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Expertise and Finance: Mergers Motivated by Technological Change*

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Abstract

This paper argues that a large technological innovation may lead to a merger wave by inducing entrepreneurs to seek funds from technologically knowledgeable firms -experts. When a large technological innovation occurs, the ability of non-experts (banks) to discriminate between good and bad quality projects is reduced. Experts can continue to charge a low rate of interest for financing because their expertise enables them to identify good quality projects and to avoid unprofitable investments. On the other hand, non-experts now charge a higher rate of interest in order to screen bad projects. More entrepreneurs, therefore, disclose their projects to experts to raise funds from them. Such experts are, however, able to copy the projects and disclosure to them invites the possibility of competition. Thus the entrepreneur and the expert may merge so as to achieve product market collusion. As well as rationalizing mergers, the model can also explain various forms of venture financing by experts such as corporate investors and business angels.

JEL Classification: G30, G34, O32
Keywords: expertise, venture financing, merger, technological innovation

1 Introduction

Technological expertise is especially valuable in times of technological change because understanding and using a new method usually requires familiarity with existing methods. This paper examines the role of expertise in identifying and financing new projects. I argue that a large technological innovation may give rise to a merger wave by increasing the demand for such expertise.

Summary of the Model: I study the funding problem of an entrepreneur who discovers a blueprint for a new idea. The entrepreneur may disclose this idea to an investor so as to demonstrate her creditworthiness. The key assumption is that an expert is an investor who can assess as well as *copy* the entrepreneur's idea. On the other hand, a non-expert, whom I will call a *bank* from now on, is *less* capable of assessing the idea and *cannot* copy it.

The optimal financing choice depends on the gap between the expert and the bank in technological knowledge about the new idea. If the bank's assessing skill is similar to that of the expert, the entrepreneur raises funds from the bank by disclosing her idea to the bank. This avoids revealing the idea to the expert and thereby inviting competition. On the other hand, when the details of the proposed project are complicated and the knowledge gap is large, the entrepreneur discloses to the expert and the expert provides funds. In this case the expert and the entrepreneur have an incentive to collude since their joint profit would decrease if both were to undertake the project. They may, therefore, decide to *merge so as to commit not to compete*.

Evidence that Technology Shocks Cause Merger Waves: The model suggests that a technological innovation may promote mergers by increasing the knowledge gap between experts and non-experts. There is evidence for a positive relationship between mergers and innovations. First, historically, target companies have tended to be in rapidly growing industries in which the rate of innovation is often high. Nelson (1959) finds that the period immediately preceding the turn of the century merger wave was characterized by an acceleration in the growth of the industries with the greatest merger activity. Ravenscraft and Scherer (1987) find that during the period 1950-75, bidders sought targets in industries that were growing significantly more rapidly than their own industries and than the economy-wide average. Second, Gort (1969) finds that the ratio of technical personnel to total employees is strongly correlated with merger rates. Third, I find that merger-intensive industries are likely to experience high subsequent total factor productivity growth. (See the Appendix.)

For the economy as a whole, the model predicts that the level of merger activity should be pro-cyclical. This seems to be the case; periods of high merger activity tend to be followed by booms (see Nelson 1959 and Melicher, Ledolter, and D'Antonio 1983).

Evidence on the Financing Motive for Mergers: The financing aspect of mergers that I model is well-documented. Mergers tend to occur between poor targets and wealthy acquirers. Bruner (1988) finds that the debt ratios of acquired firms are above average while the debt ratios of acquiring firms are below average. Morck, Shleifer and Vishny (1988, Table 4.3a) find that the average interest-to-income ratio of acquired firms is higher than average. Furthermore, they appear to need funds for growth since they are in rapidly growing industries. Finally, funds do indeed seem to be infused into acquired entities after mergers. Looking at pure conglomerate mergers, Markham (1973) finds that new capital outlays within acquired entities average 220 percent of premerger outlays.

Application to the Informal Venture Capital Market: In addition to mergers, the model can also explain forms of financing from experts such as the informal capital market for high-technology ventures. The technologically complex nature of these projects presumably yields a large knowledge gap between experts and banks. According to my model these ventures should rely on experts as their financing source. Evidence confirms this. First, established individual entrepreneurs often provide funds to venture businesses through informal channels.[1] Second, corporate expert investors are also a significant funding source for high-technology ventures. For instance, biotechnology ventures raise a large fraction of their funds from pharmaceutical firms.[2]

Literature: Within the existing literature on motives for mergers, the closest idea to the one that I advance here is in Williamson (1970). He claims that conglomerate firms use their internal capital markets to channel cash from mature sectors into growing ones. Internal funds may be cheaper than external funds because of asymmetric information. Thus mergers reduce financing costs by facilitating information sharing among sectors. I also argue

[1] Typically, these individual investors, called "*angels*" own a substantial business, finance venture firms which are engaged in a similar business, and hold a large fraction of equity in the venture firms (see Wetzel 1987, Freear and Wetzel 1990, and Freear, Sohl, and Wetzel 1994.) Wetzel (1987) finds that the amount of new funds these investors committed to venture firms was at least $5 billion in 1986 – twice as much as was provided by professional venture capital funds. Such established individuals are thought to be the largest source of financing in starting up new venture enterprises (see Fenn, Liang, and Prowse (1996)).

[2] Shane (1994) finds that between 1980 and 1993, pharmaceutical firms supplied 40% of external funds to biotechnology firms after their initial public offerings.

that the demand for cheaper funds may drive mergers, but unlike Williamson, I can also explain why merger activity concentrates in certain periods of time - periods of unusually rapid technological innovation. Furthermore, my model applies not just to conglomerate but also to horizontal and vertical mergers.

This paper also relates closely to work on financing innovation in the absence of property rights such as that of Bhattacharya and Ritter (1983), Anton and Yao (1994), and Bhattacharya and Chiesa (1995). They all study the tradeoff between disclosure and appropriation, but because they do not study the knowledge gap between experts and banks, they do not relate technological innovations and mergers - the main focus of this paper.

The rest of the paper is organized as follows. Section 2 sets up the model. Section 3 derives equilibrium using backward induction. Section 4 characterizes equilibrium and describes some testable hypotheses. Section 5 discusses the results. Section 6 concludes.

