup>27</sup>Caution is warranted here, especially in the case of Lazard, Frères. Lazard reported a constant capitalization of \$17.5 million through 1980. The New York Times (May 28, 1972) reports a limited partner of the firm claiming this low figure was used to avoid a capital contest with other firms and suggested \$60 million as a more accurate estimate. Given the enormous private wealth of the firm's senior partners as well as that of their close contacts, even this number probably understates the resources the firm could have gathered on short notice. Although there is no evidence of similar systematic underreporting of capitalization among other banks, it should be recognized that capital held within the firm might considerably understate the resources of the firm's partners.

<sup>28</sup>By this time, Loeb Rhoades maintained a substantial retail network following the 1977 acquisition of Hornblower & Weeks.

<sup>29</sup>The institutional facts provided in this section are drawn largely from "Computers are kicking up a furor as they transform the way the financial world bets its money" by David E. Sanger, New York Times, October 19, 1986, p.150.

<sup>30</sup>In the years 1970 to 1971 degree-granting institutions conferred about 26,000 masters degrees in business. In 1985 to 1986 the number rose to about 67,000 degrees (U.S. Dept. of Education, Digest of Education Statistics, 2001). In 1965, only 8 % of Harvard's MBA class accepted jobs in investment banking, whereas 21 % cent of the graduating class of 1969 entered investment banking; this remained the record until 1986, when 29 % went into investment banking (Wall Street Journal, June 16, 1987). Similarly, 18.8 % of NYU's graduating class went into investment banking in 1986.

<sup>31</sup>New York Times, May 25, 1972, p.75. It is perhaps noteworthy that LaBranche & Co. was the first specialist firm to enter the public domain via an IPO and only did so in 1999 in the wake of the massive consolidation by acquisition described below.

<sup>32</sup>In 1933, 230 specialist firms were responsible for making markets for the Exchange's 809 listed stocks (Stoll (1985)). Thus, on average, specialist firms were responsible for liquidity provision in 3.5 stocks. All specialist firms were private partnerships.

<sup>33</sup>The growth rate in capitalization per employee was especially steep in the early 1990s as more heavily capitalized commercial banks began to compete aggressively for investment banking market

share. Note that the arrival of commercial bank capital into the industry is largely reflected only indirectly in Figure 6 through the pressure it placed on investment banks to increase their own capitalization. Throughout the 1990s, the top five banks ranked by capitalization were, in differing order, Merrill Lynch, Morgan Stanley, Goldman Sachs, Lehman Brothers, and Salomon (and after 1997, Salomon Smith Barney).

<sup>34</sup>See Wilhelm and Downing (2001, p.137).

<sup>35</sup>Greenhill & Co. S-1 filing with the Securities Exchange Commission, March 11, 2004.

<sup>36</sup>We thank the anonymous referee for this suggestion.

<sup>37</sup>For example: “The brokers J. & A. Scrimgeour and Kitcat & Aitken, for example, set up a joint company in 1961 in order to share the use of an electronic computer which they required for record-keeping purposes [...] In the 1960s computerization spread rapidly among the major brokers and jobbers, increasing the capital costs involved in the business.” (Michie (1999), p.433)

<sup>38</sup>Fifty-one percent of the shares in limited-liability jobbing (i.e., market-making) firms had to be held by members, with any single nonmember restricted to 10%.

## REFERENCES

- Bar-Isaac, Heski, 2003, Something to prove: Reputational incentives in teams and promotion to partnership, working paper, London School of Economics.
- Black, Fischer, and Myron Scholes, 1973, The pricing of options and corporate liabilities, *Journal of Political Economy* 81, 637–654.
- Boot, Arnoud W. A., Stuart I. Greenbaum, and Anjan V. Thakor, 1993, Reputation and discretion in financial contracting, *American Economic Review* 83, 1165–1183.
- Chandler, Alfred D., 1990, *Scale and Scope: The Dynamics of Industrial Capitalism* (Harvard University Press: Cambridge, Mass.).
- Endlich, Lisa J., 1999, *Goldman Sachs: The Culture of Success* (Alfred A. Knopf: New York, NY).
- Farrell, Joseph, and Suzanne Scotchmer, 1988, Partnerships, *Quarterly Journal of Economics* 103, 279–297.

