A Theory of Business Reorganization

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Abstract: One interesting organizational strategy in the marketplace is the reallocation of control rights in an organization's hierarchy. When facing certain kinds of internal or external challenges, organizations are sometimes observed to reallocate certain control rights horizontally or vertically. This paper develops a theory of vertical reallocation of control rights using the incomplete contract approach. One application of this theory is to Chinese banking reforms.

Keywords: Corporate Governance, Reallocation of Control Rights, Control of Risks and Incentives

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1. Introduction

In the marketplace, when facing certain challenges, firms may adjust their inside and outside contractual relationships, form alliances, participate in joint ventures, or engage in mergers and acquisitions, etc. However, one seldom studied organizational strategy is the reallocation of control rights inside a firm.

A vertical reallocation is of particular interest in organization theory. It relates to the topic of centralization vs decentralization of the government from a new perspective. Such an organizational strategy has been seen in many organizations. For example, monetary and trade policies in developed economies have recently tended to be moved to higher levels of government, while health and education policies have tended to be moved to lower levels. We wonder if the vertical reallocation of certain types of control rights can indeed be an effective solution to certain kinds of challenges.

A major recent move by Chinese banks is to reallocate some control rights upwards in their hierarchies. This organizational reaction by Chinese banks to recent challenges presents us with a unique case for study. This reallocation occurred amid a few special events, including the beginning of the banking market (a market condition), the growing problem of non-performing loans (an external factor), extensive banking fraud (an internal factor), and privatization (a government policy). Motivated by this observation, we develop a theory of the vertical reallocation of control rights using the incomplete contract approach. We use this theory to explain the Chinese banking reforms. It turns out that the recent reallocation of control rights by Chinese banks is indeed explicable by the recent challenges. In particular, we find that either the opening of the market opening or privatization is the most explicable reason for the upward reallocation of control rights, especially the right to control risk.

We follow the incomplete contract approach proposed by Grossman-Hart-Moore (Grossman–Hart 1986, Hart (1988), Hart–Moore 1990). Building upon Coase's (1960) idea of using an organizational approach to resolving conflicts of interest, this approach focuses on the allocation of control rights in business relationships. The standard contract theory (e.g., the principal-agent model) focuses on the allocation of income rights. Grossman-Hart-Moore argue that both the allocation of control rights and the allocation of income rights are important.[2] We use this approach to establish a theory of business reorganization in response to changes in the business environment. In reality, we often observe reorganization in a company. Such a reorganization is typically defined by a change in the allocation of control rights, which

[2] So far, Wang–Zhu (2005) is the only work in the literature that endogenously determines the relationship between the two types of allocation in a joint venture. Only by this, can they explain many popular contractual relationships in reality, such as the 50-50 equity split, the 49-51 equity split, and minority control.

may imply a corresponding change in income rights. We want to investigate whether or not allocation of income rights involves a contractual agreement on the sharing of revenue. Our focus is on the allocation of control rights.

This paper is organized as follows. Section 2 presents a two-state principal-agent model. There are two uncontractable control variables in our model, each representing a key aspect in an organization. We use the incomplete contract approach to determine the allocation of control rights over the two control variables between the higher manager and the lower manager. Section 3 analyzes the solution using some specific functional forms for the underlying functions. Section 4 discusses an application to Chinese banks. Section 5 concludes the paper with a few remarks. All the proofs and derivations are presented in the Appendix.

2. Model

Consider a situation in which a firm is deciding to reallocate some control rights from a lower manager to a higher manager, or vice versa. We use a principal-agent model, in which the higher manager is the principal (she) and the lower manager is the agent (he). Two factors are important in this model: the agent's effort input and the firm's control decision about risk. The question is who should have control rights over risk control.

Specifically, we use a variable $a \in \mathrm{R}_+$ to represent the effort spent on enhancing the output and a variable $b \in \mathrm{R}_+$ to represent the effort spent on controlling risk. Assume that both effort variables are non-contractable. The control of risks and incentives is represented respectively by the right to determine a and b. The question is who should have control over b or who should have the risk control right. The answer depends on the situation that the firm is in and the relative cost of controlling b.

