Understanding the Rise and Decline of the Japanese Main Bank System:

Corporate Investment and Financing under Bank Rent Extraction

Xueping WU*

Department of Economics and Finance, City University of Hong Kong
Tat Chee Avenue 83, Kowloon, Hong Kong
Tel: (852) 2788 7577; Fax: (852) 2788 8842
email: efxpwu@cityu.edu.hk

Jun Yao

Department of Accountancy, City University of Hong Kong
Tat Chee Avenue 83, Kowloon, Hong Kong
Tel: (852) 2788 7136; Fax: (852) 2788 7002
email: efjyao@cityu.edu.hk

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Abstract

While a close firm-bank relationship mitigates market imperfections, recent research has suggested that insider banks often impose 'holdup' costs. This paper presents a model of how main bank rent extraction affects corporate decisions about investment and financing. Our model predicts that main bank control tends to produce overinvestment by the client firm. This overinvestment, however, is contained by the shortage of bank capital, even when new equity is available to the firm. Abundant bank capital aggravates overinvestment to the detriment of firm profitability. The shift of control rights back to the firm causes the main bank's holdup behaviour to backfire. The ex-ante rational bank is left financing projects with less upward potential and higher downside risk. This makes the bank's assets more sensitive to shocks. Our model sheds light on why Japan's main bank system was beneficial in the postwar (capital constrained) period, but became harmful during the (capital abundant) 1980s, and why the adverse shocks of the 1990s had such severe effects on the banking system.

Key words: Main Bank, Rent Extraction, Investment Efficiency, Financing, Downside Risk

JEL Classification Code: G21, G28, G30, G32

1. Introduction

Banks usually have a close banking relationship with client firms and are considered as corporate insiders (Fama, 1985). The main banks in Japan have even closer relationships with their client firms, and are well known for their practice of hands-on control of corporate finance and governance (Aoki, Patrick and Sheard, 1994). Unlike banks in the U.S., the main banks in Japan often hold considerable equity holdings in client firms. Prowse (1990) suggests that such equity holdings can greatly mitigate the agency problem between shareholders and debt-holders. Using data from the late-1970s to the mid-1980s, Hoshi, Kashyap and Scharfstein (1990a, 1990b, 1991) find that, thanks to the main bank ties, Japanese firms were usually less constrained by internal cash flows. This allowed them to continue investment and growth even when facing a cash flow shortage.

It has also been well documented that the main banks often play a positive role in helping business firms with financial difficulties (Kaplan and Minton, 1994; Kang and Shivdasani, 1997). It has been commonly believed that the main bank system is one of the reasons for Japan's rapid economic growth and success during most of the postwar period, because of the way main banks can mitigate the investment inefficiencies caused by many well-known market imperfections.[1]

Japan's economic troubles in the 1990s have caused the main bank system to again catch the attention of researchers, but this time in a negative way (see Allen, 1996, for a review on the reversal of opinion about the pros and cons of the main bank system). Recent research has emphasized the economic costs of a close banking relationship, and in particular, of the main bank system. Theoretically, a bank as an insider can, ex-post, extract rent from its client firm because the bank often has monopoly power over

[1] During the 1980s, American corporations felt the need to keep up with the competitiveness of the rising Japanese firms and underwent a painful corporate restructuring. Porter (1992) and Jacobs (1993) raised economic-policy concerns about the alleged lack of long-run perspective among American firms that have the tradition of financing at arm's-length.

the firm's information (Sharpe, 1990). Rajan (1992) further argues that *ex ante*, the bank's *ex post* rent extraction affects the firm's investment and financing decisions. This suggests that without effective competition from other funding sources such 'holdup' behavior can choke investment, especially in a firm with high growth potential, thus eroding firm value.

The main bank's holdup behavior on corporate investment efficiency can also cause overinvestment. A main bank can prod its client firm to take on even negative NPV projects to generate more but relatively less risky interest income for the bank, yet to the detriment of the firm's own profitability (Wu and Xu, 2004). The earlier study of Nakatani (1984) had already suggested that the main bank system (a financial or *keiretsu* industrial group with a main bank at its core), can actually weigh down the bank-affiliated firms in terms of corporate performance (see also Weinstein and Yafeh, 1998). In view that large *keiretsu* firms are most likely to have the legacy of the main bank relationship even during the financial deregulation, Wu, Sercu and Chen (2000) find that during 1974-95 it is large *keiretsu* firms that, while enjoying no advantage in the cost of capital, have significantly lower returns on investment, compared to large non-*keiretsu* peers. Kang and Stulz (2000) even question the value of the main bank system—once the envy of many other economies in the world—by showing that during the Japanese stock market meltdown in the early 1990s, firms with more bank borrowings in the late 1980s saw deeper losses in their equity value (and this cannot be explained by a leverage effect). In short, most recent empirical studies conclude that the main bank system hurts firm value.

While the existing literature has made useful attempts to explain the costs and benefits of the main bank system (see Hoshi and Kashyap, 2001, for a review), it remains unclear why the main bank system should have facilitated Japan's economic growth when the main banks were at their most powerful (in the 1950s, 1960s and 1970s), but become a burden following the financial deregulation in the 1980s.

Since the effective start of financial deregulation aimed at opening up Japanese capital markets in the early 1980s, Japanese firms previously controlled by the main banks have gradually been able to take investment and financing decisions into their own hands. Following the deregulation, Japanese corporate financing changed significantly from bank borrowing to capital market financing (Campbell and Hamao, 1994).

Yet there remain many unanswered questions about the effects of the financial deregulation on Japan's financial system. In view of the good track record of the main bank system in the past, why did the cost-benefit trade-off between bank borrowing and the arms'-length financing, change during the deregulation? Did the main banks change their modus operandi in response to the deregulation that restricted their influential power? Is the deregulation the main cause of the current malaise in Japan's banking system? The adverse shock of the burst of the high-flying equity and real estate markets in the late 1980s affected both firms and main banks. Since firms with more banking borrowings suffered deeper losses in equity value, did they drag down their main banks, or was it the other way around? While the existing literature has provided some useful insights into individual issues, it has handled these issues in isolation; there has not been a theoretical analysis that attempts to explain both the rise and fall of the main bank system.

This paper develops a model of a firm's investment and financing decisions under main bank rent extraction. It looks at how corporate decisions change with various scenarios. The evolution of these changes illustrates the effect of changes in the main banks' corporate finance and governance structure under the Japanese financial deregulation. Our basic approach is in line with Rajan (1992) who has suggested that the deterioration in the credit rating in Japan may partly reflect the deterioration in control that accompanies the movement from a relationship-oriented system to a transactions-based competitive system, but statements on the efficiency implications of this phenomenon requires an examination of the accompanying effect on corporate investment.

The model presented in this paper is a rational-expectations-based model that considers the agency conflicts between the firm's existing shareholders and the main bank. The main bank relationship is maintained not only because of regulations or historic reasons but also because firms would face higher asymmetric information costs by switching to new lenders (Sharpe, 1990). The payoffs of the main bank depend on: the value of its firm equity holdings, the perfect-market-determined risky debt income and the information rent (or rent extracted from the firm in general). Rent extraction is backed up by the bank's monopoly power over the firm's information as well as regulations in favour of banks. The information monopoly power exists even in capital market oriented economies such as the US (Houston and James, 1996). Depending on financing possibilities and who controls the firm, agency conflicts can evolve to reverse both the under- and overinvestment problems that the firm faces. These results are also influenced by market conditions.

The model has many interesting implications. It is worth highlighting here the major results although we leave a detailed review of these findings in the conclusion section. The main result of main bank rent extraction is overinvestment by the client firm under main bank control. When the main bank controls the firm, the bank is more likely to fully finance projects with better upward potential because it can reap proportionally more rent. In contrast, new equity is more likely to be issued to co-finance acceptable projects but with higher downside risk. Fair-priced new equity helps share the downside risk that the main bank otherwise would not bear alone. The costs of overinvestment are totally passed on to the existing shareholders. The main bank controlled overinvestment, however, is contained by the shortage of bank capital, because the cutoff level to accept projects has to be raised. The availability of outside new equity does not actually relieve the shortage because the bank directs equity financing only to share downside risk. Conversely, a glut of bank capital aggravates overinvestment.

When (or if) the firm resumes control, the main bank's holdup behaviour backfires, even though the main bank is ex-ante rational. The firm will seek new equity to finance projects with better upward potential. We show that this is because the asymmetric information costs of new equity, which also decrease with the market confidence about the quality of the projects, are lower than the holdup costs of bank debt. In contrast, the firm seeks bank borrowings to finance projects with higher downside risk because the debt and equity cost differential is reversed in this situation. This implies that if a main bank's control over firms is weakened, the ex-ante rational bank is likely to end up in a situation where it is financing projects with higher downside risk (such as high-flying real estate projects and aggressive production expansions in maturing industries). Note that this bias becomes even stronger during an equity market boom. If adverse shocks occur, bad debts are likely to pile up at the main bank.

This evolution in the firm and main bank relationship caused by financial deregulation reflects the recent history of the main bank system in Japan. The remainder of the paper explores this topic in greater detail and is organized as follows. Section 2 develops the model that predicts a firm's investment and financing decisions under three different scenarios. The evolution of the three scenarios seeks to track the changing contracting environment in Japan from the postwar period to the recent post-deregulation period. Section 3 synthesizes the model predictions under various settings to explain the evolution of the main bank system in Japan. Section 4 summarizes and concludes the paper.

2. The Model

In this section, we first set up the analytical framework (section 2.1). Then, we use the firm's first best investment policy to set the optimal benchmark (section 2.2). We then analyse three scenarios. In the first scenario, we focus on the firm's investment policy with bank debt only (section 2.3). In the second scenario, we study the main bank controlled corporate investment and financing policies when new equity is available (section 2.4). In the third scenario, we highlight the firm controlled financing decisions when there is a choice between bank and new equity financing, and examine the effect on the main bank system of this shift of control rights back to the firm (section 2.5).

2.1 The Basic Framework

Our analytical framework is constructed to capture the conflicts of interest between a main bank and its client firm's existing shareholders.[2] We make the following assumptions for clarity and simplicity: The firm has only one main bank, which provides all the (risky) debt for the firm. The main bank relationship

[2] John, John and Saunders (1994) also model the conflicts of interest between a firm and its main bank. However, they do not consider the main bank's rent extraction. The project payoff structure later in our framework is similar to the one from John and John (1993) and John, John and Saunders (1994).

is maintained in part because the firm would face higher asymmetric information costs by switching to new lenders and in part because of regulations or historical reasons like financial *keiretsu* in Japan. The firm's manager will either maximize existing shareholders' wealth or rules on behalf of the main bank if the bank controls the firm. There are no taxes, bankruptcy costs and other transaction costs. All the decision makers are risk neutral.

We consider a three-date, two-period model. The firm has assets-in-place at time, t=0, valued for A. The bank holds a share of the firm's total equity, α. We are interested in decisions and valuations at time, t=1. The firm has an investment opportunity at t=1, requiring an input of capital, I. At time, t=2, the project produces either a non-negative return, r_H, in the good state, or, a non-positive return, r_L, in the bad state ($-1 \leq r_L \leq 0 \leq r_H$). We assume that both the insiders and the market know (r_L, r_H) at time, t=1. The probability of reaching the good state is q. The value of q (which is exogenously determined) can be interpreted as the result of a combination of the firm's managerial skills and its business prospects. These conditions are known only by the insiders at t=1. In other words, q can be observed precisely by the manager and the main bank at t=1. But at time t=1, the outside investors in the stock market only know that q is uniformly distributed over $[q_l, q_u]$ ($0<q_l<q_u<1$). The range $[q_l, q_u]$ reflects the range of guesses by the market about the quality of the project given (r_L, r_H).