- Friend, Irwin, Arleigh P. Hess, Jr., Morris Mendelson, and J. R. Longstreet, 1967, *Investment Banking and the New Issues Market* (World Publishing Company: Cleveland, Ohio).
- Garicano, Luis, and Tano Santos, 2004, Referrals, *American Economic Review* 94, 499–525.
- Gilson, Ronald J., and Robert H. Mnookin, 1985, Sharing among the human capitalists: An economic inquiry into the corporate law firm and how partners split profits, *Stanford Law Review* 37, 313–392.
- Hayes, Samuel L., 1971, Investment banking: Power structure in flux, *Harvard Business Review* 49, 136–152.
- Hayes, Samuel L., 1979, The transformation of investment banking, *Harvard Business Review* 79, 153–170.
- Hillman, Robert W., 2001, Professional partnerships, competition, and the evolution of firm culture: The case of law firms, *Journal of Corporation Law* 26, 1061–1085.
- Jones, Charles M., 2002, A century of stock market liquidity and trading costs, Working paper University of Columbia.
- Kim, Dongcheol, Darius Palia, and Anthony Saunders, 2003, The long-run behavior of debt and equity underwriting spreads, working paper, Stern School of Business New York University.
- Kreps, David M., and Robert Wilson, 1982, Sequential equilibria, *Econometrica* 50, 863–894.
- Levin, Jonathan, and Steven Tadelis, 2005, Profit sharing and the role of professional partnerships, *Quarterly Journal of Economics* 120, 131–171.
- Michie, Ranald C., 1999, *The London Stock Exchange: A History* (Oxford University Press: Oxford, U.K.).
- Morrison, Alan D., and William J. Wilhelm, Jr, 2004, Partnership firms, reputation and human capital, *American Economic Review* 94, 1682–1692.
- Nordhaus, William D., 2001, The progress of computing, working paper, Yale University.
- Perkins, Edwin J., 1999, *Wall Street to Main Street: Charles Merrill and Middle Class Investors* (Cambridge University Press: Cambridge, U.K.).
- Polanyi, Michael, 1966, *The Tacit Dimension* (Doubleday: Garden City, NY).

Stoll, Hans, 1985, *The Stock Exchange Specialist System: An Economic Analysis*. Monograph Series in Finance and Economics (Salomon Brothers Center for the Study of Financial Institutions: Graduate School of Business Administration, New York University).

Wilhelm, Jr., William J., and Joseph D. Downing, 2001, *Information Markets* (Harvard Business School Press: Boston, MA).

Willcocks, Leslie, David Feeny, and Gerd Islei, 1997, *Managing Information Technology as a Strategic Resource* (McGraw-Hill: Oxford, U.K.).