2 The Model

All agents are risk neutral and the risk free interest rate is normalized to zero. There is one type of project that requires one unit of a producer's service, F units of capital and an idea. The project either succeeds or fails. The probability distribution of the result depends on who undertakes the project and the quality of the idea. When the project is successful, the producer gets the return $R_j, j \in \{m, d\}$ depending on the market structure, which is either monopoly m or duopoly d. When the project fails, the producer's return is zero.

2.1 Players

Each player is either an "innovator," "expert," or "bank". Both innovators and experts are producers who are capable of undertaking the project while banks are not. Experts and banks are both rich enough to self-finance F units of capital while an innovator is not. Thus an innovator can profitably manage the project, but she lacks funds; she has to convince investors of her creditworthiness.

There is a continuum of innovators, characterized by a triplet $\{W, q, s\}$ which stands for their wealth, quality, and signal, respectively. The reason for introducing differences in wealth is to ensure a positive demand for both experts and banks. The innovator's wealth W is uniformly distributed on the interval $[0, \overline{W}]$. The measure of innovators is $\overline{W}$. Each innovator's quality q is the quality of the blueprint for a project she has. I assume that q is either g (*good*) or b (*bad*). Initially, only the innovator observes q. The prior belief on the part of experts and banks that an innovator's quality is q is exogenous, and is one half for each quality type, independent of the innovator's wealth. When an innovator's quality is q, she is successful in the project with probability p_q for $q = g, b$ where $p_g > p_b$. In addition to her quality, each innovator has a *signal* of her quality, s which is also either g or b. An innovator has the right signal, (i.e. an innovator with good (bad) quality also has good (bad) signal) with probability $\alpha(> 0.5)$, and has the wrong signal with probability $1 - \alpha$, again independent of her wealth.

There are enough experts and banks to finance all good quality project in the economy.

2.2 Disclosure, Assessment, and Imitation

Assessing the Project: An innovator can communicate with investors about her idea. When an innovator discloses her idea to an expert, the expert identifies the quality of the innovator's idea without error.[3] On the other hand, when an innovator discloses to a bank, the bank observes only the innovator's signal. The index α measures the knowledge gap between a bank and an expert. This gap is the largest if $\alpha = .5$, in which case disclosing to a bank conveys no information about the quality of the project. On the other hand, if $\alpha = 1$, a bank has the same ability to identify quality as an expert does.

Interpretations of α: Several interpretations of this index α are possible. First, α probably varies cross-sectionally: it should be small for high-tech or R&D intensive borrowers, where experts should have a large advantage over banks. Second, α may vary over *time*: A significant innovation often leads to secondary innovations that exploit the first. If in the introduction period experts acquire knowledge of a major innovation before banks do, then this should give them a large advantage in assessing the value of secondary innovations.

Absence of Intellectual Property Rights: An innovator cannot stop other producers from undertaking her project once they learn of it.[4] In practice, keeping the idea secret as long as possible is essential in the appropriation of the return to an innovation. In the model, this

[3] This assumption is easily generalized to the case in which the expert observes a finer signal than the bank does.

[4] This assumption seems to be empirically valid. The property rights to a idea are at most partial even if the innovator patents the idea. For instance, Mansfield, Schwartz, and Wagners' survey (1981) shows that imitations of patented goods often occur. Levin, Klevorick, Nelson, and Winter (1987) show that the most important way to secure the return to an innovation is to maximize lead-time.

consideration prevents the innovator from publicly disclosing her project and raising funds by issuing securities. This is also why I assume that disclosure must be private, whether it be to a bank or to an expert.

Imitation by Experts: There is a tradeoff between potentially receiving funding from an expert and disclosing information to him: after disclosure, the expert can succeed in the project with the probability p_e if he were to undertake the project.

2.3 Market Structure and Payoffs

If both innovator and expert succeed in the project, each gets R_d. If only one party succeeds and the other fails, the successful party gets R_m, and the unsuccessful party gets zero. If both fail, each gets zero. The outcome is independently distributed across the innovator and the expert. I impose the following additional assumptions:

Assumption 1 $p_g R_m - F > 2p_g p_e R_d + \{p_g(1-p_e) + (1-p_g)p_e\}R_m - 2F$.

This means that the total expected return to the project is lower if one innovator and one expert undertake the project than if only the innovator undertakes it.

Assumption 2 $p_g > p_e$.

This means that the innovator is better than the expert at developing the project.[5] In conjunction with Assumption 1, this implies that the total expected return is maximized when the innovator alone undertakes the project.

Assumption 3 $p_e\{p_g R_d + (1-p_g)R_m\} - F \geq 0$.

This implies that when the expert has no stake in the return to the innovator, the expert will want to imitate the innovation. Thus if the innovator discloses to the expert, in order to maximize their joint profit, they need to design a contract which induces the innovator alone to undertake the project. Define this maximum total expected return on the project by

$$\Phi \equiv p_g R_m - F.$$

[5] This assumption reflects the fact that an innovator's accumulated knowledge leading up to the discovery of a blueprint for a project should not be easily transferred to an expert through disclosure of the blueprint alone. Such knowledge probably gives the innovator an advantage over the expert in developing the innovation.

If the innovator were to self-finance and monopolize the project, she would get this expected return.

Furthermore, rewriting Assumption 3 yields

$$p_e R_m - F \geq p_e p_g (R_m - R_d) > 0.$$

This implies that it is profitable for the expert to copy the project if he alone undertakes the project.

Assumption 4 *The project is not profitable when a bad quality innovator undertakes it.*

$$p_b R_m - F < 0.$$

This ensures that investors will want to distinguish a good quality innovator from a bad quality one in order to avoid unprofitable investments.

2.4 Contracting Structure

Due to the lack of property rights to an innovation, who develops the innovation is not contractible. On the other hand, the returns to the innovator and the expert on completion of the project are observable and contractible. Let $\{\pi_m, \pi_d, \pi_e, \pi_0\}$ be the payments to the innovator when she alone succeeds in the project, when both innovator and expert succeed, when the expert alone succeeds, and when both fail.