To finance the investment, the firm can either borrow from its main bank, or issue new equity, or do both. The perfect market interest rate, r, for risky debt, will be rationally determined. The upper bound (e.g., imposed by the government) of r is r_u. At time, t=2, if the firm is borrowing from the bank, the firm will pay off the debt and interest, if it can generate enough cash inflows. Otherwise, the bank liquidates the firm. To capture the main bank's holdup behaviour backed by its information monopoly, we assume that, only in the good state, the bank will extract rent from the firm in terms of a share, m, of the profits.[3] Let the extracted rent depend on the debt size, $D \leq I$, to reflect the extent of the firm's transactions with the

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[3] Rent extraction becomes pronounced in the good state is in the spirit of Rajan (1992). Alternatively, if we add a premium to r, all the results that follow will go though qualitatively.

bank. As a result, the bank requires, including (normal) debt payment, a total payoff of $mD(r_H-r)+D(1+r)$ in the good state.[4] The value of m is exogenously determined according to the bank's monopoly power and is presumed to be public knowledge. Equity holders will keep the residual value if the firm remains solvent at t=2. If bankruptcy occurs, the bank will liquidate the firm to pay off, if possible, part of the defaulted debt. For simplicity, we assume that $A+I(1+r_H)$ is always greater than $I(1+r)$, so that the firm is always solvent in the good state.

2.2 The First Best Investment Policy

At t=1, to maximize the firm's value, the manager should choose all the positive NPV projects:

$$NPV_{firm} = qr_H + (1-q)r_L \geq 0 . \tag{1}$$

As depicted in Figure 1, a project (r_L, r_H) will be chosen if and only if it is located above the bold line. To facilitate the discussion, following John and John (1993) and John, John and Saunders (1994), we introduce the following definition:

Definition 1: An investment policy which accepts a project for $r_H > r_H^0 = f(r_L)$ *will be denoted as investment policy* $[r_H^0]$*, in which* r_H^0 *is a function of* r_L*.*

Thus, corresponding to Condition (1), the investment policy that maximizes the firm's value can be expressed as $[r_H^*]$ where $r_H^* = -\dfrac{(1-q)r_L}{q}$. To facilitate the understanding of the decision rule, we present a numerical example in section *B1* of Appendix B.

[4] For a successful firm, the ex-post rent extracted by the main bank can include higher interest charges on the next round of new projects (Weinstein and Yafeh, 1998), required compensation balance kept at the main bank, charges on premium insurance and financial services that the firm may not really need, and the firm-bank relationship related consumption covered by the firm's entertainment expenses. The main bank enjoys this rent because of its information monopoly power. As a result, the firm is in no way to get only the perfect market interest rate, r.

2.3 Scenario I: The Investment Decision with Bank Debt Only

To focus on the conflicts between the main bank and the firm's shareholders, we assume that a potential project will be financed by bank debt only. As a result, the shareholders would like the firm to undertake a project with a non-negative return on equity,

$$NPV_{equity} = q[A + (1-m)I(r_H - r)] + (1-q)\{A + I(r_L - r)\}^+ - A \geq 0\,. \qquad (2)$$

The return on equity in (2) depends on the perfect market interest rate for the risky debt, which is rationally determined by the zero expected debt payoff (under risk neutrality), $qI(1+r) + (1-q)Min\{A + I(1+r_L), I(1+r)\} - I = 0$. This gives:

$$\begin{cases} r = 0 & \text{if} \quad r_L \geq -\dfrac{A}{I}, & (3) \\ r = \dfrac{-(1-q)(A + Ir_L)}{qI} & \text{if} \quad \dfrac{-qr_u}{1-q} - \dfrac{A}{I} \leq r_L < -\dfrac{A}{I}, & (4) \\ r = r_u & \text{if} \quad -1 < r_L < \dfrac{-qr_u}{1-q} - \dfrac{A}{I}. & (5) \end{cases}$$

Note that the interest rate cannot exceed r_u due to the upper bound assumption. The fact that the market interest rate can be positive comes from the concave payoff structure for the risky debt (not from any risk aversion). Also note that *A* as collateral should remain small to produce interesting results. For example, if $A=I$, r is zero for any $r_L \geq -1$ and there is no bankruptcy. Bankruptcy occurs if $A+I(1+r_L)<I(1+r)$, or $A/I<r-r_L$.

Proposition 1: With bank financing only, the manager, on behalf of the shareholders, chooses the investment policy [r_H^e], in which

$$
\begin{cases}
r_H^e = \dfrac{-(1-q)r_L}{q(1-m)} & \text{if} \quad r_L \geq -\dfrac{A}{I}, \qquad (6) \\[2ex]
r_H^e = \dfrac{(1-q)mA}{q(1-m)I} - \dfrac{(1-q)r_L}{q} & \text{if} \quad \dfrac{-qr_u}{1-q} - \dfrac{A}{I} \leq r_L < -\dfrac{A}{I}, \qquad (7) \\[2ex]
r_H^e = \dfrac{(1-q)A}{q(1-m)I} + r_u & \text{if} \quad -1 < r_L < \dfrac{-qr_u}{1-q} - \dfrac{A}{I}. \qquad (8)
\end{cases}
$$

Proof: See the appendix.

As shown in Figure 1, a project will be chosen only if it is located on the right-hand-side of the light solid kinked line. A numerical example is presented in section *B2* of Appendix B.

Corollary 1: With bank financing only, the manager, on behalf of the shareholders, implements a sub-optimal investment policy [r_H^e], in which r_H^e is higher than r_H^* if $r_L \geq \dfrac{-(1-q)A - q(1-m)Ir_u}{(1-q)(1-m)I}$ and in which r_H^e is lower than r_H^* if $-1 < r_L < \dfrac{-(1-q)A - q(1-m)Ir_u}{(1-q)(1-m)I}$.

This suboptimal investment policy [r_H^e] can result in both under- and overinvestment. First, the manager will pass up project (r_L,,r_H) that satisfies ($r_H^* < r_H < r_H^e$, $r_L \geq \dfrac{-(1-q)A - q(1-m)Ir_u}{(1-q)(1-m)I}$), such as the one labelled "a" in Figure 1. This underinvestment occurs because the rent extracted by the bank can render even a profitable project unattractive to the shareholders. This effect is different from the debt overhang described in Myers (1977), which is caused by old debt. Second, the manager will undertake project (r_L,,r_H) that satisfies ($r_H^e < r_H < r_H^*$, $-1 < r_L < \dfrac{-(1-q)A - q(1-m)Ir_u}{(1-q)(1-m)I}$), such as the one labelled "b" in Figure 1. This overinvestment occurs because limited liability or risk shifting enables the shareholders to benefit from even a negative NPV project. The bank cannot fully factor this risk-shifting into the market interest rate it charges because of the government regulation that puts a ceiling on interest rates.

The main bank may not agree on the investment policy detailed in equations (6) to (8). The bank's payoff at time, t=2, comes from three possible sources. As a shareholder, the bank has a share of the firm's residual value from the bank's equity holdings. As the only creditor, the bank collects debt payment including interest if it can do so. In addition, the bank can reap a holdup profit if the good state occurs. As an insider, the bank also knows the value of *q*. Thus, with sufficient control power, the bank will force the manager to implement a different policy which brings the bank a non-negative NPV at t=1:

$$
\begin{aligned}
NPV_{Bank} &= q[\alpha[A+(1-m)I(r_H-r)]+I(1+r)+mI(r_H-r)]+ \\
&\quad (1-q)[\alpha\{A+I(r_L-r)\}^{+}+Min\{I(1+r),A+I(1+r_L)\}]-(\alpha A+I)\geq 0.
\end{aligned} \tag{9}
$$

Proposition 2: With bank financing only, the manager, on behalf of the bank, will choose the investment policy [r_H^b], in which

$$
\begin{cases}
r_H^b = -\dfrac{(1-q)r_L}{q[1+m(\frac{1-\alpha}{\alpha})]} & \text{if } \; r_L \geq -\dfrac{A}{I}, \qquad (10) \\[2ex]
r_H^b = -\dfrac{(1-\alpha)(1-q)mA}{[\alpha(1-m)+m]qI}-\dfrac{(1-q)r_L}{q} & \text{if } \; \dfrac{-qr_u}{1-q}-\dfrac{A}{I}\leq r_L < -\dfrac{A}{I}, \qquad (11) \\[2ex]
r_H^b = -\dfrac{(1-\alpha)(1-q)A+(1-m)(1-\alpha)qIr_u+(1-q)Ir_L}{[\alpha(1-m)+m]qI} & \text{if } \; -1 < r_L < \dfrac{-qr_u}{1-q}-\dfrac{A}{I}. \qquad (12)
\end{cases}
$$

Proof: See the appendix.

As shown in Figure 1, a project will be chosen only if it is located on the right-hand-side of the dash-dotted kinked line. [r_H^b] is also suboptimal. See a numerical example in section *B2* of Appendix B.

Corollary 2: With bank financing only, the manager, working on behalf of the bank, implements a suboptimal investment policy [r_H^b], in which r_H^b is lower than r_H^* if $r_L \geq \frac{-(1-q)A - q(1-m)Ir_u}{(1-q)(1-m)I}$ *and in which r_H^b is higher than r_H^* if* $-1 < r_L < \frac{-(1-q)A - q(1-m)Ir_u}{(1-q)(1-m)I}$.

The suboptimal investment policy [r_H^b] also causes both under- and overinvestment. In the case of overinvestment, the manager will undertake the project (r_L,,r_H) that satisfies (r_H^b<r_H<r_H^*, $r_L \geq \frac{-(1-q)A - q(1-m)Ir_u}{(1-q)(1-m)I}$), such as the one labelled "c" in Figure 1. The bank's equity holdings may not create sufficient incentives to restrain the bank from prodding the firm to overinvest because the bank's marginal income from debt can be greater than its equity loss caused by overinvestment. On the other hand, in the case of underinvestment, the bank will pass up the project (r_L,,r_H) that satisfies (r_H^*<r_H<r_H^b, $-1 < r_L < \frac{-(1-q)A - q(1-m)Ir_u}{(1-q)(1-m)I}$), such as the one labelled "d" in Figure 1. Such underinvestment occurs among some highly risky projects with positive NPVs, because the interest rate ceiling prevents the bank from charging a higher market interest rate to factor in the higher risk (note again this is not from risk aversion).

From the above analysis, it is clear that the problems of under- and overinvestment will always exist as long as there is a conflict of interest between the firms' shareholders and the main bank. Main bank control does indeed help mitigate the under- and overinvestment problems that exist in the suboptimal investment policy of the manager working on behalf of firm shareholders. But the bank-controlled investment is not Pareto optimal either, and leads to different kinds of under and overinvestment. The severity of the main bank controlled overinvestment problem is mainly determined by the value of m and α. The higher the aggressiveness of rent extraction, m, and the lower the bank's equity incentive, α, the further [r_H^b] will deviate from [r_H^*].

2.4 Scenario II: Investment and Debt-Equity Financing Decisions under Main Bank Control

In this section, we consider the case where the main bank controls the firm, and a project can be financed by a mix of debt and new equity. That is, $I=D+e$, where D is bank debt and e is new equity. To keep a stable share, α, of the firm's equity, the bank will purchase the same share of the new equity issue, namely, $\alpha e = \alpha(I-D)$. This situation is similar to the situation in pre-deregulation Japan when a main bank had great influence on the firm's investment and financing decisions.

