The Demise of Investment-Banking Partnerships: Theory and Evidence*

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Abstract

Until 1970, the New York Stock Exchange prohibited public incorporation of member firms. After the rules were relaxed to allow joint stock firm membership, investment-banking concerns organized as partnerships or closely-held private corporations went public in waves, with Goldman Sachs (1999) the last of the bulge bracket banks to float. In this paper we ask why the Investment Banks chose to float after 1970, and why they did so in waves. Our explanation extends previous work which examined the role of partnerships in fostering the formation of human capital (Morrison and Wilhelm, 2003). We examine in this context the effect of technological innovations which serve to replace or to undermine the role of the human capitalist and hence we provide a technological theory of the partnership's going-public decision. We support our theory with a new dataset of investment bank partnership statistics.

KEY WORDS: Partnership, human capital, collective reputation, investment bank, going-public decision.

JEL CLASSIFICATION: G24, G32, J24, J41, L14, L22.

1. Introduction

In 1970 the New York Stock Exchange relaxed its rules to allow joint stock corporations to become members. The member firms, which hitherto had all been constituted as partnerships or as closely-held private corporations, did not immediately go public. An initial wave of retail and brokerage firms chose to float in 1970 and 1971[1]; 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 floatation.

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

In this paper we extend previous theoretical work (Morrison and Wilhelm, 2003) to 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 with a firm-level dataset 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 which explains the economic rationale for the partnership form. Previous work has focussed upon the importance of profit-sharing rules in incentivising hard work, signalling employee quality, and efficient task allocation.[2] Our model focuses upon the importance of tacit human capital. Tacit human capital, first discussed explicitly by Polanyi (1966), is important in traditional investment banking activities. It covers forms of knowledge and skills which do not easily lend themselves to codification or to arms-length exchange. Such skills include a range of talents such as advising clients, building relationships, reading market signals and negotiating M&A deals which are essential to investment banking. These skills can only be learnt on the job: while an MBA program can furnish a student with technical skills, it cannot teach her how to be an investment banker.

Tacit human capital is valuable to clients, but 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.

Our basic model is based upon Morrison and Wilhelm (2003). It rests upon two important distinguishing features of partnerships: 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.[3] These factors prevent outsiders from observing the quality

[2] 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 (2002) 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 (2003) argue that the profit sharing rules imposed by partnerships can improve incentives for agents to redirect jobs to those most able to perform them.

[3] Endlich (1999, p. 21) provides a striking example of the cultural tendency within the Goldman Sachs investment-

of the 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.[4] While publicly traded firms attempt to use devices such as non-compete contracts to bind employees to the firm these contracts are hard to enforce.

We incorporate these features in a simple model of an infinitely-lived firm which 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 with mentoring. After one period a fixed fraction of the associates become skilled and in equilibrium are promoted to partner; other associates are fired. The firm is assumed to be opaque and so only insiders can observe an associate's after-mentoring quality, which is learnt slowly by experience in the final period of his career. For this reason an associate who is fired is rewarded in the labour market as a low quality agent. Partnerships can therefore 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 learnt by their clients.

The partnership's institutional reputation provides the mentoring incentives in our model. A partnership which 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 will anticipate 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 will refuse promotion to partnership. So 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 which places an upper bound on the size of the partnership. This reduces the partnership's ability to make significant investments in physical

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..."

[4] For example, 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 if it wished to extend the payout schedule (Wilhelm and Downing, 2001, chapter 7).

capital: very large investments will be used by a suboptimal number of partners, and some of the capital will remain idle. 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.

Our evidence from the U.S. investment banking industry is supportive of this hypothesis. We classify active investment banks according to whether they were mostly engaged in 1970 in retail or in wholesale investment business. It is striking that retail institutions floated in one wave in the early 1970s, and that wholesale banks floated in a second wave, mostly in the 1980s. To explain this, we identify two technological shocks. Firstly, the advent in the 1960s of powerful transistor-based computers which facilitated batch-processing of transactions data; and secondly, the development of the microcomputer which facilitated the real-time implementation of new techniques in financial engineering.

The rapid increase in the 1960s in computer power allowed computers to substitute to some extent for human capital in performing routine administrative activities which were important to retail institutions, such as settling transactions, maintaining client balances, mailing confirmations and so on. At the same time, computers were costly and it was only possible to perform these activities on a large scale. Corporations could therefore implement the new capital-intensive technologies only if they generated sufficient transactions.[5]

We demonstrate using data drawn from annual NYSE membership directories and other public sources that in the decade before they started to float, retail oriented institutions saw a rapid increase in the number of partners, the capital employed per partner, and the number of employees per partner. All of these observations are consistent with the scale pressures which our theory predicts. We argue that the ultimate consequence of these pressures was the going-pubic decision. Conversely, we find little evidence of such an effect in the wholesale market. We argue that this is because wholesale firms, which have a greater emphasis upon big ticket market-making and proprietary trading, could derive little if any competitive advantage from the batch-processing capabilities of 1960s computers. For this reason, the organisational form of wholesale firms was not

[5]A similar argument is made by Chandler (1990), who argues that only large corporations could support the capital-intensive production technologies of the second industrial revolution. For this reason these technologies were only employed, and the modern corporation was born, only when improved communications networks generated sufficiently large markets.

affected by the advent of transistor-based computers in the same way as the retail firms.