Table I

## Sample Banks

	Branches <sup>a</sup>		Corporate Clients <sup>b</sup>		Private Inc <sup>c</sup>	Public Offering	Public by Acquisition or Failed While Private
	1970	1978	1970	1978			
<i>Retail Firms</i>							
Bache	94	145 (15)	2	4	1964	1971	
Dean Witter	64	230(12)	4	9	1968	1972	
E.F. Hutton	79	191(11)	1	4	1963	1972	1988, acquired by Shearson/American Express
Eastman Dillon	30	39(3)	14	37	1971		1972, combined with Blyth subsid of INA (a public corp.)
Francis I duPont	101		11				1969, combined with Glore Forgan
Glore Forgan							1974, F.I. duPont Glore Forgan closed
Goodbody							1970, partnership until acquired by Merrill Lynch
Hayden Stone	82		0		1962		1979, after acquisition by Shearson Hammill in 1974
Hornblower & Weeks	63		10		1972		1977, acquired by Loeb Rhodes
Merrill Lynch	275	322(43)	20	72	1959	1971	
Paine Webber	66	135(6)	5	7	1971	1972	1972, IPO via merger with Abacus Fund
Shearson Hammill	60	116(12)	0	3	1967		1979, acquired by American Express (a public corp.)
<i>Wholesale Firms</i>							
Bear Stearns	9	7(3)	4	5		1985	
Goldman, Sachs	9	11(3)	49	87		1999	
Kidder Peabody	0	48(7)	25	34	1964		1986, acquired by GE Financial (subsid of a public corp.)
Kuhn Loeb	0		13		1977		1978, acquired by Lehman (1984, acquired by Shearson)
Lazard, Freres	3		7	27	2005		
Lehman Brothers	5	7(2)	37	69	1972		1984, acquired by Shearson. 1994, spinout IPO
Loeb Rhoades	18	150(13)	3	12	1977		1979, acquired by Shearson
Morgan Stanley	0	2(3)	49	60	1970	1986	
Saloman Brothers	30	8(2)	6	12			1981, partnership until acquired by Phibro (a public corp.)
Smith Barney	17	80(5)	19	38	1963		1987, acquired by Primerica
White, Weld	13		17		1971		1978, acquired by Merrill Lynch

<sup>a</sup>1970 branch offices as of September 1970, NASD Manual of Members, reported by Hayes (1971, Exhibit IV). 1978 branch offices as of January 1978, reported by Hayes (1979, Exhibit IV). Foreign offices in parentheses.

<sup>b</sup>1970 number of corporate clients among Fortune 500 firms as of July 1970, reported by Hayes (1971, Exhibit VI). 1978 number of corporate clients among Fortune 500 firms as of July 1970 reported by Hayes (1979, Exhibit VI).

<sup>c</sup>Dates of private incorporation reflect the year of incorporation or (typically March of) the first year that *Finance* magazine identifies the firm as a corporation.

**Table II**  
**Fails to Deliver (\$000's)**

“Fails to Deliver” represents the dollar value of securities orders that firms are unable to deliver within 30 days. Data are obtained from *Finance* magazine, March 1970.

<i>Retail Firms</i>	1968		1969	
	Fails	% of Capital	Fails	% of Capital
Bache	4,004	4.2%	6,268	6.7%
Dean Witter	7,323	14.4%	492	1.1%
E.F. Hutton	5,023	10.4%	477	1.0%
Eastman Dillon	11,530	21.8%	2,350	4.7%
Francis I duPont	13,900	21.0%	3,163	5.3%
Glore Forgan	10,631	49.2%	1,750	9.2%
Goodbody	25,973	52.4%	na	na
Hayden Stone	13,689	27.7%	10,364	26.6%
Hornblower & Weeks	6,057	17.4%	2,476	8.0%
Merrill Lynch	5,873	2.3%	1,834	0.7%
Paine Webber	6,512	21.1%	1,123	3.6%
Shearson Hammill	4,027	12.4%	995	3.0%
Mean		21.2%		6.3%
<i>Wholesale Firms</i>				
Bear, Stearns	19,344	77.4%	374	1.5%
Goldman, Sachs	24,658	60.1%	1,400	3.0%
Kidder Peabody	4,815	17.2%	1,717	6.0%
Kuhn Loeb	293	2.9%	9	0.1%
Lazard, Freres	2,562	14.6%	21	0.1%
Lehman Brothers	1,548	2.2%	227	0.4%
Loeb Rhoades	8,686	11.3%	2,480	3.2%
Morgan Stanley	236	3.1%	na	na
Salomon Brothers	4,510	7.7%	1,278	2.0%
Smith Barney	13,571	45.2%	na	na
White, Weld	4,500	11.0%	1,949	3.9%
Mean		23.0%		2.2%