The bank's total NPV comes from its equity holdings, debt and rent extraction:

$$\begin{aligned} NPV_b = {} & q[\alpha(A+I(1+r_H)-D(1+r)-mD(r_H-r))+D(1+r)+mD(r_H-r)]+ \\ & (1-q)[\alpha\{A+I(1+r_L)-D(1+r)\}^+ + Min\{D(1+r),A+I(1+r_L)\}]-(\alpha A+\alpha e+D) \end{aligned} \tag{13}$$

Note that while α and I are exogenously given, D is a decision variable here, and that the market interest rate should be rationally determined according to the zero expected net debt payoff (under risk neutrality), $qD(1+r)+(1-q)Min\{A+I(1+r_L),D(1+r)\}-D=0$.

We summarize the financing policy optimization problem the bank faces as follows:

$$\begin{aligned} & \underset{D}{Max}\{q[\alpha(A+I(1+r_H)-D(1+r)-mD(r_H-r))+D(1+r)+mD(r_H-r)]+ \\ & (1-q)[\alpha\{A+I(1+r_L)-D(1+r)\}^+ + Min\{D(1+r),A+I(1+r_L)\}]-[\alpha(A+e)+D]\} \end{aligned} \tag{14}$$

s.t.:

$$\alpha e = \alpha(I-D) \tag{15}$$

$$\begin{cases} r = 0 & \text{if } r_L \geq \dfrac{D-A-I}{I}, & (16) \\[2ex] r = \dfrac{(1-q)\{D-[A+I(1+r_L)]\}}{qD} & \text{if } \dfrac{(1-q)(D-I)-qDr_u}{(1-q)I}-\dfrac{A}{I} \leq r_L < \dfrac{D-A-I}{I}, & (17) \\[2ex] r = r_u & \text{if } r_L < \dfrac{(1-q)(D-I)-qDr_u}{(1-q)I}-\dfrac{A}{I}. & (18) \end{cases}$$

Solving this optimization problem, we will obtain the optimal financing policy, $D*$. Furthermore, with $D*$ determined, we can obtain the investment policy, if the bank requires $NPV_b \geq 0$. We summarise the results in the following proposition.

Proposition 3: In the case of financing with new equity and debt, the manager, on behalf of the bank, will choose the optimal financing policy, D^*, and the investment policy $[r_H{}^b]$, such that

$$
\begin{cases}
D^*=I & \text{if } r_L \geq -\frac{A}{I} \text{ or } \left(\frac{-qr_u}{1-q}-\frac{A}{I} \leq r_L < -\frac{A}{I} \text{ and } r_H \geq \frac{1-q}{q}\right) \quad (19) \\
 & \text{or } \left(r_L < \frac{-qr_u}{(1-q)}-\frac{A}{I} \text{ and } r_H \geq \frac{1-q-qr_u+qmr_u}{qm}\right), \\
D^* = A+I(1+r_L) & \text{if } \frac{-qr_u}{1-q}-\frac{A}{I} \leq r_L < -\frac{A}{I} \text{ and } r_H < \frac{1-q}{q}, \quad (20) \\
D^* = \frac{A+I(1+r_L)}{1+r_u} & \text{if } r_L < \frac{-qr_u}{(1-q)}-\frac{A}{I} \text{ and } r_H < \frac{1-q-qr_u+qmr_u}{qm}, \quad (21)
\end{cases}
$$

and

$$
\begin{cases}
r_H{}^b = -\frac{(1-q)r_L}{q[1+m(\frac{1-\alpha}{\alpha})]} & \text{if } r_L \geq -\frac{A}{I}, \quad (22) \\
r_H{}^b = -\frac{\alpha(1-q)Ir_L}{\alpha qI+(1-\alpha)qm[A+I(1+r_L)]} & \text{if } \frac{-qr_u}{1-q}-\frac{A}{I} \leq r_L < -\frac{A}{I}, \quad (23) \\
r_H{}^b = -\frac{(1-q)\alpha I(1+r_u)r_L+(1-\alpha)[I(1+r_L)+A]r_u(1-qm)}{\alpha qI(1+r_u)+(1-\alpha)qm[I(1+r_L)+A]} & \text{if } r_L < \frac{-qr_u}{(1-q)}-\frac{A}{I}. \quad (24)
\end{cases}
$$

Proof: See the appendix.

As shown in Figure 2, the investment policy [r_H^b] in equations (22) to (24) is depicted as the light solid curve labelled "B". All the acceptable projects must lie on the right-hand-side of the curve. It is apparent that overinvestment occurs, as we can see that some acceptable projects are located below the first best investment policy [r_H^*], depicted as the bold straight line labelled "O".

The optimal financing policy, $D*$, varies with the quality of the project as specified in equations (19) to (21). For example, if the project's downside risk is limited, e.g., $r_L \geq -\frac{A}{I}$, the bank will finance the project only with debt, as indicated in (19). If the project is exposed to considerable downside risk and the upward potential is capped, such as specified in (20), the bank will prefer the firm to use a mix of debt and new equity to finance the project. Some new equity is needed because the bank counts on the new equity investors to share the project's downside risk, a risk that is too big for the bank to bear alone. In other words, as long as the main bank controls the firm, the main bank is happy with the opening up of equity financing, because this risk-sharing is to the bank's benefit.[5]

Risk sharing here causes overinvestment. We can prove that r_H^b is always less than r_H^* (the proof is available on request). In other words, Curve B is always below line O as shown in Figure 2. Thus, unlike the situation in Figure 1 where highly risky but profitable projects are skipped when the ceiling on the interest rate becomes binding, this underinvestment problem is mitigated when new equity is available. As a result, the opening up of the equity market helps mitigate the underinvestment problem. But the overinvestment problem remains because the bank can still extract rent from the firm's existing shareholders.

Now suppose the bank has a shortage of capital—a situation that reflects the high growth period in postwar Japan. This shortage of capital will cause the main bank to fund the most profitable projects first. With capital constraints, the bank must require a higher cutoff level for NPV_b. The more severe the capital

[5] Since the bank always keeps a constant share of the firm's equity, the pricing of new equity does not influence the bank's payoff. Thus, the bank has no incentive to unfairly price the new equity. In short, the costs of overinvestment are passed on entirely to the existing shareholders.

shortage is, the higher NPV_b cutoff level the bank requires. Suppose the bank requires a cutoff level of $X>0$. While it does not fundamentally affect the way the bank determines the optimal financing policy, D^*, the bank capital shortage will change the investment policy, as summarised in the following corollary.

Corollary 3: In the case of financing with new equity and debt, when the bank requires a higher cutoff level, X, on its payoff, i.e., $NPV_b \geq X$ *, the manager, working on behalf of the bank, will choose the investment policy* [r_H^{b1}]*, in which*

$$\begin{cases} r_H^{bx} = \dfrac{X}{\alpha q I(1+m(\dfrac{1-\alpha}{\alpha})} - \dfrac{(1-q)r_L}{q[1+m(\dfrac{1-\alpha}{\alpha})]} & \text{if } r_L \geq -\dfrac{A}{I}, \quad (25) \\[2ex] r_H^{bx} = \dfrac{X-\alpha(1-q)Ir_L}{\alpha qI+(1-\alpha)qm[A+I(1+r_L)]} & \text{if } \dfrac{-qr_u}{1-q} - \dfrac{A}{I} \leq r_L < -\dfrac{A}{I}, \quad (26) \\[2ex] r_H^{bx} = \dfrac{X-(1-q)\alpha I(1+r_u)r_L-(1-\alpha)[A+I(1+r_L)]r_u(1-qm)}{\alpha qI(1+r_u)+(1-\alpha)qm[A+I(1+r_L)]} & \text{if } r_L < \dfrac{-qr_u}{(1-q)} - \dfrac{A}{I}. \quad (27) \end{cases}$$

Proof: Repeat all the calculations for the investment policy in equations (22) to (24) by using $NPV_b \geq X$ instead of $NPV_b \geq 0$.■

The investment policy [r_H^{bx}] is illustrated in Figure 2. The bank capital shortage makes the original investment policy [r_H^{b}] in Proposition 2 shift upwards. If the cutoff level is raised only slightly, most of the bank controlled investment decision policy curve, labelled as B_x, will still be below the first best investment policy line, labelled as O in Figure 2. Although the overinvestment problem remains, it is obvious that the bank capital shortage helps shrink it, as the area of overinvestment becomes smaller. If the cutoff level is sufficiently raised, reflecting a severe shortage of capital, the bank controlled investment policy curve, labelled B_y, ($Y>X$), can be located above line O. In this case, the overinvestment problem vanishes totally. (Of course, this may result in underinvestment, a well-understood problem in the situation of severe capital shortage.) In short, a bank capital shortage restrains the bank controlled overinvestment. Conversely, when a bank accumulates sufficient capital, so that capital shortage is no longer an issue, the bank will tend to prod the firm to overinvest.

During the earlier postwar period, Japan struggled to recover from its war-torn economy. The many necessary investments facing the shortage of capital at that time made overinvestment virtually out of the question. As a result, the main bank system, which provided much needed capital and also hands-on governance for the client firms, mainly facilitated the growth of Japan's economy during that time, despite the presence of main bank rent extraction.

The main banks' methods of operation, however, became onerous as the main banks accumulated more and more capital. Figure 3 shows that deposits in Japanese banking institutions started to increase dramatically in the early 1970s. The abundance of capital (relative to the domestic investment opportunities) meant that the main banks now had more incentive to prod their client firms to overinvest. This occurred right before the Japanese financial deregulation (the policy was launched slowly in the mid-1970s and in fact only took effect in the early 1980s). Eventually, the financial deregulation undercut the main banks' influence on their client firms. Perhaps the Japanese regulators had realized that the main banks' traditional methods of operation would result in investment inefficiency in the new economic environment of abundant capital. But this movement towards a more market-oriented financial system caused new problems to emerge (because market imperfections in the new contracting environment can have new implications).

2.5 Scenario III: Firm Controlled Financing Decisions with Either Debt or Equity

In this section, we consider the situation when the manager makes financing and investment decisions on behalf of the existing shareholders, and uses either bank debt or equity to finance a project. This scenario reflects the situation during and after the deregulation in Japan. While the main bank remained an insider through its monitoring activities, the opening of the capital markets allowed many firms to access alternative funds. In addition, the main bank's equity holdings in its client firms are expected to be diluted by the deregulation. Thus, the main bank's practice of hands-on governance became difficult to maintain in those firms.

We consider now the costs of debt and equity financing. As the market interest rate is determined under risk neutrality and symmetric information, debt in this regard does not decrease the firm's expected total value. Instead, in our setting, the firm yields part of its expected NPV to the bank because of the agency costs of bank debt. If the project is fully financed by bank debt, the bank will impose—as previously assumed—a holdup cost of $mI(r_H-r)$ if the good state occurs. The bank can do so because it still has superior information over other fund providers. Note that, for simplicity, we ignore the upper bound of r in this section. Thus, the firm's expected costs of using debt are, $qmI(r_H-r)$.

Alternatively, the firm could seek full equity financing from new outside investors for the project. These outside investors would require a certain share of the firm's total assets at time, t=2. This required share, which we denote as β, may yield a positive NPV (expected by the firm) to the new equity investors due to information asymmetry. Under asymmetric information, albeit a zero expected net payoff by new shareholders under risk neutrality, they may obtain either positive or negative NPVs expected by the firm, depending whether they under- or overestimate the inside information, q. Such a positive expected NPV for the new shareholders is the firm's expected asymmetric information cost. We will show later that the share of firm assets paid to outside investors, β, is rationally determined under asymmetric information.