The development in the late 1970s of the microcomputer and its subsequent widescale adoption in the 1980s did however have significant implications for wholesale trading houses. 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: firstly, it increased the relative importance in the investment banking industry of technical skills which would be learnt in the classroom; and secondly, 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 so undermined the partnership form. The second caused a sharp drop in bid/ask spreads. Tighter spreads increased the minimum scale at which market making could be profitable: this resulted in a greatly increased need for financial capital and so generated size pressures in the partnerships. Given the reduced need for tacit human capital, the rational response to size pressures was for the trading houses to float.

We present our theory of partnerships and their going public decision in section 2. Section 3 contains supporting evidence. Section 4 concludes.

2. Theory

Our model extends Morrison and Wilhelm (2003) to incorporate investment in physical capital and the going public decision.

2.1. 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 labour 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 which relies upon human capital. The human capital may be augmented by physical capital: the minimum investment in physical capital is M. Without physical capital the per-period product of an unskilled agent is w_l, and 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 so

$$\begin{aligned} W_h &\equiv w_h + v_h - r; \\ W_l &\equiv w_l + v_l - r. \end{aligned}$$

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

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

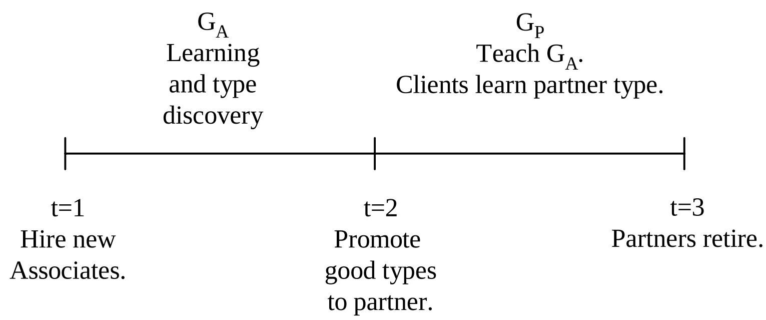

Figure 1: Career path of a partner.

The career path of an agent who is hired at time 1 is illustrated in figure 1: the associate and partner generations are labelled G_A and G_P. At each time there are N partners and n associates are hired per partner. An associate and the partners learn his 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.

We assume, in line with observations in the introduction, that partners cannot leave the firm before retirement. Skilled partners are able at a personal cost c to mentor associates. If $M \leq N$

[6] This is in contrast to Levin and Tadelis' (2002) 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 size, which would depend in turn upon the wage level. Joint determination of wage levels and of 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.

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: they learn it at time 3 through experience. At this stage it becomes common knowledge,[7] but it is not verifiable in a court and so 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*[8] P *at which new partners acquire a partnership stake, wages* w_A, 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: 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 which cannot be exchanged at arm's length.

Partnerships are of course socially useful only if mentoring is optimal. The respective conditions

[7]It is reasonable to assume that performance information would become common knowledge over several generations. In the interests of tractability we assume that it is shared immediately.

[8]Constraining P to be a constant as in definition 1 is without loss of generality. It 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.

for this to be the case with and without physical capital are given by equations 1 and 2:

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

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

2.2. Existence of Equilibria

In this section we examine the conditions under which a partnership equilibrium exists. To do so, we define π_l and π_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 which we explain below, the value of π_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 realised partner quality. We set w_C equal to π_h if every previous partner was skilled; and equal to π_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 incentivises 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 need firstly 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 (2003) 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 π_l, to accepting a partnership, in which case they will earn π_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 π_l and the value of an untrustworthy firm will therefore be 0.

Now consider a trustworthy firm in which every agent in the current generation acts in accordance with rules PE3-5 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 behaviour. 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 $n(\pi_l - w_A) + \pi_h$. New associates will in the second period of their career receive this sum less the cost c of mentoring new associates with probability $\frac{1}{n}$ and will otherwise earn π_l. Their outside option is to earn π_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 π_l by assumption, so PE2 is satisfied at any non-negative wage.[9] □

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

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

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

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

A skilled agent earns utility $\pi_h + n\pi_l - c$ from accepting a partnership offer. If he refuses and is fired then the labour market knows that precisely one of the $N(n-1) + 1$ agents returning to the workforce is skilled[10] 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

[9] 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.