2.5 Sequence of Events

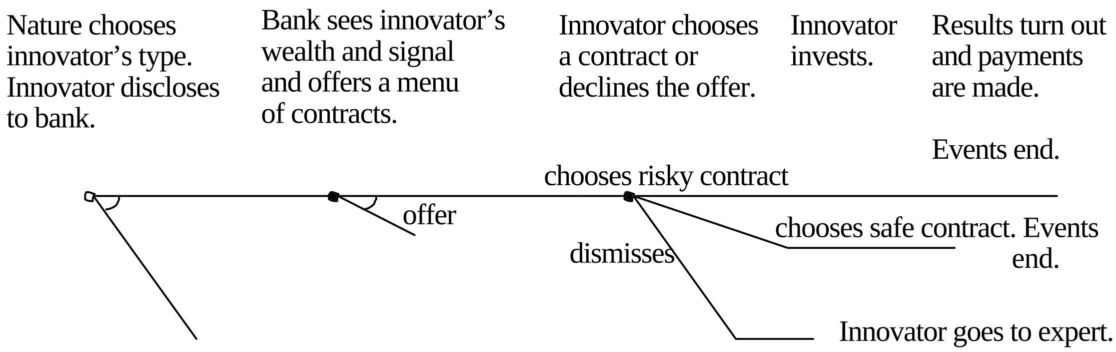
There are three dates:

Date 0 (Banks Offer a Menu of Contracts): An innovator draws her type $\{W, q, s\}$ and communicates with a bank. The bank observes W and s, and then offers the innovator a risky contract which is meant to attract good quality innovators, and a safe contract which is meant to attract bad quality innovators.[6] Under the risky contract, the bank lends F to

[6] The model can be generalized to the case in which the bank cannot always but can sometimes see the innovator's wealth. Instead, suppose that the innovator reports and verifies her wealth to the bank. Furthermore, suppose that the innovator can underreport her wealth but can not overstate it. As will be seen, in equilibrium, only a bad quality innovator would be better off underreporting; a good quality innovator wants to report her true wealth since her payoff function is increasing in her wealth while a bad quality innovator wants to hide her wealth since her payoff function is decreasing in her wealth. The bank thus declines to make an offer of financial contracts to the innovator if underreporting is detected: that reveals that the innovator is of the bad quality type. If this detection probability is large enough, a bad quality innovator will have an incentive to report her true wealth, thereby avoiding the cost of being detected.

the innovator. If the innovator succeeds in the project, she gets $\pi_m^B + W$ and the bank gets $R_m - \pi_m^B$. If the innovator fails in the project, she gets $\pi_0^B + W$ and the bank gets $-\pi_0^B$. Under the safe contract, the bank transfers T to the innovator. Summing up, a risky/safe contract pair is expressed by a triplet $\{\pi_m^B, \pi_0^B, T\}$.

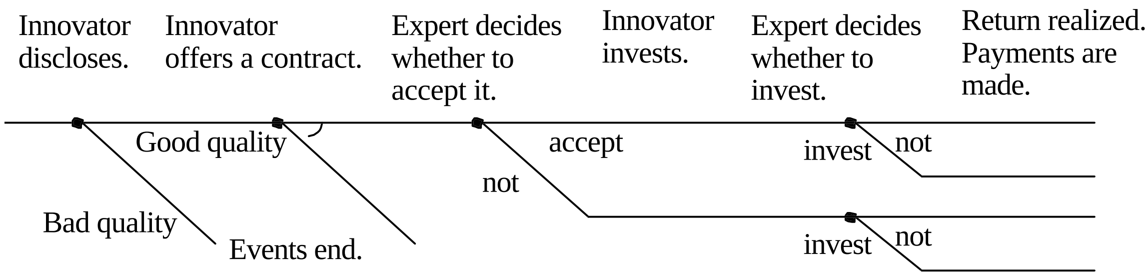
Date 1 (Innovator's Choice of a Contract): The innovator has three options: to dismiss the bank and go to an expert, to choose the safe contract, or to choose the risky contract. If the innovator chooses the safe contract, the transfer will be made and events will end; If the innovator chooses the risky contract, she invests F in the project. The return to the project is then realized and payments are made.



Date 2 (Contracting with an Expert): If the innovator dismisses the banks' offers, she discloses her idea to an expert. If she has a bad quality idea, events end.[7] If her idea is of the good quality type, the innovator makes a take it or leave it offer of a contract to the expert.[8] A contract specifies the payment the innovator receives depending on the return to both innovator and expert. The innovator receives π_m^E if the innovator's return is R_m and the expert's return is zero, π_d^E if the return to both is R_d, π_e^E if the innovator's return is zero and the expert's return is R_m, and π_0^E if the return to both is zero. The expert then decides whether to accept the contract. If he accepts it, the innovator undertakes the project and the expert decides whether to copy the innovator's idea or not. If he declines, the innovator does not undertake the project and the expert decides whether to copy. Finally the returns to the innovator and the expert are realized and payments are made.

[7] Here, I implicitly assume an equilibrium story in that the expert should not deal with a bad quality innovator.

[8] At a first glance, this negotiation process may appear to be asymmetric to the one with a bank who offers a menu of contracts. These specifications of negotiation processes, however, will turn out to be consistent and symmetric in the sense that the innovator has all the bargaining power for both processes. This is because I will assume that a bank's offer must be competitive.



3 Equilibrium

In this section, I solve this game backwards.

3.1 Equilibrium at Date 2

I now derive the subgame perfect equilibrium at date 2.

If the expert were to decline an innovator's offer of a contract, by Assumption 3, his optimal strategy is to copy the innovator's idea and his expected return is

$$X \equiv p_e R_m - F,$$

where I call X the *expropriation gain*. On the other hand, the innovator's expected return if this happens is zero. Thus the innovator could conceivably get more if she could motivate the expert to finance the innovator and not to copy her idea by offering an appropriate contract. To be specific, the optimal contract should maximize the innovator's expected net payoff,

$$p_g \pi_m^E + (1 - p_g)\pi_0^E. \tag{1}$$

subject to the expert's participation constraint

$$p_g(R_m - \pi_m^E) - (1 - p_g)\pi_0^E - F \geq X, \tag{2}$$

and the no-expropriation constraint under which the expert does not want to copy conditional on his accepting the offer of the contract,

$$\begin{aligned}&p_g(R_m - \pi_m^E) - (1 - p_g)\pi_0^E \geq \\ &\qquad p_g\{(1 - p_e)(R_m - \pi_m^E) + p_e(2R_d - \pi_d^E)\} + (1 - p_g)\{p_e(R_m - \pi_e^E) - (1 - p_e)\pi_0^E\} - F\end{aligned}$$

which can be rewritten,

$$p_e[p_g\{(2R_d - \pi_d^E) - (R_m - \pi_m^E)\} + (1-p_g)(R_m - \pi_e^E) + (1-p_g)\pi_0^E] - F \leq 0. \qquad (3)$$

Lemma 1 *In equilibrium at date 2, the expected payoff of the innovator is equal to*

$$U_E(W) = \Phi - X.$$

Proof:
The proof will be in two steps. The first step involves showing that $U_E(L)$ is the upper bound for the expected payoff of a good quality innovator. The second step is to show that there exists a contract $\{\pi_m^E, \pi_d^E, \pi_e^E, \pi_0^E\}$ which attains this upper bound and satisfies all the constraints. Rewriting the participation constraint (2), I obtain

$$p_g\pi_m^E + (1-p_g)\pi_0^E \leq \Phi - X.$$

Set π_m^E and π_0^E such that the above equation is an equality. The no-expropriation constraint can be satisfied by choosing π_d^E and π_e^E to be high enough. Q.E.D.