Proposition 4: When using either debt or new equity to finance a project, the manager, working on behalf of the existing shareholders, weighs the agency costs of debt and the asymmetric information costs of new equity. The firm's expected agency costs of using debt are:

$$\begin{cases} C_{Bank} = qmIr_H & \text{if } r_L \geq -\dfrac{A}{I}, & (28) \\[2ex] C_{Bank} = qmIr_H + (1-q)m(A+Ir_L) & \text{if } r_L < -\dfrac{A}{I}; & (29) \end{cases}$$

The firm's expected asymmetric information cost of new equity at time, t=1, is equal to the share, β, of the firm's expected total value minus the new equity investors' investment, namely,

$$C_{Equity} = \beta\{A + I[1 + qr_H + (1-q)r_L]\} - I \ . \tag{30}$$

Proof: See the appendix.

To obtain the financing decision rule, we have to understand how β is determined in the market. This is because, as shown in equation (30), β affects the asymmetric information costs of new equity. The equity market is unable to observe the inside information, q. It can only form an expected value of q based on its uniform distribution over [q_l, q_u]—the range of guesses by the market about the project's quality.[6] The lower bound (reflecting the most conservative guess by the market about q), q_l, is exogenously given. On the other hand, the upper bound, q_u, is endogenously determined. We denote the expected value of q as E[q]. Note that the market knows (r_L, r_H) at time, t=1. Thus, β is related to E[q], according to rational pricing under risk neutrality, $\beta\{A + I\{1 + E[q]r_H + (1-E[q])r_L\} = I$, or,

$$\beta = \frac{I}{A + I\{1 + E[q]r_H + (1-E[q])r_L\}} \ . \tag{31}$$

According to equation (31), the required share, β, by the new shareholders decreases with their expected q, $E[q]$. In other words, the cost of new equity decreases with $E[q]$. The firm prefers new equity over debt only if $C_{Equity} < C_{Bank}$. According to equations (28) to (30), this decision rule corresponds to:

$$\begin{cases} \beta\{A + I(1 + qr_H + (1-q)r_L)\} - I < mqIr_H & \text{if } r_L \geq -\dfrac{A}{I}, \quad (32) \\[2ex] \beta\{A + I(1 + qr_H + (1-q)r_L)\} - I < mqIr_H + m(1-q)(A + Ir_L) & \text{if } r_L < -\dfrac{A}{I}. \quad (33) \end{cases}$$

In effect, E[q], which determines β, is endogenously determined with the firm's financing decisions. If the firm uses new equity instead of debt, the market can infer the best possible quality of the project and

[6] r_H and r_L, which are under symmetric information in our model, are also part of the project's quality.

hence form E[q] with the presumed uniform distribution over [q_l, q_u]. We describe the determination of q_u and E[q] in the follow proposition.

Proposition 5: When using either debt or new equity to finance a project, the manager, acting on behalf of the existing shareholders, may prefer new equity over debt. If so, the market can infer the best possible quality of the project as follows:

$$\begin{cases} q_u = \dfrac{E[q]I(r_H - r_L)}{I(r_H - r_L) - m\{A + I(1 + E[q]r_H + (1 - E[q]r_L)\}r_H} & \text{if } r_L \geq -\dfrac{A}{I}, \quad (34) \\[2ex] q_u = \dfrac{E[q]I^2(r_H - r_L) + m(A + Ir_L)\{A + I(1 + E[q]r_H + (1 - E[q])r_L)\}}{I^2(r_H - r_L) + m\{A + I(1 + E[q]r_H + (1 - E[q])r_L)\}\{A + I(r_L - r_H)\}} & \text{if } r_L < -\dfrac{A}{I}, \quad (35) \end{cases}$$

where

$$E[q] = \frac{q_l + q_u}{2}. \tag{36}$$

Proof: See the appendix.

We are now ready to determine the financing decision rule based on all of the exogenous variables. We summarise the results in the follow proposition.

Proposition 6: When using either debt or new equity to finance a project, the manager, acting on behalf of the existing shareholders, prefers new equity over debt as long as $C_{Bank} > C_{Equity}$, namely,

$$\begin{cases} \left(\dfrac{A + I(1 + qr_H + (1 - q)r_L)}{A + I(1 + E[q]r_H + (1 - E[q])r_L)\}} - 1\right) < mqr_H & \text{if } r_L \geq -\dfrac{A}{I}, \quad (37) \\[2ex] \left(\dfrac{A + I(1 + qr_H + (1 - q)r_L)}{A + I(1 + E[q]r_H + (1 - E[q])r_L)\}} - 1\right)I < mqIr_H + m(1 - q)(A + Ir_L) & \text{if } r_L < -\dfrac{A}{I}, \quad (38) \end{cases}$$

where E[q] is determined by the following implicit functions:

$$\begin{cases} E[q] = \dfrac{1}{2}\left(q_l + \dfrac{E[q]I(r_H - r_L)}{I(r_H - r_L) - m\{A + I(1 + E[q]r_H + (1 - E[q]r_L)\}r_H} \right) & if\ r_L \geq -\dfrac{A}{I}, \quad (39) \\ E[q] = \dfrac{1}{2}\left(q_l + \dfrac{E[q]I^2(r_H - r_L) + m(A + Ir_L)\{A + I(1 + E[q]r_H + (1 - E[q])r_L)\}}{I^2(r_H - r_L) + m\{A + I(1 + E[q]r_H + (1 - E[q])r_L)\}\{A + I(r_L - r_H)\}} \right) & if\ r_L < -\dfrac{A}{I}. \quad (40) \end{cases}$$

Proof: Inserting β from equation (31) into conditions (32) and (33) easily gives conditions (37) and (38). Equations (34) to (36) in Proposition 5 directly produce equations (39) and (40). ■

The financing decision rule in (37) and (38), where E[q] is known in the equilibrium, can be depicted on the (r_L, r_H) plane. Note that there is no investment inefficiency when assets in place are not subject to asymmetric information (Myers and Majluf, 1984; Myers, 2002). Thus, the adverse selection that would have caused the firm to skip some profitable projects is not an issue here. Overinvestment is also not an issue because the manager, working on behalf of the existing shareholders, has no incentive to overinvest. In other words, the financing decision rule is the relevant issue in this section.

The financing decision rule obtained from conditions (37) and (38) is an implicit function. For simplicity, we can use the follow numerical procedure to produce the indifference curve on the (r_L, r_H) plane accordingly:

a. Set parameters A, I, q, m, and q_l;
b. pick a value for r_L;
c. input the parameters along with the picked value for r_L into conditions (37) to (40) so that there are only two unknown variables, r_H and E[q];
d. try a value of r_H (from small to big);
e. input the value of r_H into equations (39) and (40) to get the value of E[q];
f. input the value of E[q] along with the value of r_H into conditions (37) and (38);
g. if inequality in (37) and (38) holds, restart from Step (d) to try another value of r_H;
h. if inequality in (37) and (38) becomes equality, we get a point of (r_L, r_H) on the indifference curve, restart from Step (b) to pick another r_L.

The above procedure will produce a set of (r_L, r_H)-points that plot the indifference curve for the financing decisions. For example, set A=4, I=25, m=0.2, q=0.6, and q_l=0.4. Then, try r_L =(0, –0.1, –0.2, –0.3, –0.4, –0.5) consecutively using the numerical procedure described above. This will generate a corresponding series, r_H = (0, 0.21, 0.45, 0.71, 0.94, 1.15). In Figure 4, we use the six (r_L, r_H)-points to plot the indifference curve, a light solid curve with black dots. A project in the area below this indifference curve (i.e., regions I and II in Figure 4), will be financed with bank loans. In contrast, a project in the area above this curve (i.e., regions III and IV) will be financed with equity. Note that a project in the area below the first best investment line (the bold solid line in Figure 4) will not be accepted.

According to this financing decision rule, the lower the value of r_H, given the value of r_L, the more likely it is for the project to be financed with bank debt. In contrast, it is more likely for a project with a higher value of r_H to be financed with equity. In other words, when the main bank cannot control the firm, the bank is more likely to end up financing projects with higher downside risk. And equity investors are more likely to be called for to finance projects with better upward potential. The intuition behind this financing decision rule is straightforward. Since the bank extracts rent in the good state, the holdup costs imposed by the bank will be higher if the firm uses bank debt rather than equity to finance projects with better upward potential. The asymmetric information costs of equity are determined by the required share, β, which is negatively related to $E[q]$. Note that the asymmetric information costs of equity here are fundamentally different from the classic adverse selection costs, because in our setting there is no asymmetric information about assets in place.[7]

[7] Myers and Maljuf (1984) point out that the asymmetric information about growth alone never deters new equity issues. In a generalized Myers and Majluf framework, Wu and Wang (2004) show that the classic adverse selection discount at the announcement of new equity issues does not come from asymmetric information about investment opportunities. This discount can even be reversed for firms with asymmetric information arising mainly from growth instead of assets-in-place (see also Ambarish, John and Williams, 1987; Cooney and Kalay, 1993).

A static analysis with various parameter values shows some interesting results. In Figure 4, we also plot two more indifference curves where we only reset the parameter value for q_l. The curve with q_l=0.3 is the one with solid squares, and the curve with q_l=0.5 is the one with hollow squares.[8] q_l is the most conservative guess by the market about q, reflecting the market confidence about business prospects (besides the managerial skills). Recall that E[q] increases with q_l according to equations (39) and (40). This means that the firm's expected cost of new equity decreases with the market confidence. As shown in Figure 4, the higher the confidence is, the lower the indifference curve is, and hence the more likely it is for projects to be financed by equity. For example, with lower confidence, say, q_l=0.3, the debt financing area spreads over regions I+II+III and the equity financing area covers only region IV. But with higher confidence, say, q_l=0.5, the debt financing area shrinks to region I and the equity financing area expands to regions II+III+IV.

During the 1980s, and in particular the second half of that decade, Japan witnessed an unprecedented equity market boom, reflecting the high confidence of equity investors. It has been observed that during that time, corporate Japan changed drastically from debt financing to equity financing (Campbell and Hamao, 1995; Wu, Sercu and Chan, 2000). In the very period when the main banks' ability to control finance and governance were waning due to deregulation, market conditions gave rise to lower information costs for new equity and relatively higher holdup costs for bank financing. During the 1980s market boom, it was natural that projects were expected to have very good upward potential.

Bank financing lost its traditional appeal because of its rent extraction costs on firms. Thus, the financing decision rule is related to the extent of the main banks' holdup behaviour. In Figure 5, given q_l=0.4, we plot two more indifference curves where we only reset the parameter value for proportional rent extraction, m. The curve with m=0.15 is the one with solid squares, and the curve with m=0.3 is the one with hollow squares. The value of m measures the aggressiveness of the main bank's rent extraction.

[8] Detailed data for plots are reported in Appendix C.

As shown in Figure 5, the more aggressive the bank's rent extraction is, the lower the indifference curve is, and hence the more likely it is for projects to be financed by equity. Worse, the main bank's rent extraction not only discourages bank financing, but also leaves the main bank only financing those projects that have higher downside risk. If a severe adverse systemic shock occurs, the main bank is likely to be overwhelmed with bad debts.