Table III

## Capital per Partner

	1955			1960			1965			1970			
	Partners	Cap/Part	Partners	Cap/Part	Partners	Cap/Part	Partners	Cap/Part	Partners	Cap/Part	Partners	Cap/Part	Employees/Part <sup>a</sup>
<i>Retail Firms</i>													
Bache	34	496,471	47	554,355	69	670,310	na	na	na	na	na	na	na
Dean Witter	30	377,129	50	367,615	70	513,408	95	451,316	95	451,316	95	451,316	49.1
E.F. Hutton	28	353,240	31	481,473	45	501,953	96	446,573	96	446,573	96	446,573	38.5
Eastman Dillon	17	608,782	35	583,218	39	821,338	73	626,027	73	626,027	73	626,027	28.0
Francis I duPont	20	933,214	29	900,752	39	1,187,583	65	776,923	65	776,923	65	776,923	66.2
Glore Forgan	17	360,385	20	308,350	24	375,067							
Goodbody	16	342,453	19	381,579	42	530,952							
Hayden Stone	16	251,188	34	239,852	44	373,759	61	334,623	61	334,623	61	334,623	27.9
Hornblower & Weeks	38	239,019	34	259,846	64	333,339	65	879,523	65	879,523	65	879,523	43.8
Merrill Lynch	73	431,507	114	624,920	137	973,644	217	1,403,452	217	1,403,452	217	1,403,452	82.9
Paine Webber	35	208,069	45	247,685	59	295,407	82	386,012	82	386,012	82	386,012	48.8
Shearson Hammill	13	504,654	24	441,749	31	546,080	82	371,878	82	371,878	82	371,878	37.2
Mean	28	425,509	40	449,283	55	593,570	93	630,703	93	630,703	93	630,703	47
<i>Wholesale firms</i>													
Bear, Stearns	14	1,334,945	20	976,818	20	750,000	28	892,857	28	892,857	28	892,857	26.8
Goldman, Sachs	12	776,004	21	658,440	28	747,607	45	1,088,889	45	1,088,889	45	1,088,889	32.6
Kidder Peabody	22	286,165	23	571,192	59	285,299	86	369,465	86	369,465	86	369,465	19.8
Kuhn Loeb	11	600,000	12	550,000	21	406,262	26	421,154	26	421,154	26	421,154	17.3
Lazard, Freres	9	1,774,269	19	921,053	20	875,000	24	729,167	24	729,167	24	729,167	9.0
Lehman Brothers	18	972,857	22	1,600,521	29	1,018,642	36	889,111	36	889,111	36	889,111	33.3
Loeb Rhoades	17	735,294	23	543,478	27	740,741	51	1,320,529	51	1,320,529	51	1,320,529	39.2
Morgan Stanley	20	254,600	21	240,000	21	285,714	34	276,294	34	276,294	34	276,294	7.7
Salomon Brothers	20	601,000	23	508,696	22	940,909	31	2,990,323	31	2,990,323	31	2,990,323	34.4
Smith Barney	21	400,667	28	312,393	44	227,273	37	945,946	37	945,946	37	945,946	36.5
White, Weld	20	805,000	34	636,496	35	696,673	43	1,061,395	43	1,061,395	43	1,061,395	33.7
Mean	17	776,436	22	683,553	30	634,011	40	998,648	40	998,648	40	998,648	26

<sup>a</sup>The number of employees is for the calendar year 1971 as reported in the July 1972 issue of *Fortune* magazine.