The innovator's payoff is strictly less than the total rent Φ since the expert captures a part of the rent to the innovator by threatening the innovator with expropriation. *This positive rent X is the cost to the innovator of revealing valuable information to the expert who is a potential competitor.*

The proof implies that the following conditions characterize an innovator's optimal offer:

Optimality 1 *The innovator's offer is optimal if and only if it satisfies*

$$p_g\pi_m^E + (1-p_g)\pi_0^E = \Phi - X, \qquad (4)$$

and

$$p_e[p_g(2R_d - \pi_d^E) - (1-p_g)\pi_e^E + (1-2p_g)R_m + \Phi - X] - F \leq 0,. \qquad (5)$$

The second equation is obtained by substituting (4) into the no-expropriation constraint (3). There are four unknowns R_m^E, R_d^E, R_e^E, and R_0^E, and just one equation and one inequality. Thus unknowns are not uniquely determined.

How does this optimal contract relate to commonly observed contracts? The following arrangements are in the class of optimal contracts:

1. *Merger*: A merger is, indeed, an example of an optimal contract. By merging with the innovator, the expert's payoff structure which is his payoff and state correspondence, becomes a positive linear transformation of their joint profit because he is risk neutral. Thus the expert's payoff maximization behavior should be not to copy the project.

If contracts are restricted to be of the merger type, the payment structure must satisfy the following restrictions depending on the form of the merger deal. First, if the expert acquires the innovator by granting shares of his firm to the innovator, a contract will satisfy,

$$\frac{\pi_m^E}{R_m + V} = \frac{\pi_d^E}{2R_d + V - F} = \frac{\pi_0^E}{R_m + V - F} = \frac{\pi_0^E}{V},$$

where V stands for the existing value of the expert's firm. It is easy to check that these equations are compatible with equations (4) and (5).

Second, if the expert acquires the innovator by paying in cash or default-free debt, the payment to the innovator does not depend on the return to the innovator. Thus the payment structure must satisfy

$$\pi_m^E = \pi_d^E = \pi_e^E = \pi_0^E.$$

These equations are also compatible with equations (4) and (5).

2.*Large Shareholding in the Innovator's Firm by the Expert*: A large stake in the return to the innovator's firm should also motivate the expert to choose not to copy the idea. Let σ be the fraction of the innovator's equity held by the expert. His payoff from this equity holding is σR_m when the innovator alone is successful in the project, σR_d when both innovator and expert are successful in the project, and is zero when the innovator fails in the project. Thus the expected payoff to the expert when he copies the project is

$$(1+\sigma)p_g p_e R_d + \{\sigma p_g(1-p_e) + (1-p_g)p_e\}R_m - F.$$

If this payoff is smaller than $\sigma p_g R_m$ which equals the expected payoff to the expert when he chooses not to copy the project, he will choose not to copy. After calculations, I obtain that that is the case if

$$\sigma \geq \frac{p_e R_m - F}{p_e p_g (R_m - R_d)} - 1. \tag{6}$$

By Assumption 3, this must be greater than zero. The right-hand side of equation (6) is increasing in p_e, R_m, and R_d and decreasing in p_g. Intuitively, the expert should hold a bigger share in the innovator's firm if he gains a larger expected payoff from copying the idea.

Under this large share holding contract, the payments to the innovator do not depend on the return to the expert and the innovator's payoff is linear in the return to her project. Thus, the payment structure must satisfy $\pi_0^E = \pi_e^E = 0$.

3.2 Equilibrium at Date 1

As described in the previous section, a good quality innovator can get $\Phi - X$ by declining the offers from a bank and financing from an expert. If a bad quality innovator does this, she gets zero. Thus in equilibrium at date 1,

Optimality 2 *A good quality innovator should accept a contract only if it offers at least as much as $\Phi - X$. A bad quality innovator should accept a contract only if it offers a non-negative amount.*

3.3 Equilibrium at Date 0

Given the innovator's optimal strategy above, a bank offers a menu of contracts which map pairs $\{W, s\}$ into $\{\pi_m^B, \pi_d^B, T\}$. A profit maximizing bank should choose to finance a good quality innovator as long as the bank can offer such an innovator at least $\Phi - X$. I now show when a competitive bank can make such an offer.

A bank maximizes a good quality innovator's expected payoff much like in Rothschild and Stiglitz (1976).[9] Unlike in Rothschild and Stiglitz, a bank's expected profit for each offer will be zero *conditional on the innovator's wealth and signal* in equilibrium. In particular, having observed the innovator's signal s and wealth W, a bank revises its prior belief about the innovator's quality. The posterior probability with which the innovator has quality q is

$$prob(q = g|s = g) = \frac{.5\alpha}{.5\alpha + .5(1-\alpha)} = \alpha,$$

$prob(q = b|s = b) = \alpha$, $prob(q = b|s = g) = prob(q = g|s = b) = 1 - \alpha$. Based on this posterior belief, the bank offers a menu of contracts. Suppose that the bank believes that a

[9] Rothschild and Stiglitz (1976) model a competitive insurance market in which an insurance company offers a menu of contracts to customers in order to distinguish safe customers from risky ones. I model a competitive banking market in which a bank offers a menu of contracts to innovators in order to identify the quality of their ideas. Analogous to the result of Rothschild and Stiglitz (1976), separating equilibria alone may exist: by choosing a contract, innovators reveal their type. Unlike Rothschild and Stiglitz (1976), an equilibrium always exists because innovators are risk neutral.

good quality innovator would accept an offer of a contract even if her expected payoff under the contract is less than $\Phi - X$.