[10] This is an off-equilibrium path belief: it is again consistent in the Kreps and Wilson (1982) sense.

the outgoing partners can arrange financing for the penniless associate to purchase his partnership share.[11]

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* $N \geq \sqrt{1+r}\left(\sqrt{r} + \sqrt{1+r}\right)$.

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 that at the prevailing share price no unskilled agent will enter 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 0. In the meantime, he can earn a wage π_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.[12] 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 1 for

$$N \geq \sqrt{1+r}\left(\sqrt{r} + \sqrt{1+r}\right). \tag{6}$$

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*

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

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

[11] This assumption is crucial, as if the associate could signal his quality to the labour 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.

[12] 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.

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 behaviour are shared equally amongst 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 summarised 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. □

2.3. 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 π_h of a partner may drop below W_h. In this section we examine this effect and demonstrate that it may in some situations 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 amongst the partners. In a partnership firm with capital the output of a partner *net of the cost of idle capital* is therefore

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

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*

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

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

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

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

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

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 (8) of π_h, this is true if and only if

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

where

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

The first of the conditions in equation (11) is satisfied iff $M \leq M_l$, in which case $N = \operatorname{int} N_{NIC}$. 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 is 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 $\operatorname{int} N_{NIC}$ 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 $\operatorname{int} N_{NIC}$ and this will have 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 which 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 which satisfies the condition (3) for associates to pay for mentoring if and only if $c \leq \bar{c}$, where*

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

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 $\frac{r}{1+r}\left(\frac{M}{\operatorname{int} N_{IC}} - (1+n)\right)$. This renders mentoring unsustainable in a partnership equilibrium even in some circumstances where it would with with perfect contracts 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 EQUILIBIRA 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.*

2.4. 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: the optimality condition (1) for mentoring is therefore satisfied. Suppose that some innovation gives the partnership access to a physical technology which has minimum operating scale M, unit per-period cost r, and which 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. Firstly, it could continue to operate without the use of the new technology, in which case its per employee output will be $\frac{w_h+nw_l-c}{n+1}$. Secondly, it could adopt the new technology and continue to function as a partnership. In this case, as in proposition 2, its size will be $\bar{N}$ and its per employee output will be $\frac{\pi_h+nW_l-c}{n+1}$. Thirdly, it could adopt the new technology and cease to function as a partnership. In this case mentoring will cease to be incentive compatible and the per employee output will 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 non-adoption 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:

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

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[13]. 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: i.e., when

$$c > \frac{\Delta W}{1+r}. \tag{15}$$

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.

[13] Although we do not explicitly model the support role of associates, it seems reasonable to assume that it exists.

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

$$M > M_h, \tag{16}$$

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 the following

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

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

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

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 summarise 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: 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.*

3. Evidence

Proposition 3 predicts that partnership firms will go public in response to technological shocks which 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 US investment-banking industry in the second half of the twentieth century.

Our empirical analysis rests on industry data from 1955-2000. The starting date is the approximate starting point for which we can reliably gather capitalization measures for U.S. investment banks. We have actually assembled financial capital measures annually for at least the top 100 investment banks by capitalization dating to 1953.[14] Figure 2 provides a summary of three data series central to our analysis of the theory.