3. Discussion

The predictions of the model developed above help explain many questions that remain unresolved in the existing literature. For example, why did the main bank system work well in the period before the financial deregulation, when the main banks were at their most powerful? If the main bank system helped Japan's economy to grow during the postwar period, what was the rationale behind the financial deregulation that opened up the capital markets and eventually undercut the main bank system? Did the main banks benefit from the opening up of the capital markets, or were they only hurt by it? Why did the financial deregulation eventually hurt the banking system even though the reform was well intentioned? We can use the insights produced by the model presented in the previous section to address these issues.

One of the main features of our model is the rent extraction by the main banks. This rent extraction can cause underinvestment if the firm makes the decisions on behalf of its shareholders, as suggested by Rajan (1992). This underinvestment problem, however, disappears if the main bank controls the firm's decisions. Thus, a strong main bank system can mitigate the investment inefficiencies due to two problems. The first is the well understood problem of asymmetric information and agency conflicts as suggested by Powers (1990) and Berglof and Perotti (1994). The second is the holdup induced underinvestment problem mentioned above.

The main bank's holdup behavior, however, can lead to overinvestment when the main bank has control over the firm (Wu and Xu, 2004). Financing with a mix of debt and new equity tends to aggravate main bank controlled overinvestment. With main bank controlled financing and investment, new equity only plays a risk-sharing role in projects with high downside risk that is too big for the bank to bear alone.

While the new equity is fairly priced, the bank controlled financing and investment hurts the existing shareholders because the firm undertakes some otherwise unacceptable projects. This suggests that, as long as the main banks retained control, the opening up of the capital markets was to the benefit of the main banks.

The main bank controlled overinvestment becomes contained if the bank is capital constrained, since the cutoff level to accept new projects will be raised accordingly. New equity does not relieve the capital shortage because equity only helps to share the downside risk. Yet it is in the bank's own interest for the firm to invest in the most profitable projects (or projects with the best upward potentials). The bank's non-interest payoff comes from its insider equity holdings and the extracted rent, both depending on the upward potential of new projects. This explains why bank controlled overinvestment was not a main concern until the banks had accumulated sufficient capital. This occurred in the late 1970s, when Japan started to become one of the richest economies in the world. In view of the benefits of the main bank system when capital is not abundant, it becomes understandable why Japanese corporations were able to enjoy such well-respected rapid growth, especially before the financial deregulation when the main banks were at their most powerful.

After Japan accumulated a glut of bank capital, however, the main bank controlled overinvestment posed a problem to the system. The financial deregulation that undercut the main bank system was justified. But the effect of the shift of control rights back to the firm was profound. If the firm makes the decisions on behalf of its existing shareholders, it is more likely to seek new equity investors rather than bank financing for projects with better upward potential. This is because the main bank would extract more proportional rent if the project has a positive outcome. As a result, while the main bank's payoff remains ex-ante optimal, the main bank is more likely to end up funding projects with relatively higher downside risk. This explains why bank assets become highly sensitive to adverse shocks, foreshadowing the troubles of the Japanese banking system in the 1990s and beyond. But during the market boom that accompanied the financial reforms in the 1980s, who could have anticipated the unprecedented adverse shocks of the 1990s?

Japan's financial deregulation was launched in the mid 1970s, but the capital markets only opened up in the early 1980s—perhaps reflecting the reluctance and resistance of main banks to give up control over business firms. A significant increase in corporate equity financing occurred in the mid 1980s (Campbell and Hamao, 1995). This means that some funds, instead of becoming savings, were diverted into the stock market. Wu, Sercu and Yao (2003) also found that many firms with higher growth potential tended to use more public debt rather than bank borrowings. Competition from alterative funding sources weakened the main banks' position. Moreover, the late 1970s regulatory decision, to lower the cap on a bank' equity holdings in a firm from 10 percent to 5 percent, was expected to take effect in 1987. These changes affected the main bank system in a profound way.

As we have shown so far, if the firm has access to both bank borrowings and new equity, bank financing (because of rent extraction) is chosen mainly for projects with higher downside risk. This causes the main bank's rent extraction policy to backfire. The glut of bank capital in the 1980s made the main banks' lending policy more aggressive. The main banks, which used to finance mainly *keiretsu* firms, were willing to finance new, mostly less creditworthy firms, during the 1980s boom. These risky firms, without the legacy of a main bank relationship, were more likely to make decisions largely free of the main bank's influence. Additionally, the main bank's governance capability was stretched thin during the boom in the 1980s; the main bank had not come to realize that more stringent risk management was especially required in that situation.

As our model predicts, firms with projects that have better upward potential were likely to go for new equity, and those with projects that have higher downside risk were likely to seek bank financing. Worse, this risk bias against the main bank became even stronger during an equity market boom. Unfortunately, large adverse shocks occurred in the early 1990s. Taken together, this explains why Japanese main banks piled up such a lot of bad debt in the 1990s. This also provides an explanation for Kang and Stulz's (2000) finding that firms with more bank borrowings in the late 1980s had more equity losses during the stock market slump in the early 1990s. According to our model's prediction, more bank borrowings during this period simply proxy for higher real risk, consistent with the claim by Kang and Stulz (2000) that their finding is beyond a leverage effect.

The legacy of the main bank relationship, however, was not totally lost during the deregulation process. To some extent the main bank's influence remains for *keiretsu* firms (historically controlled by the main banks). But the legacy has largely become a burden to those firms. Morck, Nakamura and Shivdasani (2000) found that main banks' equity holdings have a significantly negative effect on firm value, consistent with Morck and Nakamura (1999) who argue that bank oversight is worse than shareholder oversight in corporate governance. Wu and Xu (2004) found that the value information of investment and financing decisions during the 1980s are significantly different between *keiretsu* and non-*keiretsu* firms, reflecting an adverse *keiretsu* effect regarding investment and bank financing. In effect, the main bank controlled overinvestment (with low average returns on investment) of *keiretsu* firms is widely documented for the deregulation period (Nakatani, 1984; Weinstein and Yafeh, 1998; Wu, Sercu and Chen, 2000). On the other hand, the financial deregulation has fundamentally changed Japanese corporate finance and governance. Wu and Xu (2004) found that the value information of Japanese corporate finance in the early 1990s supports a market-oriented market contracting environment.[9] Taken together, this explains why in the 1990s, the *keiretsu* firms, after an extended period of overinvestment and main bank relationships being weakened as a result of the deregulation, cannot be good candidates for rescuing their bad debt ridden main banks. It also explains why Japan's banking system has suffered for so long.

[9] For example, Dewenter and Warther (1998) find that the stock prices do not respond to the dividend policy of *keiretsu* firms in the 1980s. Their interpretation is that the *keiretsu* firm-bank relationship mitigates the well understood market imperfections which would occur in a market-oriented economy. As a result, the *keiretsu* dividend policy does not need to cater to the capital markets (see also Kato, Lowenstein and Tsay, 1997). Wu and Xu (2004) confirm the findings by Dewenter and Warther (1998) but find that the value information of the dividend policy becomes significant in the early 1990s, indicating the fundamental shift of the Japanese corporate finance toward market-oriented practices.

4. Conclusion

In this paper, we have presented a model that explains and predicts corporate decisions about investment and financing under main bank rent extraction. We analyzed the model under various scenarios to capture the evolution of Japan's bank-centered corporate finance and governance in recent decades. By focusing on corporate investment efficiency, the model's predictions help us understand why the main bank system was beneficial in the postwar period, but became harmful afterwards. The model is also able to address the issue how the financial deregulation in the 1980s affected the corporations and the main bank system in Japan. Our main results can be summarized as follows.

1. With only bank financing available, a firm that maximizes shareholder value may underinvest because of main bank rent extraction. Rent extraction lowers the net payoff for shareholders and makes less profitable but otherwise acceptable projects unattractive. This is consistent with the bank holdup literature. However, if the main bank is able to control the firm's investment decisions, the types of investment inefficiency will be reversed: Main bank control can mitigate underinvestment but introduce the possibility of overinvestment. The overinvestment problem will become more severe if the bank's rent extraction becomes more aggressive, or if the bank's equity holdings in the firm becomes smaller, or both.
2. If a mix of bank debt and new equity is allowed, and the main bank maintains control by keeping a stable share of firm equity holding, the bank controlled firm will use only bank debt to finance projects with better upward potential and limited downside risk. This enables the main bank to extract proportionally more rent with lower risk. For an acceptable project with considerable downside risk, the bank will prefer the firm to use a mix of debt and new equity to finance the project. The new equity plays a risk-sharing role for the project's downside risk, as the risk is too big for the main bank to bear alone.
3. Risk sharing by the new equity worsens overinvestment, to the detriment of only the existing shareholders. The bank controlled firm will undertake a negative NPV project affected by marginally more downside risk, because the fairly-priced new equity will share this risk. In other words, as long

as the main bank retains control, the opening up of equity markets works in favour of the main bank and tends to aggravate overinvestment.

4. The main bank controlled overinvestment, however, is contained by the shortage of bank capital. A shortage of bank capital raises the cutoff level for acceptable projects, and mitigates overinvestment. The availability of new equity to the firm does not help relieve the capital shortage, because the main bank directs new equity only for downside risk sharing. Conversely, when the main bank has accumulated an abundance of capital, the main bank will pressure its client firms to overinvest. This explains why the costs of the main bank system were contained during Japan's economic takeoff in the postwar period, and why it loomed large when bank savings accumulated and Japan started to become one of the richest countries in the world.
5. When the main bank loses control over the firm, and when the firm is free to choose between bank debt and new equity, the bank's holdup behaviour backfires, even though the bank's policy is ex-ante rational. The firm, acting on behalf of its existing shareholders, is more likely to seek bank financing for projects with higher downside risk, and to seek new equity investors for projects with better upward potential. As the main bank extracts rent when the project has a positive outcome, the bank holdup costs will be higher for the firm, if the firm uses bank debt instead of equity to finance projects with better upward potential. As the Japanese financial deregulation significantly weakened the main banks' control over firms, the financial reform caused the ex-ante rational main banks to accumulate higher downside risk.
6. If equity investors' confidence about the quality of projects improves, the firm's expected asymmetric information costs of new equity decrease (a situation similar to that in late 1980s Japan). Thus, the increase in the market confidence (let alone the main bank's rent extraction may also become more aggressive as the last effort to holdup the client firm) makes it even more likely that the holdup costs of bank financing are higher than the asymmetric information costs of equity for financing projects with better upward potentials. As a result, with firms acting on behalf of the shareholders, main banks will end up mainly financing projects with higher downside risk, and this bias against main banks will

become even stronger during an equity market boom. If an adverse systemic shock occurs, main banks are likely to become overburdened with bad debts. This provides an explanation for why the main banks were almost impervious to the oil shocks in the 1970s, but became much more vulnerable to shocks in the early 1990s.

In conclusion, our model helps us understand the reasons behind the rise and decline of the Japanese main bank system in the second half of the 20th century. The evolution in firm and main bank behavior predicted by our model coincides well with the recent history of Japan's main bank system. When market imperfections cause serious problems, regulatory reforms are often called for. But an important side effect of these necessary reforms can be the transformation of current agency problems into new kinds of problems. As an involuntary shift of control rights is likely to sow the seeds for future trouble, Japan's financial deregulation (which can be viewed as a process for redefining agency conflicts) should have been accompanied by more stringent risk management. Using the Japanese experience, our analysis provides useful object lessons for financial reformers everywhere.