1. When the good signal is observed.: First, I examine the optimal offer when the bank observes a good signal. The bank chooses a menu of contracts to offer so as to maximize the expected (gross) payoff for a good quality innovator,

$$p_g \pi_m^B + (1 - p_g)\pi_{\mathbf{0}}^B, \tag{7}$$

subject to the bank's participation constraint,

$$\alpha[\Phi - \{p_g \pi_m^B + (1 - p_g)\pi_{\mathbf{0}}^B\}] - (1 - \alpha)T \geq 0, \tag{8}$$

the incentive compatibility condition,[10]

$$p_b \pi_m^B + (1 - p_b)\pi_{\mathbf{0}}^B \leq T, \tag{9}$$

and a limited liability condition under which a negative payoff is not possible,

$$\pi_{\mathbf{0}}^B + W \geq 0. \tag{10}$$

Lemma 2 *The expected payoff for a good quality innovator if she has a good signal is*

$$U_g(W) \equiv min\left[\Phi, \frac{\alpha p_g \Phi}{\tilde{p}} + \left(\frac{p_g}{\tilde{p}} - 1\right)W\right];$$

the expected payoff for a bad quality innovator if she has a good signal is

$$T_g(W) = max\left[0, \frac{\alpha}{\tilde{p}}\left\{p_b\Phi - (p_g - p_b)W\right\}\right],$$

where $\tilde{p} = \alpha p_g + (1 - \alpha)p_b$.

Proof:
The proof will proceed in a similar way to the proof of Lemma 1. Using the bank's participation constraint (8), the incentive compatibility condition (9) can be rewritten as follows:

$$\pi_m^B \leq \frac{\alpha\Phi - \{(1 - \alpha)(1 - p_b) + \alpha(1 - p_g)\}\pi_{\mathbf{0}}^B}{\tilde{p}}.$$

[10] In equilibrium, the incentive compatibility condition under which an good quality innovator will not choose the contract intended for a bad quality innovator is not binding.

Then, from (10), we have

$$\begin{aligned} p_g\pi_m^B + (1-p_g)\pi_0^B &\le \frac{\alpha p_g\Phi}{\tilde{p}} - \frac{(1-\alpha)(p_g-p_b)}{\tilde{p}}\pi_0^b + \left(\frac{p_g}{\tilde{p}}-1\right)W \\ &\le \frac{\alpha p_g\Phi}{\tilde{p}} + \left(\frac{p_g}{\tilde{p}}-1\right)W. \end{aligned} \tag{11}$$

This upper bound for the expected payoff for a good quality innovator if she has a good signal can be achieved by setting $\pi_0^B = -W$, and

$$\pi_m^B = \frac{\alpha\Phi + W}{\tilde{p}}. \tag{12}$$

These values can be shown to satisfy all the constraints.

Furthermore, sticking $\pi_m^B = -W$ and (12) into (8) and (9), and solving with respect to T, we obtain $T_g(W)$. Q.E.D.

2. When the bad signal is observed.: The problem that the bank solves when the bad signal is observed is identical to the one when the good signal is observed EXCEPT that the bank's participation constraint (8) is replaced with

$$(1-\alpha)[\Phi - \{p_g\pi_m^B + (1-p_g)\pi_0^B\}] - \alpha T \ge 0.$$

Lemma 3 *The expected payoff for a good quality innovator if she has a bad signal is*

$$U_b(W) = min\left[\Phi, \frac{(1-\alpha)p_g\Phi}{\hat{p}} + \left(\frac{p_g}{\hat{p}}-1\right)W\right];$$

the expected payoff for a bad quality innovator if she has a bad signal is

$$T_b(W) = max\left[0, \frac{1-\alpha}{\hat{p}}\{p_b\Phi - (p_g-p_b)W\}\right],$$

where $\hat{p} = (1-\alpha)p_g + \alpha p_b$.

Proof: Similar to the proof of lemma 2. Q.E.D

Figure 1 summarizes the maximum expected payoffs for the various types of innovators that a competitive bank can offer.

These results can be characterized as follows:

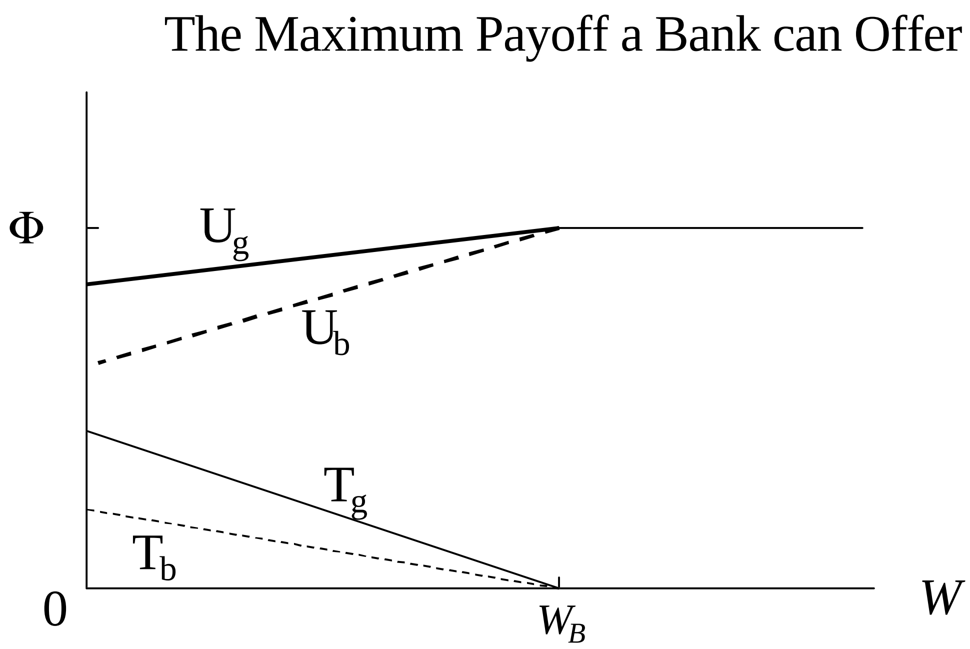


Figure 1:

A. $U_q(W)$ is increasing in W: The expected payoff for a good quality innovator is increasing in W no matter what her signal is. As wealth rises, the bank can reduce π_0^B and increase π_m^B. This means that the bad quality type can be offered a lower T and still choose the safe contract. In other words, if an innovator's wealth is high, the bank can write a contract that ensures a high expected payment to good quality innovators because it is now cheaper to screen out bad quality borrowers. In particular, if her wealth is no less than

$$W_B \equiv \frac{p_b/p_g}{1 - p_b/p_g}\Phi,$$

the innovator can capture the entire rent of the project as she would if there was no asymmetric information.