Table IV

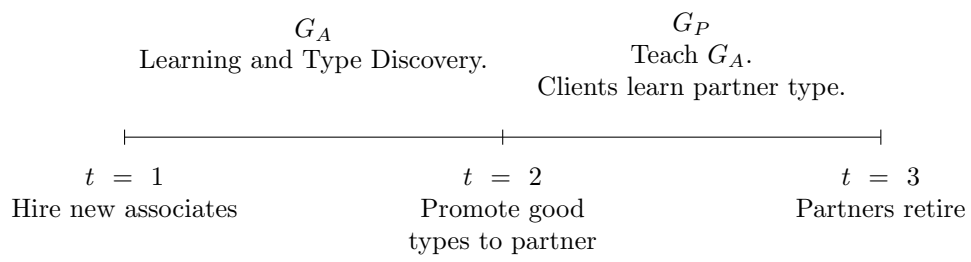
Average Partner Tenure in 17 Prominent Investment Banks

	1952		1960	
	Number of Partners	Av. Partner Tenure	Avg. Partner Tenure	% Change From 1952
Paine Webber	36	16	16	0.00%
Hayden Stone	14	16	12	-25.00%
Shearson Ham	13	19	16	-15.79%
Merrill	64	19	14	-26.32%
White Weld	21	20	19	-5.00%
Smith Barney	20	22	21	-4.55%
Hutton	16	23	18	-21.74%
Morgan Stanley	14	23	24	4.35%
Goodbody	18	24	17	-29.17%
Cowen	9	24	24	0.00%
Goldman	13	24	22	-8.33%
Hornblower	27	24	20	-16.67%
Dean Witter	26	26	19	-26.92%
Lehman	19	26	23	-11.54%
Kidder	17	27	25	-7.41%
Wm Blair	8	27	28	3.70%
A. Brown	8	28	27	-3.57%