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Figure 1: The First Best Investment Policy and Other Investment Policies in Scenario I

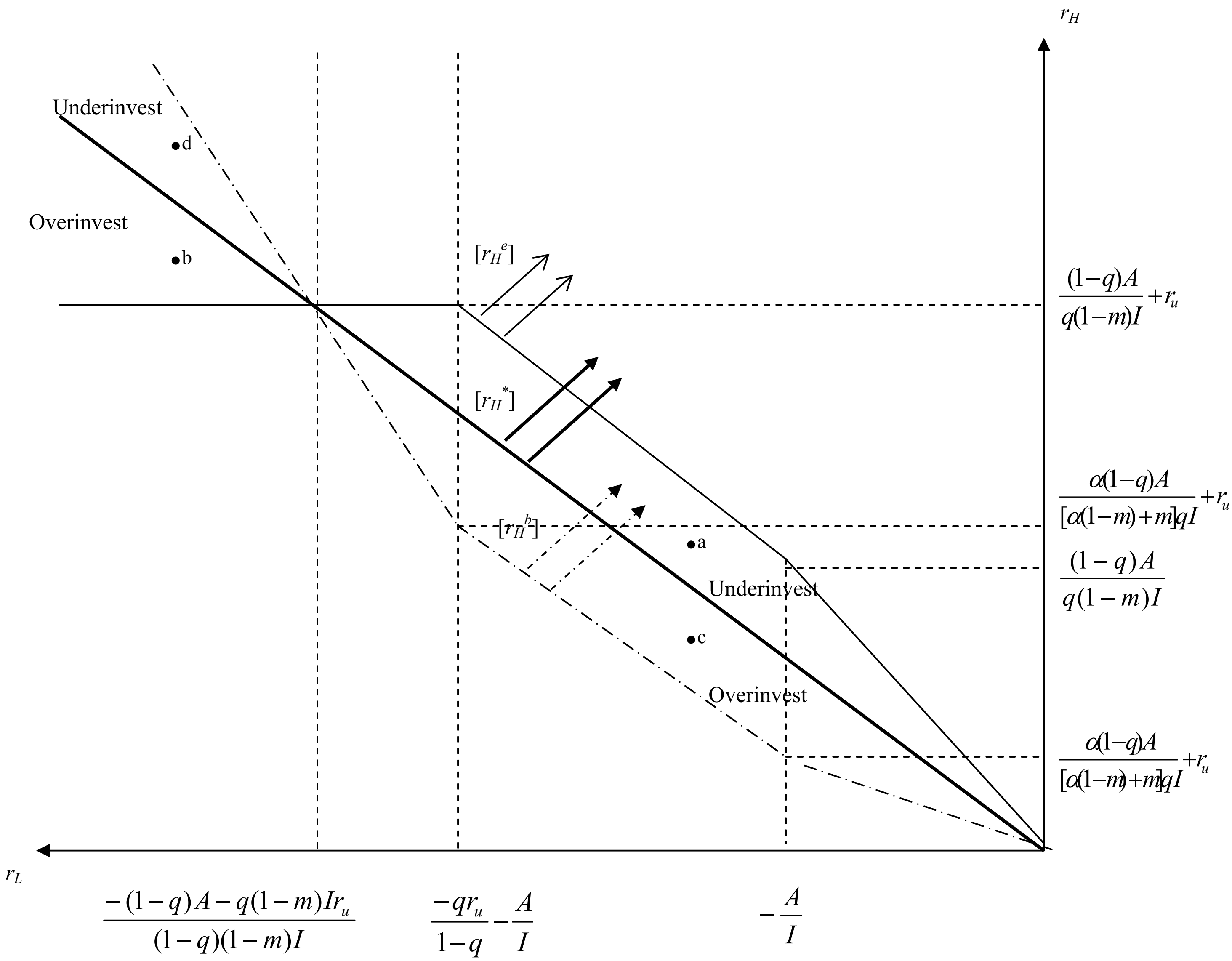


Figure 2 Main Bank Controlled Investment Policies in Scenario II

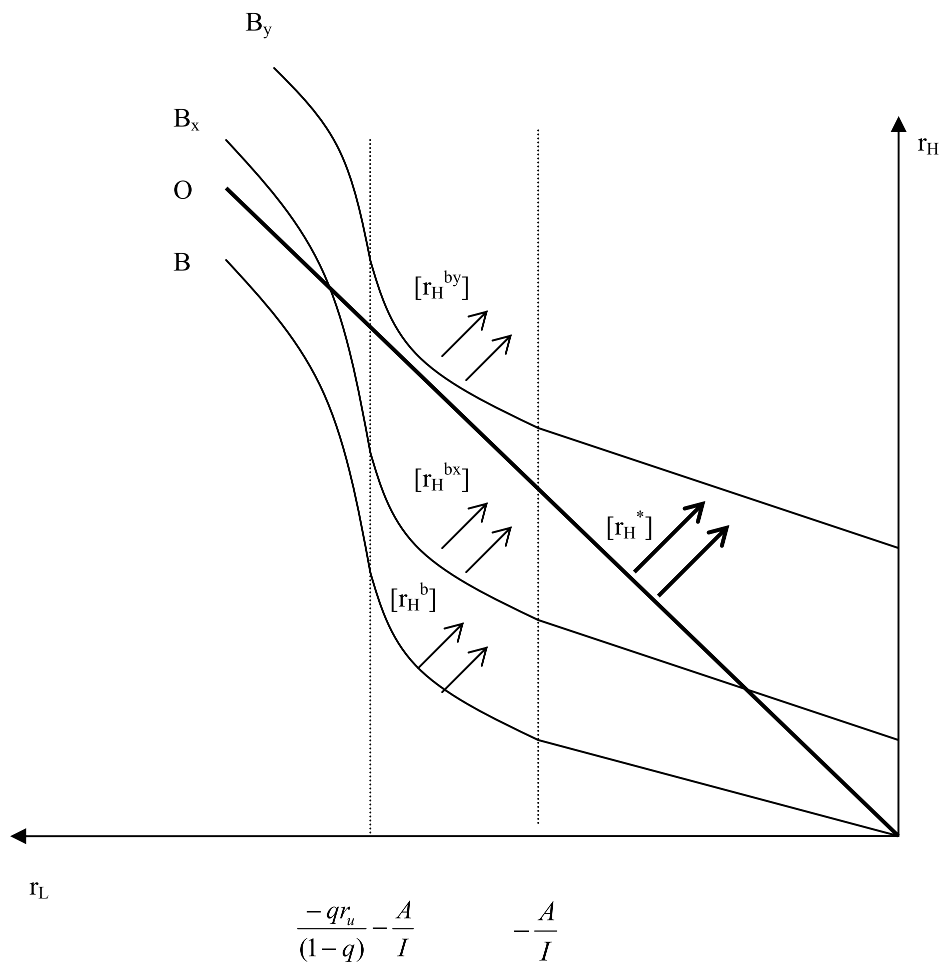
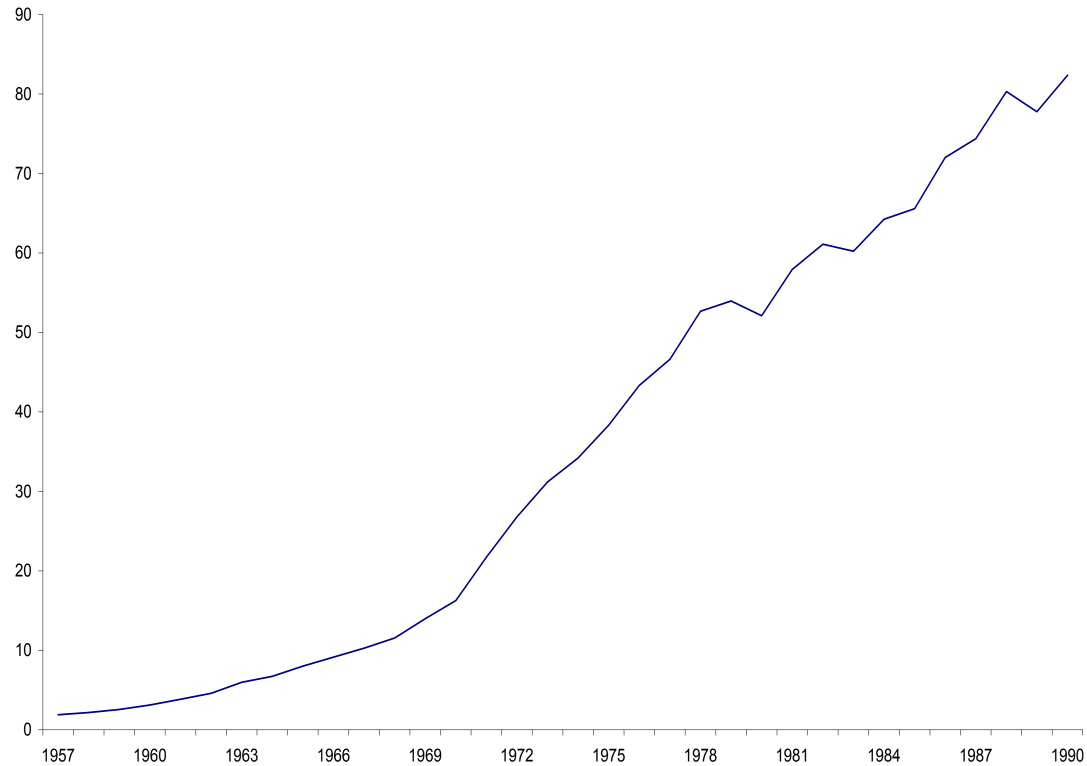


Figure 3 Deposits in Japanese Banking Institutions (Trillion Yen)