B. $T_q(W)$ is decreasing in W: On the other hand, the expected payoff for a bad quality innovator is decreasing in her wealth since the expected payoff for a good quality innovator is positively related to her wealth and a bank's expected profit given L and s is zero. If two innovators have the same wealth and the same signal but one has good quality and the other has bad, then if the expected payoff for the good quality type is increasing in wealth then the expected payoff for the other type must be decreasing.

C. $U_g(W)$ and $T_g(W)$ are increasing in α: When a bank is better at assessing, fewer bad quality innovators have the wrong signal. Thus the probability that the bank incurs losses from transferring to such innovators decreases and the bank can pay more to innovators with good signals. Furthermore, when $\alpha = 1$,

$$U_g(W) = \Phi \qquad \forall W,$$

i.e., a good quality innovator can obtain all the rent from the innovation irrespective of her wealth. In this case, a bank can see whether the innovator has good or bad quality without observing a choice of contract. A bad quality innovator will therefore get zero.

D. $U_b(W)$ and $T_b(W)$ are decreasing in α: On the other hand, the larger α is, the less an innovator with a bad signal gets since a bank expects higher losses from transferring to innovators with bad quality.

In equilibrium, a bank offers the menu of contracts which solves the above problem if and only if the bank believes that a good quality innovator will accept. Otherwise, the bank knows that only a bad quality innovator would accept an offer. Thus a bank's optimal strategy can be summarized as follows:

Optimality 3 *A bank offers a menu of contracts which is obtained by solving the above problem if and only if $U_q(W)$ is at least as much as $\Phi - X$. Otherwise, a bank offers a menu of contracts which no innovator would accept.*

Optimality 1, 2, and 3 constitute the equilibrium strategy profile.

4 Characterizing Equilibrium and Implications

In this section, I characterize the equilibrium source of financing and discuss the empirical implications of the model.

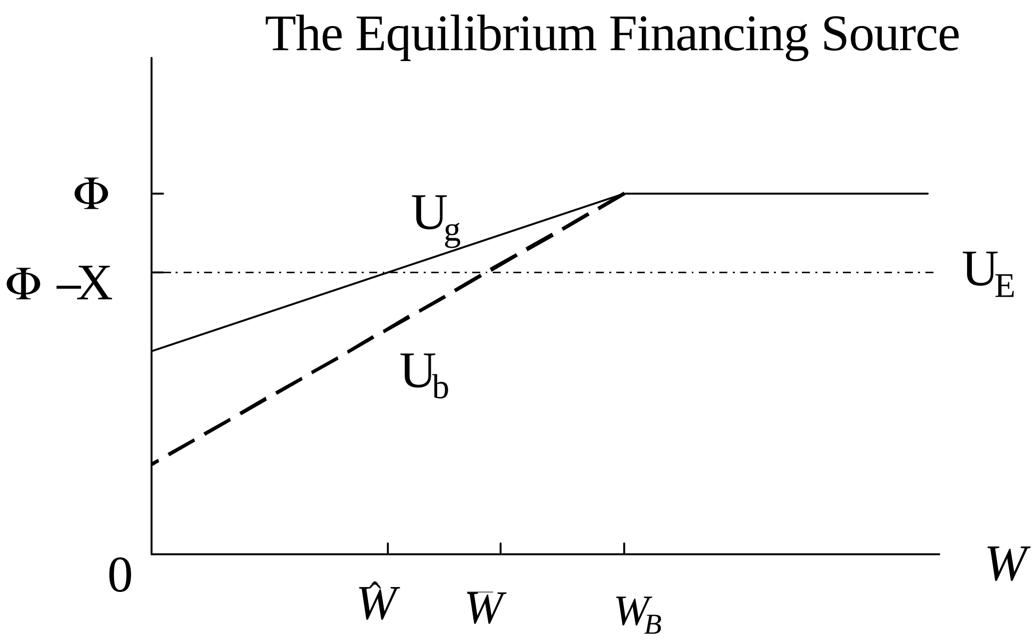


Figure 2:

4.1 The Equilibrium Financing Source

First of all, financing sources differ depending on the innovator's wealth and signal. For convenience, define $\tilde{W}$ and $\hat{W}$ as follows,

$$U_E = U_g(\tilde{W}) = U_b(\hat{W}).$$

A (good quality) innovator whose wealth is between $[0, \tilde{W}]$ should finance from an expert since a bank cannot offer more than U_E to any innovators due to a severe adverse selection problem. An innovator whose wealth is between $[\hat{W}, \overline{W}]$ should finance from a bank because her wealth is large enough to overcome the cost of adverse selection. An innovator whose wealth is between $[\tilde{W}, \hat{W}]$ finances from a bank if she has a good signal and from an expert if she has a bad signal. (See Figure 2).

The differences in financing choices resulting from differences in innovators' wealth can be summarized as follows:

Proposition 1 *The fraction of innovators who finance from a bank is increasing in W. The fraction of innovators who finance from an expert is decreasing in W.*

Proof: See Figure 2.

The distribution of the financing source depends on the knowledge gap α in the following way:

Proposition 2 *The measure of innovators who finance from experts is decreasing in α, and the measure of innovators who finance from banks is increasing in α.*

Proof: See Appendix.

When the knowledge gap is small, a bank can make a better offer to good quality innovators who have a good signal because more accurate assessment means that a bank confuses fewer bad quality innovators with good ones at the disclosure stage. Thus, at the contracting stage, the expected cost of screening bad quality innovators is reduced and these savings can be used to offer a more attractive contract to good quality innovators.

Furthermore, the results explain why internal funds and collateralized debt are a dominant financing source. When an innovator finances from a bank, her expected payoff is increasing in her wealth because of the adverse selection problem. Using internal funds and collateralized debt as much as possible, the innovator can lessen this problem and get a higher payoff. Adverse selection does not exist when an expert finances, so the expert's internal funds or collateralized debt could be a cheaper financing source when the innovator is poor.

4.2 Testable Hypotheses

I now discuss some testable implications of the model relating to mergers.