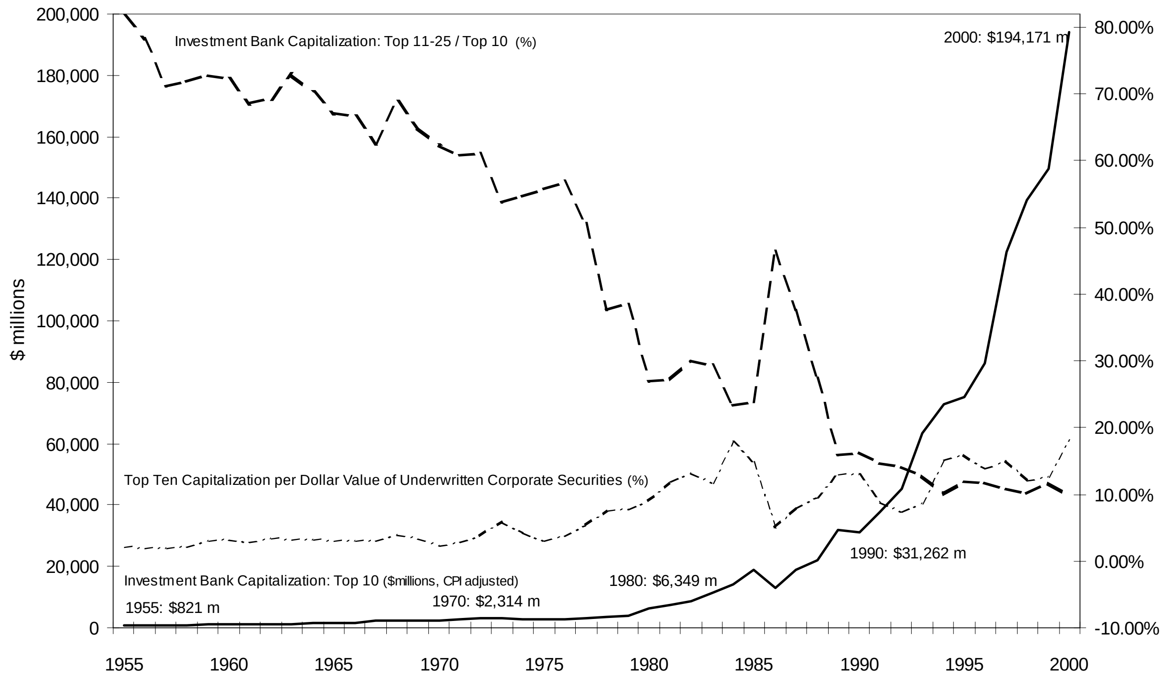

Figure 2: The U.S. investment banking industry, 1955 - 2000 (capitalisation numbers are CPI-adjusted).

First, we plot the total capitalization for the top ten investment banks (ranked by capitalization). In 1955, 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, capitalization of the next 15 most heavily capitalized firms as a percentage of the top ten, illustrates a massive increase in

[14] 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 where broker-dealer operations are carried out by a subsidiary of a parent firm, the parent's capitalization is the number reported.

concentration of capital within the industry. In 1955, this second tier of banks maintained capital greater than 80 per cent of the capital maintained by the top ten banks. By 2000, this ratio had declined to around 10 per cent.

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 declined as a consequence and yet capitalization per dollar underwritten nearly doubled. This change in the industry, 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.[15]

The substantial increases in industry capitalisation illustrated in figure 2 are certainly consonant with an increase in the minimum operating scale for industry participants. In the remainder of this section we present firm-level data which supports our capital-based theory of the partnership's going-public decision.

3.1. Sample Banks

Private banking partnerships were, and remain, subject to few reporting requirements. Moreover, our theory shows that these firms have strong incentives to minimise voluntary reporting in order to remain opaque.[16] For both of these reasons there is little data for individual banks. In the 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 1 is a cross-section of

[15] 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 which they invested in designing transaction structures.

[16] 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, 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, p. 195). Competitors benefited from the firm's efforts as evidenced by the defection of about 25 per cent 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, pp. 198-200).

prominent banking partnerships as of 1955.

[Table 1 here]

Until fairly recently, investment-banking firms could be characterized roughly as either retail or wholesale oriented. Retail firms more nearly specialized 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, the distinction was blurring as firms like 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 1 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 1).

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, Dec 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.[17]

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 in trading and institutional distribution while Lazard, Freres (along with its partner firm in Paris) was perhaps the most influential global mergers and acquisition advisor at the time (see New York Times, May 28, 1972, F1).

[17] 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.

Table 1 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.[18]

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.[19] 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, Freres remained private partnerships.

3.2. The First Wave of Floatations

(i) Technological Change

We argue that changes from partnership to joint stock form are precipitated by technological shocks which drive new physical capital investment in the production process. Part (1) of proposition 3 characterises "physical capital" as non-human investment which 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 arms length. The latter substitutes for tacit human capital embodied in a reputation for fair dealing (see Boot *et. al.*, 1993).

Advances in data-processing technology are illustrated in figure 3. Nordhaus (2001, appendix

[18] A mild qualification is perhaps in order. A common reason given for private incorporation among 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).

[19] Hayden Stone merged with Cogan, Berlind, Weill & Levitt, Inc. in 1970 and was acquired by Shearson Hammill in 1974.