Although our model is applicable to a typical organization, we will often refer to a bank to give our variables specific meanings. For a bank, in an uncertain environment, a bank manager's task can be divided into two sub-tasks: extending loans and controlling risks. In this case, variable $a \in \mathrm{R}_+$ represents the effort spent on extending loans and variable $b \in \mathrm{R}_+$ represents the effort spent on controlling risk. In particular, the value of variable b can be interpreted as the quality/ability of the manager to make loan decisions. A capable manager chooses the right projects to invest in, which implies a good balance of expected value and risk. Variable b can also be interpreted as the information that a manager tries to gather in a loan decision. If the manager spends more effort in gathering information, he/she tends to make the right choice, which means a higher expected return and/or lower risk. In reality, loan seeking and promotion are usually done at the lower level, while the task of risk control can be assigned to different levels of management along the bank's hierarchy. How much authority is allocated to a local manager depends on the circumstances. Hence, we assume that a is always controlled by the lower manager, while b can be controlled by either the higher manager or the lower manager.

Let $v(\cdot)$ be the principal's utility function and $u(\cdot)$ being the agent's utility function. Assume that $u(0) = v(0) = 0$. Let the agent's cost of supplying a be a, the agent's cost of supplying b be $c(b)$, and the principal's cost of supplying b be $C(b)$.

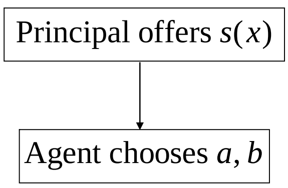
Instead of the complete-contract approach (the standard contract theory), our model is based on the incomplete-contract approach. This approach emphasizes the allocations of income rights and control rights. In addition to an output-sharing agreement based on the standard contract theory, this approach allows various mechanisms to deal with various problems such as information revelation, renegotiation, incentives, ex-post options, and holdups. In particular, this approach treats an hierarchy and an allocation of control rights as mechanisms adopted by economic agents to deal with various information and incentive problems.

A contract in our model consists of two parts: income rights and control rights. The income rights to a manager are defined by an output-sharing contract, which follows the standard agency theory, as defined in Mirrlees (1974, 1975, 1976) and Holmström (1979). The control rights define the manager's right in deciding the two control variables a and b. Issues about control rights follow the incomplete-contract approach, as defined by Coase (1960), Grossman–Hart (1986), Hart (1988) and Hart–Moore (1990). In this paper, the focus is on control rights. In fact, we will not discuss income rights at all, even though we do solve for an optimal output-sharing contract.

2.1. Lower Control

The Setup

We first consider the control structure in which the lower manager has the control rights over the risk control variable b, as shown in the following figure.



With a limited liability condition of the form $s(x) \geq 0$, an optimal contract must have $s(0) = 0$.[4] Then, the agent's payoff function is

$$U = p(b)u[s(x(a))] - a - c(b). \tag{1}$$

The principal's payoff function is

$$V = p(b)v\left[x(a) - s(x(a))\right]. \tag{2}$$

[4] The intuition is as follows: in a two-state situation, the principal's strategy should reward the agent properly in a good state (too good a reward can cause an over-investment) and to punish the agent as much as possible in a bad state. With the limited liability condition $s(0) \geq 0$, the principal can only impose $s(0) = 0$. Alternatively, if we have limited liability for the higher manager also, we need to impose $s(x) \leq x$. Then, the condition $0 \leq s(x) \leq x$ obviously implies that $s(0) = 0$.

The First-Best Problem under Lower Control

The first-best (FB) problem is

$$\max_{a,b,s(\cdot)} \; p(b)v\left[x(a)-s(x(a))\right]$$
$$\text{s.t.} \quad IR: \; p(b)u[s(x(a))] \geq a + c(b).$$

The individual rationality (IR) condition must be binding in this case. This means that the solution (a_l^{**}, b_l^{**}) is determined by

$$\max_{a,b} \; p(b)v\left[x(a) - u^{-1}\left(\frac{a+c(b)}{p(b)}\right)\right]. \tag{3}$$

An optimal contract can be a fixed contract, $s(x) = x_0$, satisfying the binding IR condition, where x_0 is a positive constant defined by

$$x_0 = u^{-1}\left[\frac{a_l^{**} + c(b_l^{**})}{p(b_l^{**})}\right].$$

The Second-Best Problem under Lower Control

When a and b are uncontractable, incentive conditions must be introduced. The incentive compatibility (IC) conditions are

$$IC_a: \; p(b)u'[s(x(a))]s'[x(a)]x'(a) = 1, \tag{4}$$
$$IC_b: \; p'(b)u[s(x(a))] = c'(b). \tag{5}$$