1. *Significant innovations promote mergers.*

As I argued in section 2, significant innovations should lower α by generating delays in non-experts learning new technology. As a consequence, more innovators should ask for funds from experts rather than banks. Thus, at such a time, we should observe more mergers which are considered to be forms of financing by experts. There are many facts supporting a positive relationship between significant innovations and mergers, as I illustrated in the introduction.

1'. *Merger waves occur at arrivals of new GPTs (general purpose technologies).*

Furthermore, when a revolutionary innovation occurs affecting industrywide technology, it may cause a merger wave. Such “general purpose technologies” (GPTs) are exemplified by the steam engine, the electric dynamo, the laser, and the computer (See Bresnahan and Trajtenberg (1995)).

The merger wave at the turn of the century might have been caused by both the emergence of electrification and the introduction of automobiles. The active merger movement seen in the primary metals sector in this period may reflect these technology shocks. (See Table 1.) As a consequence of the implementation of these innovations, the primary metals sector yielded various secondary innovations, such as wires for conducting electricity and automobile bodies. The merger wave of the late 1960s followed the introduction of the laser, whose accuracy facilitated the miniaturization of various machinery, most notably the microchip. This industry-wide technology shock may have caused the subsequent merger wave.

2. *Firms intensively engaged in R&D are likely to be taken over.*
R&D intensity may be a good negative proxy for α because a R&D-intensive firm should have large intangible technological assets which experts have an advantage in assessing. Evidence, however, does not seem to support hypothesis 2. For instance, Hall (1988) finds that the R&D-to-assets ratio is negatively related to the probability of being acquired (Table 3.4). This may suggest that wealth and R&D effort are *endogenous*. The model showed that a high net worth entrepreneur who should finance from a bank can appropriate a greater fraction of the return to her innovation. Thus only a high net worth entrepreneur may choose to be engaged in R&D since the return to R&D may not pay off for low net worth entrepreneurs. R&D intensity may therefore be negatively correlated with the probability of taken over since low net worth entrepreneurs, who would finance their projects from experts, will not want to undertake new projects and do not need finance. Concerning this relationship between firms' wealth and R&D, Hall (1992, Table 3), finds that the correlation between R&D intensity and leverage is substantially negative.

3. *Financially weak firms are likely to be taken over.*
Takeovers should be more common among firms that are financially weak and short of collateral to pledge to a bank in case of failure. Such firms should be charged a high interest rate by a bank and therefore being acquired should be a more attractive option for them. This prediction fits the empirical findings supporting a financing motive for mergers that I described in the introduction.

5 Discussion

5.1 The Target Management Hypothesis

The inefficient target management hypothesis argues that a merger is a way to remove a *poor* manager of a target firm. On the contrary, I argue that a merger is a way to finance a *good* target manager who *can* undertake a profitable project. Are target managers poor or efficient performers? Evidence favors the efficient target management hypothesis: Ravenscraft and Scherer (1987) find that target firms' profitability prior to voluntary mergers was nearly twice that of their nonacquired peers.

5.2 When are Mergers Chosen among Various Forms of Financing by Experts?

In addition to mergers, the model applies to various forms of financing by experts such as joint ventures, angel funds, and a parent firm's investment in an infant firm. Put another way, the model does not explain why an innovator chooses a particular form of financing from an expert. When are mergers better than other forms of financing from experts? A merger may be chosen when cash-flow is not contractible and when the ownership of an innovation is not contractible even after the implementation of the innovation. In such a case, the innovator, to whom the return accrues, cannot commit to pay out dividends to the expert. A merger ensures, that the expert gets his return. On the other hand, if ownership is contractible at least after the implementation of the innovation then a merger is not necessary. For instance, pharmaceutical firms' funding of biotechnology firms often includes a license agreement under which the pharmaceutical firm acquires monopoly rights to sell a product when the biotechnology firm's new product is approved by the FDA. Such a contract clause makes it possible to transfer ownership of an innovation to an expert (pharmaceutical firm) from an innovator (biotechnology firm) and to secure the return from financing to the expert.

A merger may also be chosen when an expert has managerial excess capacity. When there exists a potential scale economy due to excess capacity, a merger may yield a higher return to innovation than when the innovator and the expert operate independently. Furthermore, disclosure to the expert may *endogenously* yield this scale economy. After disclosure, the newly informed expert may now expect it to be more profitable to manage the innovator's firm than he did before he knew about the innovator's technology.

5.3 Why Does a Bank not Consult an Expert?

A bank may be able to avoid making mistakes in assessing the project by hiring an expert. An innovator, however, would not want to disclose the project to the bank in this case because the bank would be able to require a high return to lending by threatening the innovator with having the expert copy the project. A lack of expertise may be to a bank's advantage since the bank can commit not to imitate an innovator's idea.

5.4 How Does a Bank Screen Bad Quality Innovators?

I assumed that a bank offers a menu of contracts to distinguish the quality of innovators. How does a bank do this in practice? Although banks do not seem to offer menus of contracts explicitly (unlike insurance companies), other elaborate financial arrangements may overcome the adverse selection problem. For instance, a bank sometimes offers favorable terms for large sums of deposits. This may work to screen a bad quality innovator since such an innovator must prefer a high safe return to a risky contract which is meant to attract good quality innovators. Staging of finance may also work as a screening device: A bank may initially lend a part of the total funds required at a low rate of interest and later the rest of the funds at a high rate of interest. A good quality innovator will be confident enough of accomplishing the project to borrow the full amount required whereas a bad quality innovator will not want to borrow at the later stage.

6 Concluding Remarks

In this paper, I studied the choice of financing sources when rival producers can assess an innovator's idea better than other investors can. Although this assessment advantage makes financing from rival firms attractive, such financing entails the cost of revealing the technological information to potential competitors. When an innovator finances from a bank, she has to incur a signaling cost due to the bank's poorer assessment skill but can avoid the threat of being copied. The innovator's wealth and the knowledge gap between an expert and a bank determine the choice of financing source. Wealthy innovators prefer bank lending because they have more collateral. When the knowledge gap widens because of significant technological innovations, more innovators seek finance from experts.

Finally, I want to briefly mention a possible extension of the model. Throughout this paper, I assumed that the prior distribution of the quality of the innovators is exogenous.

When this distribution is endogenous and an individual needs to incur a cost to acquire a good quality idea, a poor individual may never do so since the expected return to her investment is low: without collateral she cannot expect an attractive contract from a bank. This possibility will be explored in future work.