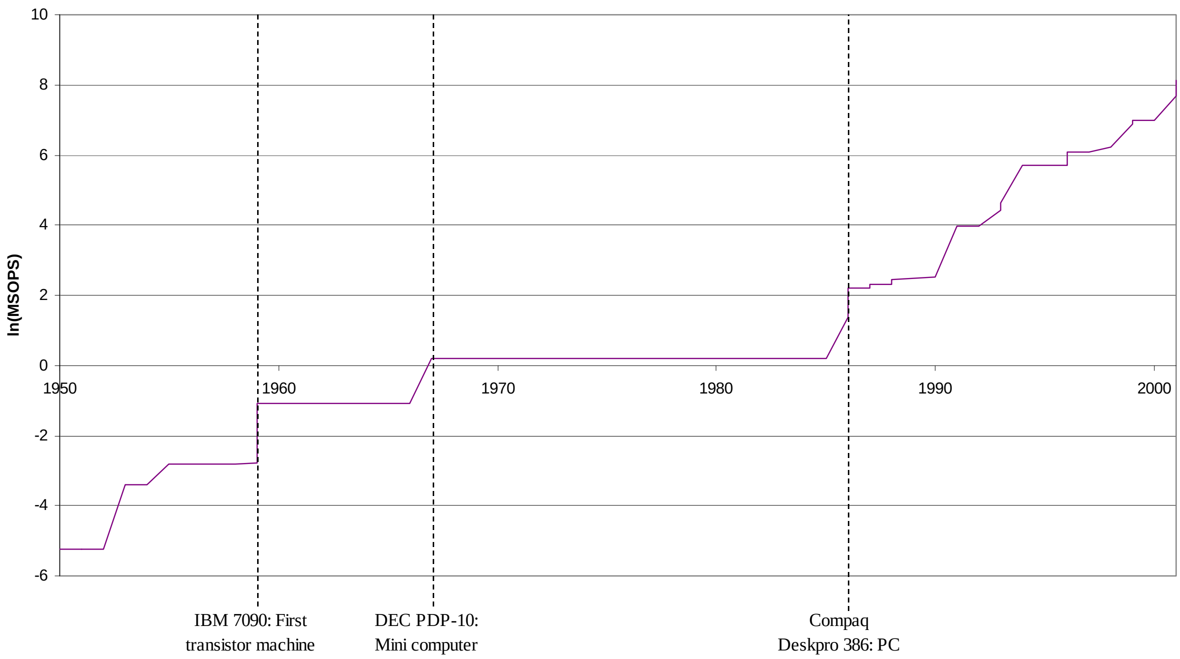

Figure 3: Advances in processing power, 1950 - 2001 (source: Nordhaus, 2001, Appendix 2).

2) provides statistics on computer advances between 1950 and 2001: these are used to compute a time series of most powerful machines to date as measured by a standardised information-theoretic measure, millions of standardised instructions per second, or MSOPS. We exclude supercomputers from our data because they were are intended for the scientific analysis of large non-linear dynamic systems and hence seem of minimal importance to the investment banking industry, at least in the period which we analyse.[20]

The decade before the first investment bank floatation saw substantial advances in computer architecture. Firstly, 1959 saw the production of the first computers which used transistor rather than valve technology. Moreover, 1959 was something of a watershed year for the investment banking industry. Although some large firms like Merrill Lynch had "for some time" (New York Times, May 15, 1961), maintained their own computer systems, both RCA and IBM announced in 1959 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 substantially to have lowered the minimum scale of computerized securities transaction processing. For example, in October 1959, RCA introduced

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

new computers for both small- and large-scale data processing.[21] 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).[22] Later in the 1960s the Digital Equipment Corporation produced the first minicomputers, which allowed smaller scale computing than the previously ubiqitous IBM mainframe.

As a result of the technological and organisational advances identified above, computers became able in the 1960s to perform many routine tasks which were formerly the preserve of human agents. Notwithstanding this advance, Wall Street firms were slow to computerise 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 2 here]

Table 2 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 per cent of the firm's capitalization. Similarly, Hayden, Stone and Glore Forgan suffered fails equal to about 28 per cent and 49 per cent of their capitalization.[23] In contrast, Merrill Lynch and Bache suffered modest levels of fails relative

[21] 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).

[22] 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 per cent of commission dollars and derided fears that outsourcing of data processing would expose customer lists or secrets to competitors.

[23] Descriptions of back office operations at these firms (e.g., New York Times, Dec 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 Inc., 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).

to their peers and 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.[24] During the slower markets of 1969, fails as a percentage of capital among wholesale firms were about one third of the level suffered by retail firms.

To summarise, the 1960s saw significant advances in computer technology. These changes were of most importance in retail-oriented firms with large branch networks (see section 3.1 above) 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.

(ii) The Human/Physical Capital Tradeoff

Condition (2) of the going-public proposition examines the tradeoff between physical and human capital. Floatation 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 which the partnership maintains. In this section, we analyse 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 required partnership firms to tradeoff reaping the efficiency gains which the new technology could bring to their back offices against the value of tacit front office skills.[25] We

[24] 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).

[25] Although we note in section 3.2.i that investment banks could share or rent computer time, there is a substantial management literature which suggests that there is a limit to the relevance of this technique, since it undermines

argue that retail firms with trading volumes chose to respond by jettisoning the partnership form and expanding to the point where investment in the new back office technologies was efficient. Moreover, any increases in 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 both in the difficulty of peer-group monitoring amongst 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 smallest group of people within the partnership the results of 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 3 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.[26]

[Table 3 here]

Throughout the 1955-1970 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

the ability of the bank's management to identify the commercial uses of new technologies (see e.g., Wilcocks *et. al.*, 1997). Our data, which shows 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.

[26] In cases where the bank has 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 non-voting 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 immediately to withdraw their capital, 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.

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 226 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 $1.35 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").

To summarize, in the case of the 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. The operational structure of the wholesale-oriented Morgan Stanley changed relatively little by comparison. The data reported for the remaining sample banks suggests 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 per cent among retail firms but less than 30 per cent among wholesale firms.