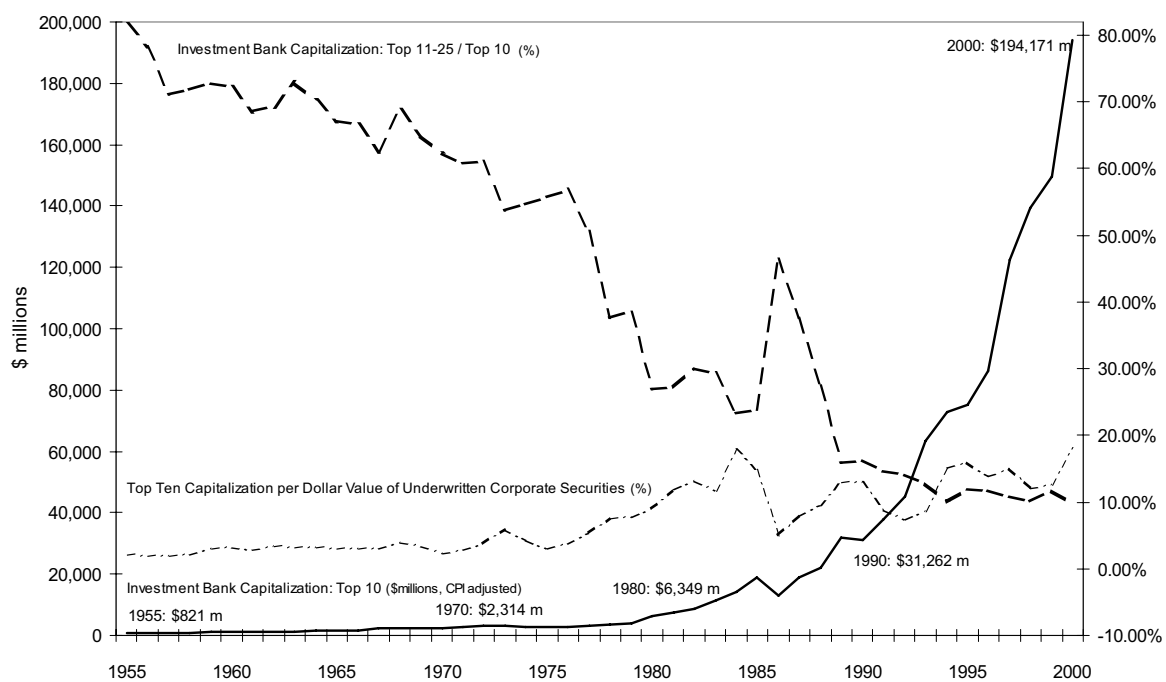
**Table V**

**New York Stock Exchange Specialist Firms: October 31, 2004**

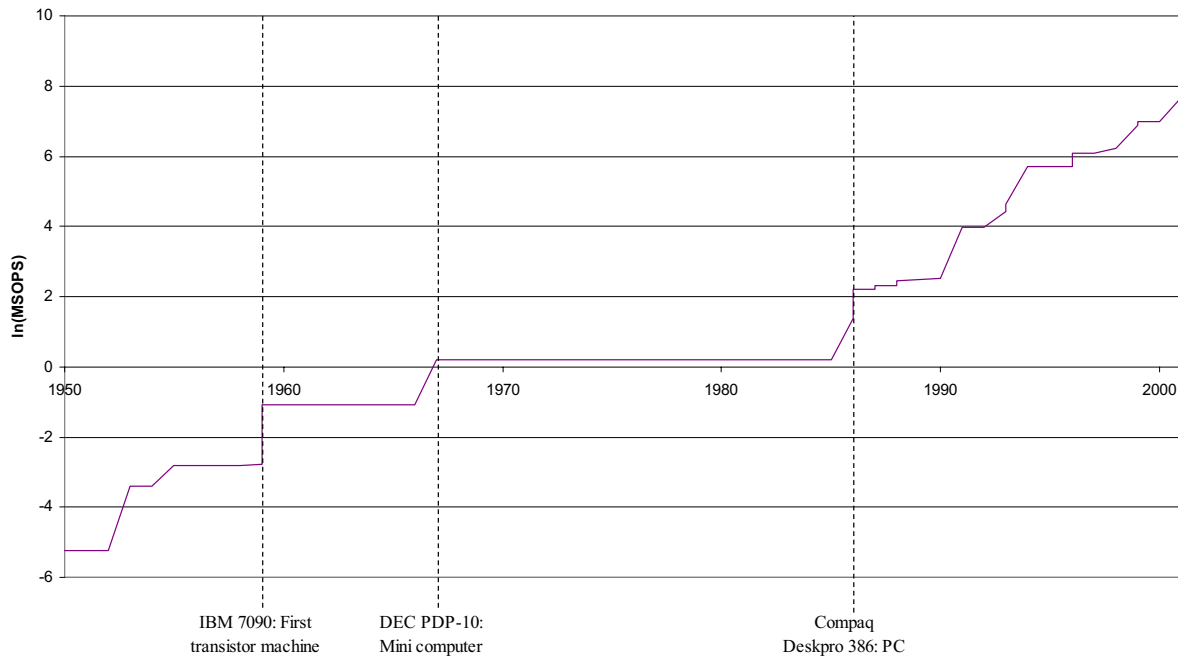
Specialist Firm	Number of Stocks	Parent or Affiliate
LaBranche & Co. LLC	577	LaBranche & Co. Inc.
Spear Leeds & Kellogg Specialists	557	Goldman Sachs
Fleet Specialist, Inc.	434	Bank of America
Van Den Moolen Specialists USA	380	Van Der Moolen
Bear Wagner Specialists LLC	353	Bear, Stearns
Performance Specialist Group LLC	179	Kellogg Group
SIG Specialists, Inc	129	Susquehanna Intl. Group