APPENDIX 1 (Innovations and Mergers)

In this appendix, using a panel data set on merger activity, I study the relationship between the degree of merger activity and subsequent TFP growth which is a proxy for the magnitude of innovations.

Sample: The test is conducted for two sample periods which cover two of the major merger waves on record. The first sample consists of sectoral *relative merger activities* (RMAs) between 1895-1907 taken from Nelson (1959) and TFP growth since 1899 - the peak year for the turn of the century merger wave. RMA is the ratio of assets acquired in an industry during the sample period to total assets held by the industry in 1904. The second sample consists of twenty industries' RMAs between 1966-1970 and TFP growth since 1968 -the peak of 1960s merger wave. I calculate RMA by dividing the value of assets acquired during 1966-1970 by total assets in 1967.

Results: Table 1 summarizes the data and the results for the turn-of-the-century merger wave. Both ten and twenty years' subsequent TFP growth are positively and significantly related to RMA. The correlation for ten years' TFP growth is stronger than for twenty years'. Two industries are notable. The primary metals sector, characterized by the heaviest merger activity, experienced the second highest TFP growth during the subsequent ten years. The transportation equipment sector, characterized by the second heaviest merger activity, had the highest TFP growth during the subsequent 20 years.

Table 1 shows the results for the 1960s merger wave. Both four and eight years' subsequent TFP growth are positively and significantly related to RMA. The correlation coefficient for the subsequent eight years' TFP growth is 0.4855, which exceeds the value for the first four years, 0.1496. The highest TFP growth after eight years was in the apparel industry, in which prior merger activity was heaviest.

Remark: These two sample periods are not necessarily comparable for several reasons. First of all, Nelson's RMA figures measure total assets held by an industry in 1904 - six years after the peak of the merger wave, while for 1960s merger wave, I choose 1967 as the base year. Nelson's data may underestimate merger activity by using a late year because target industries often have a higher growth rate than the average. The later the year one chooses, the more assets will have accumulated in such industries and the smaller RMA will appear. Second, because of data restrictions, the subsequent TFP growth for the-turn-of-century merger wave is measured at ten and twenty years intervals, while for the 1960s mergers four and eight years' growth is examined. Third, the FTC data used for the 1960s merger wave includes only large firms whose acquired assets are $10 million dollars or more. This may underestimate merger movements in industries in which acquired firms are relatively small.

Table 1

**Mergers and Subsequent TFP Growth:
The Turn of the Century Merger Wave**

	RMA	TFP Growth (1899=1)	
	1895-1907	1899-1909	1899-1919
Food and Kindred Products	0.394	1.035	0.990
Tobacco	0.476	1.131	1.821
Textile Mill Products	0.145	1.120	1.230
Lumber and Products	0.082	0.943	0.869
Paper and Allied Products	0.567	1.273	1.315
Printing and Publishing	0.049	1.460	1.969
Chemical and Allied Products	0.506	1.067	0.994
Petroleum and Coal Products	0.015	1.068	0.965
Leather and Products	0.186	1.006	1.053
Stone Clay, Glass Products	0.405	1.245	1.339
Primary Metal Industries	2.100	1.300	1.237
Machinery, Nonelectric	0.719	1.109	1.195
Electric Machinery	0.438	1.066	1.094
Transportation Equipment	0.751	1.113	2.197
Correlation between RMA and TFP Growth		0.3009*	0.09972*

*-Signifficantly different from zero at the 1% level using a two-tailed t-test

Sources: for RMA, Nelson (1959), p.52; for TFP growth, Kendrick (1980).

Table 2

Mergers and Subsequent TFP Growth (1960s Merger Wave)

	RMA	**TFP Growth (1968=1)**	
	1966-1970	1968-1972	1968-1976
Food and Kindred products	0.1207	1.153	1.283
Tobacco manufactures	0.1133	1.129	1.200
Textiles	0.0613	1.054	1.051
Apparel	0.2278	1.110	1.323
Lumber	0.0384	1.017	0.989
Furniture	0.0786	1.108	1.132
Paper and allied products	0.1455	1.063	1.169
Printing and Publishing	0.0531	1.014	1.010
Chemicals	0.0721	1.168	1.194
Petroleum	0.0625	1.050	1.042
Rubber and plastics products	0.0204	1.066	1.063
Leather products	0.0602	0.980	1.141
Stone, clay, and glass products	0.0456	1.078	1.068
Primary metals	0.1238	0.957	0.914
Fabricated metal products	0.0715	1.032	1.019
Machinery except electrical	0.1202	1.075	1.072
Electrical Machinery	0.0617	1.177	1.261
Transportation Equipment	0.0957	1.066	1.166
Professional scientific instruments	0.0358	1.064	1.070
Miscellaneous and ordnance	0.0672	1.160	1.209
Correlation between RMA and TFP Growth		0.1496*	0.4855*

* - Significantly different from zero at the 1% level using a two-tailed t-test.

Sources: for value of assets acquired, Federal Trade Commission, Statistical Report on Mergers and Acquisitions(Washington, DC.: Government Printing Office); for . assets outstanding in 1968, Internal Revenue Service, U.S Treasury Department, Income Statistics of Income, Corporation Tax; for TFP, Kendrick and Grossman (1980).

APPENDIX 2 (Proof of Proposition 2)

The measure of good quality innovators who finance from experts is

$$\tilde{W} + (1-\alpha)(\hat{W} - \tilde{W}). \tag{13}$$

Substituting

$$\tilde{W} = \frac{\tilde{p}}{(1-\alpha)(p_g - p_b)} \left\{ \frac{(1-\alpha)p_b}{\tilde{p}} \Phi - X \right\},$$

$$\hat{W} = \frac{\hat{p}}{\alpha(p_g - p_b)} \left(\frac{\alpha p_b}{\hat{p}} \Phi - X \right)$$

in (13), we obtain

$$\frac{1}{p_g - p_b} \left[p_b \Phi - \left\{ \frac{\alpha \hat{p}}{1-\alpha} + \frac{(1-\alpha)\tilde{p}}{\alpha} \right\} X \right].$$

Differentiating the expression with respect to α yields

$$\frac{p_g X}{p_g - p_b} \left\{ \frac{1}{\alpha^2} - \frac{1}{(1-\alpha)^2} \right\} < 0.$$

Q.E.D.

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