Source: Datastream

Figure 4 The Firm's Financing Decisions with Various Inputs of q_l

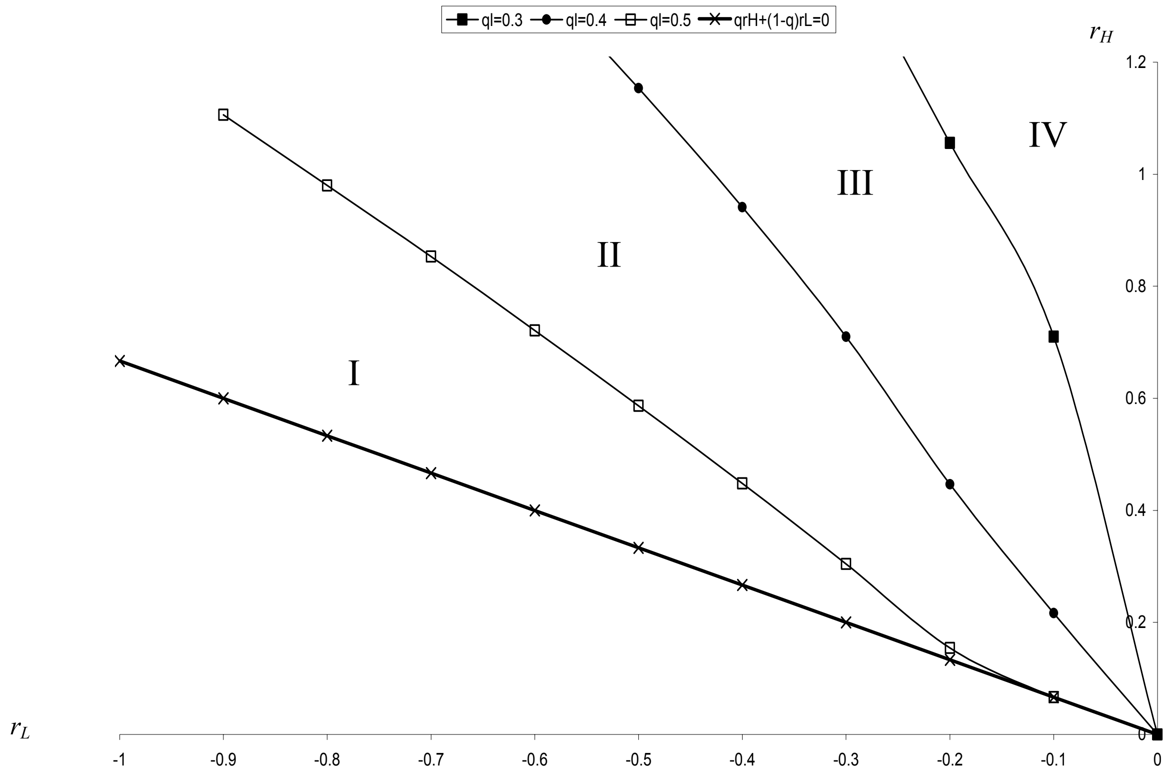
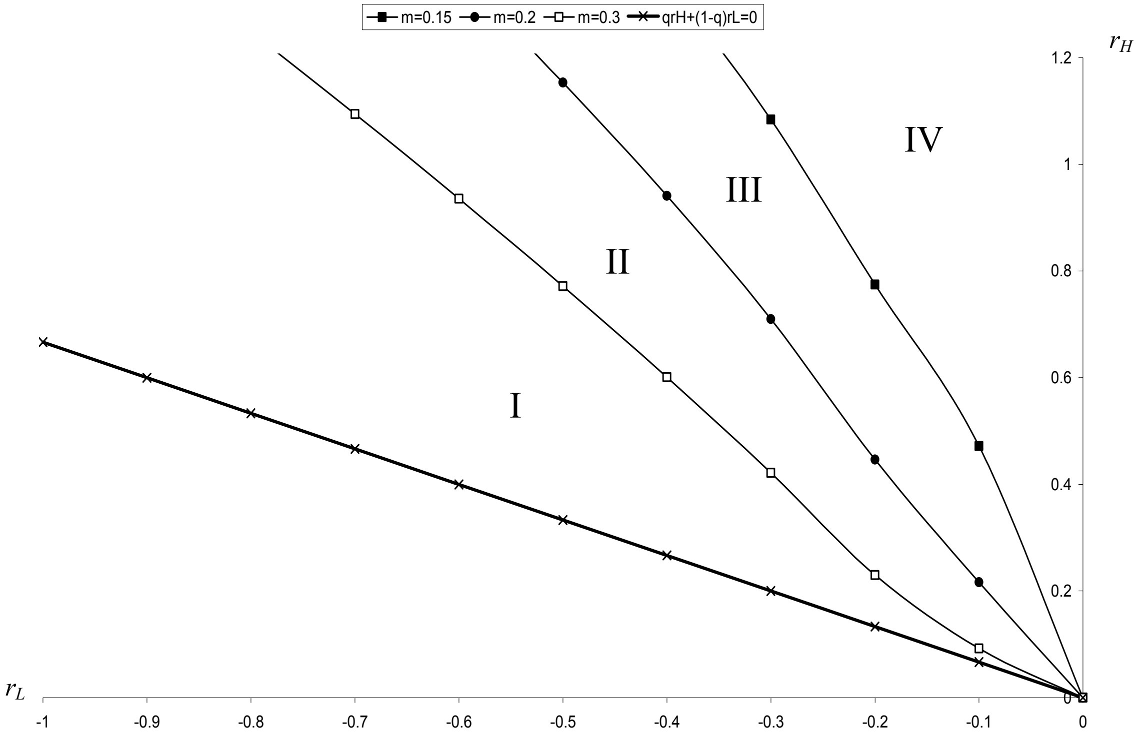


Figure 5 The Firm's Financing Decisions with Various Inputs of *m*



Appendix A: Proofs for Propositions

A.1 Proof for proposition 1

If $r_L \geq -A/I$, according to (2) and (3), we have

$$\begin{aligned} NPV_e &= q[A+(1-m)I(r_H - r)] + (1-q)\{A+I(r_L - r)\}^+ - A \\ &= q[A+(1-m)Ir_H] + (1-q)(A+Ir_L) - A \\ &= q(1-m)Ir_H + (1-q)Ir_L. \end{aligned} \tag{41}$$

$NPV_e \geq 0$ only if $r_H \geq \dfrac{-(1-q)r_L}{q(1-m)}$. Thus, $r_H{}^e = \dfrac{-(1-q)r_L}{q(1-m)}$, i.e., (6).

If $\dfrac{-qr_u}{1-q} - \dfrac{A}{I} \leq r_L < -A/I$, according to (2) and (4), we have

$$\begin{aligned} NPV_e &= q[A+(1-m)I(r_H - r)] + (1-q)\{A+I(r_L - r)\}^+ - A \\ &= q[A+(1-m)I[r_H + \frac{(1-q)(A+Ir_L)}{qI}]] - A \\ &= q(1-m)Ir_H + (1-q)[(1-m)(A+Ir_L) - A]. \end{aligned} \tag{42}$$

$NPV_e \geq 0$ only if $r_H \geq \dfrac{(1-q)mA}{q(1-m)I} - \dfrac{(1-q)r_L}{q}$. Thus, $r_H{}^e = \dfrac{(1-q)mA}{q(1-m)I} - \dfrac{(1-q)r_L}{q}$, i.e., (7).

If $-1 < r_L < \dfrac{-qr_u}{1-q} - \dfrac{A}{I}$, according to (2) and (5), we have

$$\begin{aligned} NPV_e &= q[A+(1-m)I(r_H - r)] + (1-q)\{A+I(r_L - r)\}^+ - A \\ &= q[A+(1-m)I[r_H - r_u]] - A \end{aligned} \tag{43}$$

$NPV_e \geq 0$ only if $r_H \geq \dfrac{(1-q)A}{q(1-m)I} + r_u$. Thus, $r_H{}^e = \dfrac{(1-q)A}{q(1-m)I} + r_u$, i.e., (8). ■

A.2 Proof for Proposition 2

If $r_L \geq -A/I$, according to (3) and (9), we have

$$
\begin{aligned}
NPV_b &= q[\alpha[A+(1-m)I(r_H-r)]+I(1+r)+mI(r_H-r)]+ \\
&\quad (1-q)[\alpha\{A+I(r_L-r)\}^+ + Min\{I(1+r), A+I(1+r_L)\}]-(\alpha A+I) \\
&= q[\alpha[A+(1-m)Ir_H]+I+mIr_H]+(1-q)[\alpha(A+Ir_L)+I]-(\alpha A+I) \\
&= qI[\alpha(1-m)+m]r_H+(1-q)I\alpha r_L
\end{aligned} \tag{44}
$$

$NPV_b \geq 0$ only if $r_H \geq -\dfrac{(1-q)r_L}{q[1+m(\dfrac{1-\alpha}{\alpha})]}$. Thus $r_H{}^b = -\dfrac{(1-q)r_L}{q[1+m(\dfrac{1-\alpha}{\alpha})]}$, i.e., (10).

If $\dfrac{-qr_u}{1-q}-\dfrac{A}{I} \leq r_L < -A/I$, according to (4) and (9), we have

$$
\begin{aligned}
NPV_b &= q[\alpha[A+(1-m)I(r_H-r)]+I(1+r)+mI(r_H-r)] \\
&\quad +(1-q)[\alpha\{A+I(r_L-r)\}^+ + Min\{I(1+r), A+I(1+r_L)\}]-(\alpha A+I) \\
&= q[\alpha[A+(1-m)I(r_H+\frac{(1-q)(A+Ir_L)}{qI})]+I(1-\frac{(1-q)(A+Ir_L)}{qI}) \\
&\quad +mI(r_H+\frac{(1-q)(A+Ir_L)}{qI})]+(1-q)(A+Ir_L+I)-(\alpha A+I).
\end{aligned} \tag{45}
$$

$NPV_b \geq 0$ only if $r_H \geq -\dfrac{(1-\alpha)(1-q)mA}{(\alpha-\alpha m+m)qI}-\dfrac{(1-q)r_L}{q}$. Thus, $r_H{}^b = -\dfrac{(1-\alpha)(1-q)mA}{[\alpha(1-m)+m]qI}-\dfrac{(1-q)r_L}{q}$,

i.e., (11).

If $-1 < r_L < \dfrac{-qr_u}{1-q}-\dfrac{A}{I}$, according to (5) and (9),

$$
\begin{aligned}
NPV_b &= q[\alpha[A+(1-m)I(r_H-r)]+I(1+r)+mI(r_H-r)] \\
&\quad +(1-q)[\alpha\{A+I(r_L-r)\}^+ + Min\{I(1+r), A+I(1+r_L)\}]-(\alpha A+I) \\
&= q[\alpha[A+(1-m)I(r_H-r_u)]+I(1+r_u)+mI(r_H-r_u)] \\
&\quad +(1-q)(A+Ir_L+I)-(\alpha A+I).
\end{aligned} \tag{46}
$$

$NPV_b \geq 0$ only if $r_H \geq -\dfrac{(1-\alpha)(1-q)A+(1-m)(1-\alpha)qIr_u+(1-q)Ir_L}{(\alpha-\alpha m+m)qI}$. Thus,

$r_H{}^b = -\dfrac{(1-\alpha)(1-q)A+(1-m)(1-\alpha)qIr_u+(1-q)Ir_L}{[\alpha(1-m)+m]qI}$, i.e., (12). ■

A.3 Proof for Proposition 3

If $r_L \geq -\frac{A}{I}$, according to (13) and (16), we have

$$\begin{aligned}NPV_b &= q[\alpha(A+I(1+r_H)-D(1+r)-mD(r_H-r))+D(1+r)+mD(r_H-r)] \\ &\quad +(1-q)[\alpha\{A+I(1+r_L)-D(1+r)\}^{+}+Min\{D(1+r),A+I(1+r_L)\}]-(\alpha A+\alpha e+D) \\ &= q[\alpha(A+I(1+r_H)-D-mDr_H)+D+mDr_H] \\ &\quad +(1-q)[\alpha[A+I(1+r_L)-D]+D]-[\alpha A+\alpha I+(1-\alpha)D],\end{aligned} \tag{47}$$

and

$$\begin{aligned}\frac{dNPV_b}{dD} &= -q\alpha(1+mr_H)+q+qmr_H-(1-q)\alpha+(1-q)-(1-\alpha) \\ &= qmr_H(1-\alpha)\geq 0.\end{aligned} \tag{48}$$

Since NPV_b is an increasing function of D which is no larger than I, $D^*=I$.

Now the investment decision rule is the same as in Scenario I: $r_H{}^b = -\dfrac{(1-q)r_L}{q[1+m(\frac{1-\alpha}{\alpha})]}$, i.e., (22).

If $\dfrac{(1-q)D-qDr_u-(1-q)I}{(1-q)I}-\dfrac{A}{I}\leq r_L<\dfrac{D-A-I}{I}$, according to (13) and (17),

$$\begin{aligned}NPV_b &= q\{\alpha(A+I(1+r_H)-D(1+\frac{(1-q)D-(1-q)[A+I(1+r_L)]}{qD}) \\ &\quad -mD(r_H-\frac{(1-q)D-(1-q)[A+I(1+r_L)]}{qD}))+D(1+\frac{(1-q)D-(1-q)[A+I(1+r_L)]}{qD}) \\ &\quad +mD(r_H-\frac{(1-q)D-(1-q)[A+I(1+r_L)]}{qD})\} \\ &\quad +(1-q)[A+I(1+r_L)]-[\alpha A+\alpha I+(1-\alpha)D],\end{aligned} \tag{49}$$

and

$$\frac{dNPV_b}{dD} = qm(1-\alpha)(r_H-\frac{1-q}{q}). \tag{50}$$

There are two cases: $r_H \geq \frac{1-q}{q}$ and $r_H < \frac{1-q}{q}$.