**Figure 1. Career path of a partner.**



**Figure 2. The U.S. investment banking industry, 1955 - 2000.** (Capitalization numbers are CPI-adjusted).



**Figure 3. Advances in processing power, 1950 - 2001.** (Source: Nordhaus (2001), Appendix 2).

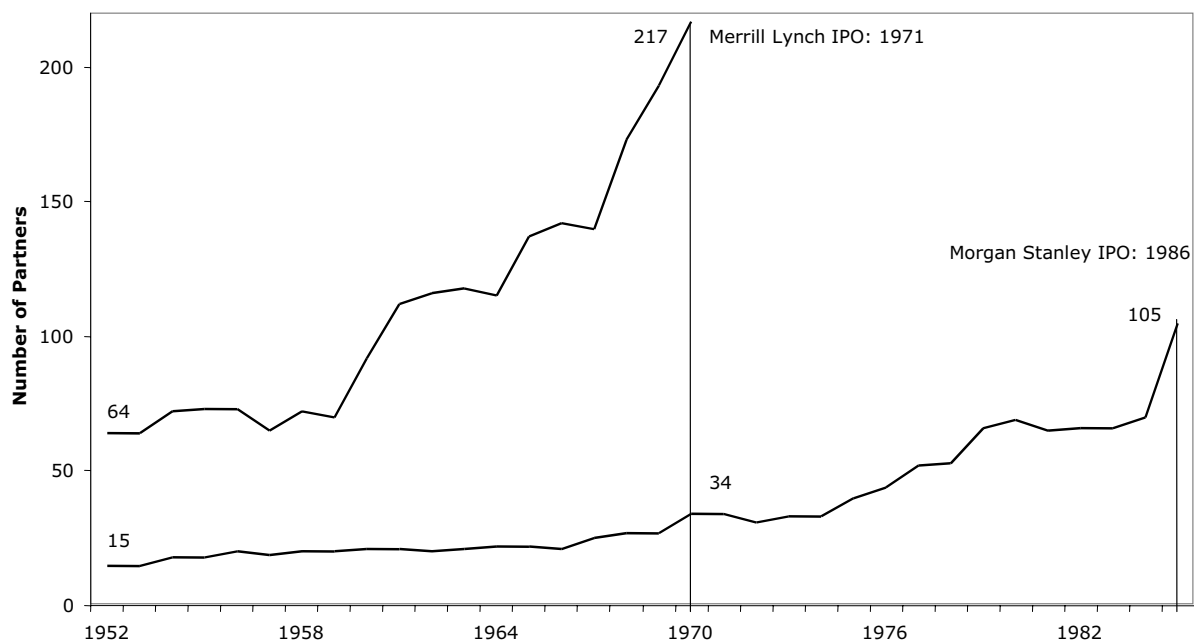
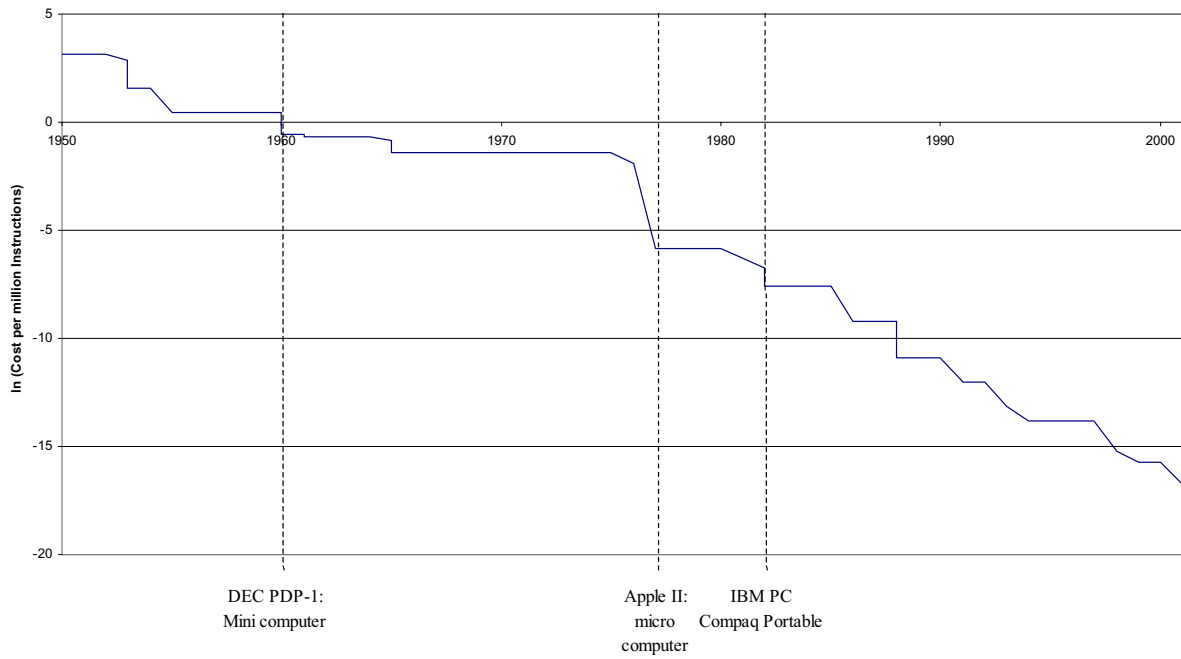