The capital growth among retail firms is particularly noteworthy in the light of substantial losses stemming from operational failures at several of the sample banks during the late 1960s discussed in section 3.2.i. 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 that 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.[27]

[27] Caution is warranted here, especially in the case of Lazard, Freres. 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

In addition to the above indirect evidence that technology-induced increases in minimum efficient scale were aggravating free-riding among partners, there is a good deal of casual evidence of increasing codification of the substantial body of human capital which resided within the account executives of retail firms. Footnote 16 documents as early as 1945 efforts 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 twelve 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.

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 both 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 altogether the need for human skills.

Our going-public proposition (3) predicts that partnerships will choose to float when a technological innovation substitutes for capital and also 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 floatations lends further weight to the argument.

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.

3.3. The Second Wave of Floatations

The first wave of technological change left most banks with 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.

(i) Technological Change

Our going-public proposition predicts that floatation will be preceded by a technological change which substitutes for physical capital. Unlike the first wave of floatations, 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 were concerned rather with 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 4: using data from Nordhaus (2001, appendix 2), it shows 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.

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 revolutionised 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

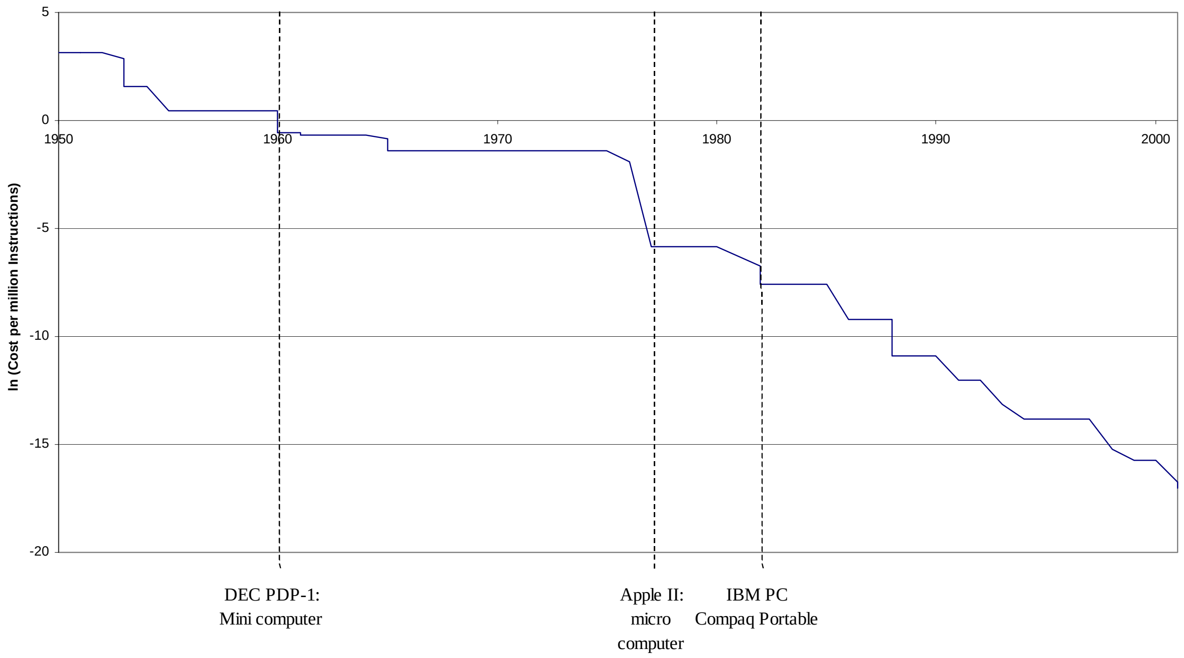

Figure 4: Cost of computing, 1950 - 2001 (source: Nordhaus, 2001, appendix 2).

of institutional investors.[28] 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 which occurred at this time in distributed real-time processing.

In summary, the late 1970s and early 1980s were characterised 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 so that condition (1) of the going-public proposition (3) was satisfied.

[28]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, Oct. 19, 1986, p.150.

(ii) The Human/Physical Capital Tradeoff

The impact of distributed real-time computing upon the tradeoff in wholesale investment banks between human and physical capital can be understood only against a backdrop of the cotemporaneous 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. A basic understanding of financial economics was in the 1980s increasingly regarded as essential for trading room personnel.

As we discuss in section 3.3.i, 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 which 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.[29]

The codification and dissemination of what was previously tacit knowledge had the additional effect of promoting competition within the industry. Entry costs for market making and trading functions declined and trading expertise became replicable. The consequence was a substantial reduction in bid-ask and underwriting spreads. Derivative trading on a small scale was no longer a profitable activity: trading houses had to operate at scale which allowed them to reap economies of scale in marketing and risk management, and to deploy sufficient sums to profit from reduced spreads. In other words, a reduction 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. As in section 3.2.ii, the minimum operating scale could only be achieved by increasing the transaction volume, and this in turn required a greater number of front office staff, and also in this case a greater level of financial capital.