If $r_H \geq \frac{1-q}{q}$, NPV_b is an increasing function in *D*, and hence $D^*=I$.

In this case, according to (11) in Scenario I, $r_H \geq -\frac{(1-\alpha)(1-q)mA}{[\alpha(1-m)+m]qI} - \frac{(1-q)r_L}{q}$.

Since $-\frac{(1-\alpha)(1-q)mA}{[\alpha(1-m)+m]qI} - \frac{(1-q)r_L}{q} < \frac{(1-q)}{q}$, $r_H{}^b = \frac{1-q}{q}$.

But if $r_H < \frac{1-q}{q}$, NPV_b is a decreasing function in *D*. Since $r_L \leq \frac{D-A-I}{I}$, *D* is no smaller than

$Ir_L + I + A$, and hence $D^* = A + I(1+r_L)$. Thus, for $NPV_b \geq 0$,

$r_H{}^b = -\frac{\alpha(1-q)Ir_L}{\alpha qI + (1-\alpha)qm[A + I(1+r_L)]}$, i.e., (23).

Taken together the two cases: $r_H{}^b = \frac{1-q}{q}$ if $r_H \geq \frac{1-q}{q}$, and $r_H{}^b = -\frac{\alpha(1-q)Ir_L}{\alpha qI + (1-\alpha)qm[A + I(1+r_L)]}$ if

$r_H < \frac{1-q}{q}$, the investment policy should be defined in (23).

If $r_L < \frac{(1-q)D - qDr_u - (1-q)I}{(1-q)I} - \frac{A}{I}$, according to (13) and (18),

$$\begin{aligned} NPV_b = {} & q[\alpha(A+I(1+r_H)) - D(1+r_u) - mD(r_H - r_u)) + D(1+r) + mD(r_H - r_u)] \\ & + (1-q)[A + I(1+r_L)] - [\alpha A + \alpha I + (1-\alpha)D], \end{aligned} \tag{51}$$

and

$$\frac{dNPV_b}{dD} = (1-\alpha)(q + qr_u + qmr_H - qmr_u - 1). \tag{52}$$

There are two cases: $r_H \geq \frac{1-q-qr_u+qmr_u}{qm}$ and $r_H < \frac{1-q-qr_u+qmr_u}{qm}$.

If $r_H \geq \frac{1-q-qr_u+qmr_u}{qm}$, NPV_b is an increasing function in *D*, and hence $D^*=I$.

In this case, according to (12) in Scenario I, $r_H \geq -\frac{(1-\alpha)(1-q)A+(1-m)(1-\alpha)qIr_u+(1-q)Ir_L}{[\alpha(1-m)+m]qI}$.

It can be proven that $-\frac{(1-\alpha)(1-q)A+(1-m)(1-\alpha)qIr_u+(1-q)Ir_L}{[\alpha(1-m)+m]qI} < \frac{1-q-qr_u+qmr_u}{qm}$ when α is small.

As a result, $r_H{}^b = \frac{1-q-qr_u+qmr_u}{qm}$.

But if $r_H < \frac{1-q-qr_u+qmr_u}{qm}$, NPV_b is a decreasing function in D.

Since $r_L \leq \frac{(1-q)D-qDr_u-(1-q)I}{(1-q)I} - \frac{A}{I}$, D is no smaller than $\frac{Ir_L+I+A}{1+r_u}$, and hence

$D^* = \frac{Ir_L+I+A}{1+r_u}$.

Thus, for $NPV_b \geq 0$, $r_H{}^b = -\frac{(1-q)\alpha I(1+r_u)r_L+(1-\alpha)(Ir_L+I+A)r_u(1-qm)}{\alpha qI(1+r_u)+(1-\alpha)qm((Ir_L+I+A)}$, i.e., (24).

Taken together the two cases: $r_H{}^b = \frac{1-q-qr_u+qmr_u}{qm}$ if $r_H \geq \frac{1-q-qr_u+qmr_u}{qm}$, and

$r_H{}^b = -\frac{(1-q)\alpha I(1+r_u)r_L+(1-\alpha)(Ir_L+I+A)r_u(1-qm)}{\alpha qI(1+r_u)+(1-\alpha)qm((Ir_L+I+A)}$ if $r_H < \frac{1-q-qr_u+qmr_u}{qm}$, the investment policy should be defined in (24). ■

A.4 Proof for Proposition 4

If the project is financed by bank debt, the holdup cost is $qmI(r_H-r)$.

If $r_L \geq -\frac{A}{I}$, $r=0$. Thus, $C_{Bank} = qmI(r_H - r) = qmIr_H$, i.e., (28).

If $r_L < -\frac{A}{I}$, $r = \frac{(1-q)I-(1-q)[A+I(1+r_L)]}{qI}$. Thus,

$$C_{Bank} = qmI(r_H - r) = qmI(r_H - \frac{(1-q)I - (1-q)[A + I(1+r_L)]}{qI})$$
$$= qmIr_H - (1-q)mI + (1-q)m(A + I + Ir_L)$$
$$= qmIr_H + (1-q)m(A + Ir_L),$$

i.e., (29).

If the project is financed by new equity, new investors require $\beta\{A + I[1 + qr_H + (1-q)r_L]\}$.

Thus, the cost of using new equity for the firm is $C_{Equity} = \beta\{A + I[1 + qr_H + (1-q)r_L]\} - I$, i.e., (30). ■

A.5 Proof for Proposition 5

If $r_L \geq -\frac{A}{I}$, given $\beta\{A + I + I[qr_H + (1-q)r_L]\} - I < mqIr_H$ and

$\beta = \frac{I}{A + I + I[E[q]r_H + (1-E[q])r_L]}$, we have

$$q < \frac{I - \beta A - \beta I - \beta I r_L}{\beta I r_H - \beta I r_L - mIr_H}$$
$$= \frac{I^2[E[q]r_H + (1-E[q])r_L - r_L]}{I^2[r_H - r_L - mr_H - mr_H(E[q]r_H + (1-E[q])r_L)] - mAIr_H}$$
$$= \frac{E[q]I(r_H - r_L)}{I(r_H - r_L) - m\{A + I + I[E[q]r_H + (1-E[q])r_L]\}r_H},$$

i.e., (34).

If $r_L < -\frac{A}{I}$, given $\beta\{A + I + I[qr_H + (1-q)r_L]\} - I < mqIr_H + m(1-q)(A + Ir_L)$ and

$\beta = \frac{I}{A + I + I[E[q]r_H + (1-E[q])r_L]}$, we have

$$
\begin{aligned}
q &< \frac{I + m(A + Ir_L) - \beta A - \beta I - \beta Ir_L}{\beta Ir_H - \beta Ir_L - mIr_H + m(A + Ir_L)} \\
&= \frac{I^2[E[q]r_H + (1 - E[q])r_L - r_L] + m(A + Ir_L)\{A + I + I[E[q]r_H + (1 - E[q])r_L]\}}{I^2[r_H - r_L - mr_H - mr_H(E[q]r_H + (1 - E[q])r_L)] - mAIr_H + m(A + Ir_L)\{A + I + I[E[q]r_H + (1 - E[q])r_L]\}} \\
&= \frac{E[q]I^2(r_H - r_L) + m(A + Ir_L)\{A + I + I[E[q]r_H + (1 - E[q])r_L]\}}{I^2(r_H - r_L) + m\{A + I + I[E[q]r_H + (1 - E[q])r_L]\}(A + Ir_L - Ir_H)},
\end{aligned}
$$

i.e., (35).

Given that q is uniformly distributed in [q_l, q_u], the outside equity investors' expected payoffs will be:

$$
\begin{aligned}
E &= \int_{q_l}^{q_u} \frac{1}{q_u - q_l} \beta\{A + I + I[qr_H + (1 - q)r_L]\}dq \\
&= \int_{q_l}^{q_u} \frac{1}{q_u - q_l} \{A + I + I[qr_H + (1 - q)r_L]\} \frac{I}{A + I + I[E[q]r_H + (1 - E[q])r_L]} dq.
\end{aligned}
$$

A fair market price under risk neutrality makes the investors' expected earnings exactly equal to their initial investment I. Thus, E=I. Solve it, we have $E[q] = \dfrac{q_l + q_u}{2}$, i.e. (36). ■

Appendix B: Numerical Examples

B.1 The investment policy that maximizes the firm's value

Suppose the value of a firm's initial assets in place is 4 million dollars at t=0. The firm's main bank owns *10%* of firm equity. So the main bank has an initial stake of *0.4* million dollars. At t=1, the firm has an investment opportunity that requires an investment of 25 million dollars. The returns on the investment for t=1 to 2 are [*0.14, –0.2*] in the good and bad states, respectively. The firm's manager knows that the probability for the project to reach the good state is 60%. Should she accept this project? To maximize the firm's total value, the manager should implement an investment policy that undertakes all positive NPV projects. Such a policy can be expressed as [r_H^*] where $r_H^* = -\frac{(1-q)r_L}{q} = -\frac{0.4*(-0.2)}{0.6} = 0.13$. In this sample, r_H for the new project is 0.14 which is higher than r_H^*. Thus, this project should be accepted.

B.2 The investment policies in Scenario I

The manager has to finance the project by borrowing 25 million dollars from the main bank. Otherwise, she has to skip the project. In addition to interest charges, the main bank can extract a proportional rent, *m*=20%, from the firm's payoff in the good stake. Suppose r_u is non-binding at the moment. Since $r_L = -0.2$ and $-A/I = -0.16$, $r_L < -A/I$. Thus, the bank will charge a market interest rate, $r = \frac{-(1-q)(A+Ir_L)}{qI} = \frac{-0.4*(4-25*0.2)}{0.6*25} = 2.67\%$. The manager, acting on behalf of the shareholders, will undertake the investment policy [r_H^e] where $r_H^e = \frac{(1-q)mA}{q(1-m)I} - \frac{(1-q)r_L}{q} = 0.145$.

Since r_H for the new project is 0.14, or $r_H^e > 0.14$, the manager has to forgo the investment.

If the main bank controls the firm and makes the decisions, the investment policy $[r_H^b]$ where r_H^b $= -\dfrac{(1-\alpha)(1-q)mA}{[\alpha(1-m)+m]qI} - \dfrac{(1-q)r_L}{q} = 0.113$ will be softer. This time $r_H^b < 0.14$ and the firm will undertake the investment.

Appendix C: Data for Plots in Figures 4 and 5

		r_L	0.0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9
m=0.2	q_L=0.3	r_H	0.000	0.710	1.056							
		$E[q]$	0.430	0.450	0.450							
	q_L=0.4	r_H	0.000	0.216	0.446	0.710	0.941	1.153				
		$E[q]$	0.573	0.500	0.500	0.500	0.500	0.500				
	q_L=0.5	r_H	0.000	0.067	0.155	0.305	0.448	0.587	0.721	0.853	0.980	1.106
		$E[q]$	0.716	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550
q_L=0.4	m=0.15	r_H	0.000	0.472	0.775	1.084						
		$E[q]$	0.507	0.352	0.500	0.500						
	m=0.2	r_H	0.000	0.216	0.446	0.710	0.941	1.153				
		$E[q]$	0.573	0.500	0.500	0.500	0.500	0.500				
	m=0.3	r_H	0.000	0.092	0.230	0.422	0.601	0.772	0.936	1.095		
		$E[q]$	0.858	0.500	0.500	0.500	0.500	0.500	0.500	0.500		