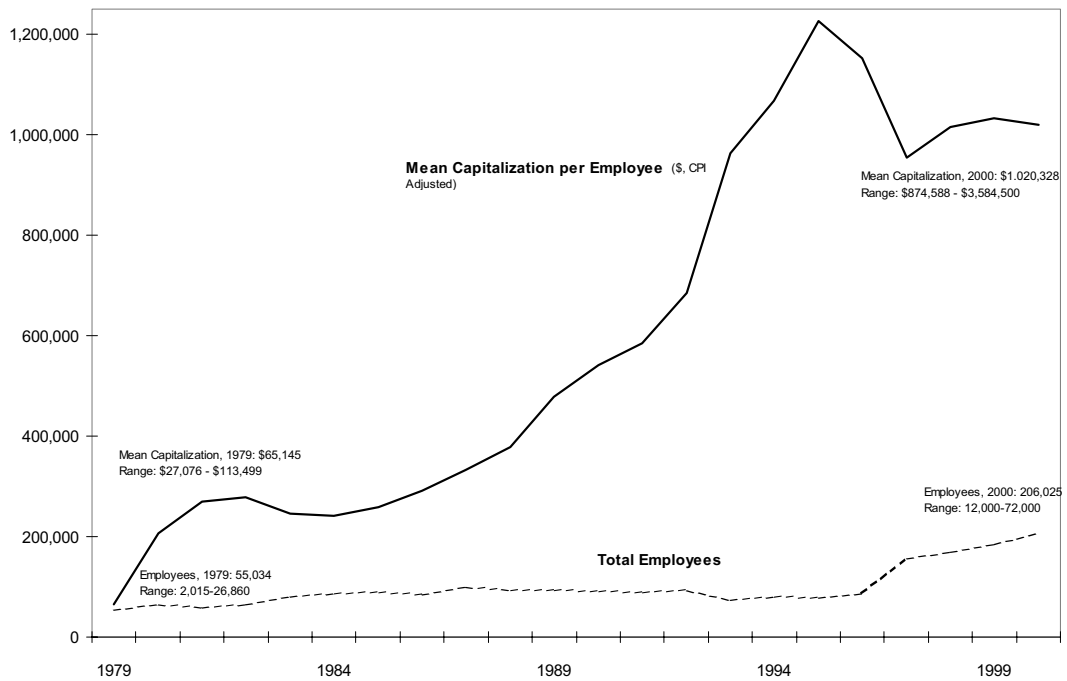


Figure 4. Partnership growth prior to public offering: Merrill Lynch and Morgan Stanley.



**Figure 5. Cost of computing, 1950 - 2001.** (Source: Nordhaus (2001), Appendix 2).



**Figure 6. Investment Bank Employees and Capitalization, 1979-2000.** (Top five banks by capitalization)