This point is illustrated in figure 5. We regard the 1979 acquisition by American Express of

[29] In the years 1970-71 degree-granting institutions conferred about 26,000 masters degrees in business. In 1985-86 the number rose to about 67,000 degrees (U.S. Dept. of Education, Digest of Education Statistics, 2001). In 1965, only 8 per cent of Harvard's MBA class accepted jobs in investment banking. 21 per cent of the graduating class of 1969 entered investment banking and this remained the record until 1986 when 29% went into investment banking (Wall Street Journal, June 16, 1987). Similarly, 18.8 per cent of NYU's graduating class went into investment banking in 1986.

Shearson Hammill as the culmination of the first wave of floatations 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.[30]

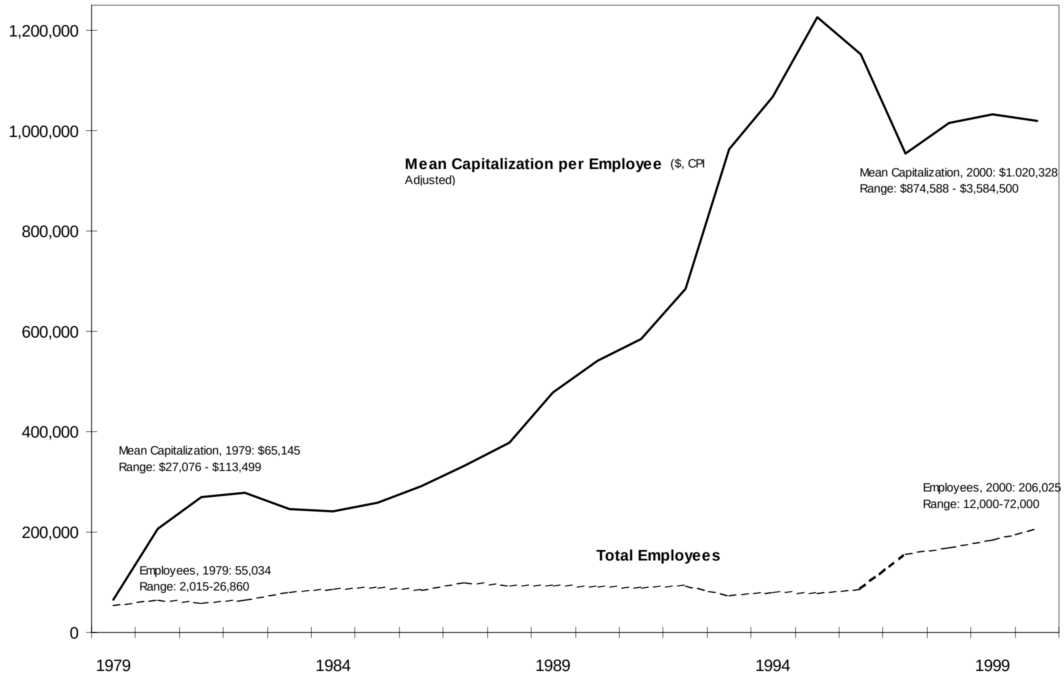

Figure 5: Investment Bank Employees and Capitalization, 1979-2000. (Top five banks by capitalisation)

We see from table 1 that the second wave started when White, Weld and Loeb Rhoades were acquired by Merrill Lynch and Shearson.[31] Salomon was then acquired in 1981 by Phibro (a public commodities trading operation) and Shearson acquired Lehman in 1984. By 1985, when

[30] 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 5 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).

[31] By this time, Loeb Rhoades maintained a substantial retail network following the 1977 acquisition of Hornblower & Weeks.

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 concluded with Morgan Stanley's 1986 IPO, GE Financial's 1986 acquisition of Kidder Peabody and Primerica's 1987 acquisition of Smith Barney.

Thus among our sample firms only Goldman and Lazard remained partnerships by year-end 1987. Neither case runs strongly counter to our argument. Lazard remained a prominent but highly specialized and human-capital intensive operation focused in M&A advisory services and private equity investment (primarily involving the firm's own capital). By this time, Goldman clearly maintained comparative advantage in human capital-intensive as opposed to financial capital-intensive lines of business as evidenced by its ranking first in 1986 league tables for both equity underwriting and M&A advising. Moreover, Goldman partners maintained capital in the firm of around $1 billion in 1986 or about twice that of perhaps it's closest competitor, Morgan Stanley (pre-IPO capitalization). In spite of the partnership's relative wealth of capital, 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 per cent of the firm's annual profits and appreciation in equity value. (The Bank Holding Act of 1956 precluded Sumitomo 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.[32]

To summarise, an important consequence of cheap distributed computing was a greatly increased emphasis upon financial engineering. This served both to reduce the value of tacit human capital, and also unleashed competitive forces which reduced trading spreads and increased the minimum financial scale at which wholesale investment banks could operate.[33] 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 floatations follows the pattern suggested by our theory.

[32] Although by this time there was casual evidence that many partners viewed the firm as a partnership in name only as bonuses paid to non-partner traders rose sharply. See Wilhelm and Downing (2001).

[33] Jones (2002) provides broad systematic evidence of declines in bid-ask spreads for DJIA stocks. Similarly systematic data from over-the-counter markets, especially for derivative securities, is not widely available but numerous references in the financial press to this effect leave little doubt regarding the accuracy of our claim for trading spreads.

4. Conclusion

In this paper we provide a theory of the partnership which 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 which 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 where corporate reputation is important: this is indeed true of law, consulting, and of financial services.

While law and consulting firms have for the most part remained partnerships, the U.S. investment banking industry has jetisoned the partnership form: since the New York Stock Exchange ammended 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 amongst the 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 chose between the human capital which a partnership generates, and the efficient operating scale which is possible in a joint stock corporation. When the latter is more valuable than the former partnerships will choose to go public.

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. Firstly, 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 early adopters like 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 floatation 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 floatations 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 floatations involving primarily wholesale firms is thus consistent with the tradeoff 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 globalisation 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 which this put on the limited capital resources of the partnership member firms.[34] 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.[35] These were finally lifted in the 1985 "Big Bang" in response to the

[34] For example (Michie, p.433): "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."

[35] Fifty one per cent of the shares in limited-liability jobbing (i.e., market-making) firms had to be held by members,

increasing competitive pressures which precipitated the second wave of floatations in the United States.

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

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Table 1: Sample Banks

	Branches*		Corporate Clients**		Private Inc.***	Public Offering	Public by Acquisition or Failed while Private
	1970	1978	1970	1978			
Retail Firms							
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.)
Wholesale Firms							
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	Remains a private partnership		
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

* 1970 branch offices as of September 1970, NASDManual 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.

** 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, reported by Hayes (1979, exhibit VI).

*** Dates of private incorporation reflect year of incorporation or (typically March of) the first year *Finance* identifies the firm as a corporation.

Table 2: Fails to Deliver ($000's)

	1968		1969	
Retail Firms	**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%
Wholesale Firms				
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%	2480	3.2%
Morgan Stanley	236	3.1%	na	na
Saloman Brothers	4,510	7.7%	1278	2.0%
Smith Barney	13,571	45.2%	na	na
White, Weld	4,500	11.0%	1949	3.9%
Mean		23.0%		2.2%

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

Table 3: Capital per Partner

	1955		1960		1965		1970		
Retail Firms	Partners	Cap/Part	Partners	Cap/Part	Partners	Cap/Part	Partners	Cap/Part	Employees per Partner*
Bache	34	496,471	47	554,355	69	670,310	na	na	na
Dean Witter	30	377,129	50	367,615	70	513,408	95	451,316	49.1
E.F. Hutton	28	353,240	31	481,473	45	501,953	96	446,573	38.5
Eastman Dillon	17	608,782	35	583,218	39	821,338	73	626,027	28.0
Francis I duPont	20	933,214	29	900,752	39	1,187,583	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	27.9
Hornblower & Weeks	38	239,019	34	259,846	64	333,339	65	879,523	43.8
Merrill Lynch	73	431,507	114	624,920	137	973,644	226	1,347,562	79.6
Paine Webber	35	208,069	45	247,685	59	295,407	82	386,012	48.8
Shearson Hammill	13	504,654	24	441,749	31	546,080	82	371,878	37.2
Mean	28	425,509	40	449,283	55	593,570	94	624,493	47
Wholesale Firms									
Bear, Stearns	14	1,334,945	20	976,818	20	750,000	28	892,857	26.8
Goldman, Sachs	12	776,004	21	658,440	28	747,607	45	1,088,889	32.6
Kidder Peabody	22	286,165	23	571,192	59	285,299	86	369,465	19.8
Kuhn Loeb	11	600,000	12	550,000	21	406,262	26	421,154	17.3
Lazard, Freres	9	1,774,269	19	921,053	20	875,000	24	729,167	9.0
Lehman Brothers	18	972,857	22	1,600,521	29	1,018,642	36	889,111	33.3
Loeb Rhoades	17	735,294	23	543,478	27	740,741	51	1,320,529	39.2
Morgan Stanley	20	254,600	21	240,000	21	285,714	34	276,294	7.7
Saloman Brothers	20	601,000	23	508,696	22	940,909	31	2,990,323	34.4
Smith Barney	21	400,667	28	312,393	44	227,273	37	945,946	36.5
White, Weld	20	805,000	34	636,496	35	696,673	43	1,061,395	33.7
Mean	17	776,436	22	683,553	30	634,011	40	998,648	26

"Partners" in private corporations are voting stockholders except where noted.
*The number of employees is for the calendar year 1971 as reported in the July 1972 issue of *Finance* magazine.