The IR condition is

$$IR: \; p(b)u[s(x(a))] \geq a + c(b). \tag{6}$$

Hence, the principal's second-best (SB) problem is

$$\begin{aligned} \max_{a,b,s(\cdot)} \quad & p(b)v\left[x(a)-s(x(a))\right] \\ \text{s.t.} \quad & IC_a: \; p(b)u'[s(x(a))]s'[x(a)]x'(a) = 1, \\ & IC_b: \; p'(b)u[s(x(a))] = c'(b), \\ & \qquad SOCs, \\ & IR: \; p(b)u[s(x(a))] \geq a + c(b). \end{aligned} \tag{7}$$

Where, since IC_a and IC_b are the first-order conditions (FOCs), we include the second-order conditions (SOCs) to ensure the validity of the first-order approach (FOA).[5] The IC_b and IR conditions imply that

[5] For discussions about the FOA, see Holmström (1979), Rogerson (1985) and Jewitt (1988).

$$\frac{p'(b)}{p(b)} \leq \frac{c'(b)}{a+c(b)}. \tag{8}$$

We can then replace the IR condition by (8). Further, we can solve the IC_b condition for $s[x(a)]$ and substitute it into the objective function. Hence, problem (7) can be rewritten as:

$$\begin{aligned} \max_{a,\, b,\, s(\cdot)} \quad & p(b)v\left[x(a) - u^{-1}\left(\frac{c'(b)}{p'(b)}\right)\right] \\ \text{s.t.} \quad & IC_a: \; p(b)u'[s(x(a))]s'[x(a)]x'(a) = 1, \\ & IC_b: \; p'(b)u[s(x(a))] = c'(b), \\ & \qquad SOCs, \\ & IR: \; \frac{p'(b)}{p(b)} \leq \frac{c'(b)}{a+c(b)}. \end{aligned}$$

This problem can be solved in two steps. First, the principal chooses (a_l^*, b_l^*) in the following problem:

$$\begin{aligned} \max_{a,\, b} \quad & p(b)v\left[x(a) - u^{-1}\left(\frac{c'(b)}{p'(b)}\right)\right] \\ \text{s.t.} \quad & \frac{p'(b)}{p(b)} \leq \frac{c'(b)}{a+c(b)}. \end{aligned} \tag{9}$$

Second, given (a,b), the principal designs a contract to satisfy the two IC conditions and the SOCs.

Given (a,b), we can easily define a contract $s(x)$ to satisfy the two IC conditions IC_a and IC_b. Such a contract is an optimal contract. For example, we can define a one-step contract of the form:

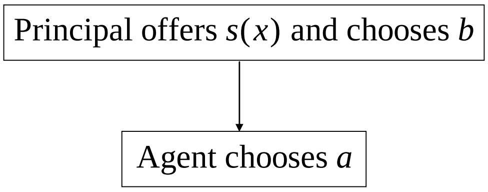
$$s(x) = \begin{cases} 0 & \text{if } \; x < x_0 \\ \rho(x - x_0) & \text{if } \; x \geq x_0, \end{cases} \tag{10}$$

and use the two IC conditions to determine the two positive constants x_0 and ρ. Furthermore, for such a simple contract, we can easily ensure the SOCs. See Appendix A.1 for a rigorous derivation. It turns out that, in the issue of control rights allocation, the focus will be on the determination of (a,b) in problem (9) and we have no need to discuss optimal contracts.

2.2. Higher Control

The Setup

We now consider the control structure in which the higher manager has the control rights over the risk variable b, as shown in the following figure:



In this case, the principal does not need to provide an incentive to the agent to choose a proper b; instead, she needs an incentive for herself to commit to a proper b. Then, the agent's payoff function is

$$U = p(b)u[s(x(a))] - a.$$

The principal's payoff function is

$$V = p(b)v\left[x(a) - s(x(a))\right] - C(b).$$

The First-Best Problem under Higher Control

The first-best problem is

$$\begin{aligned} \max_{a,\,b,\,s(\cdot)} \quad & p(b)v\left[x(a) - s(x(a))\right] - C(b) \\ \text{s.t.} \quad & IR: \;\; p(b)u[s(x(a))] \geq a. \end{aligned}$$

The IR condition must be binding, implying that the solution (a_h^{**}, b_h^{**}) is determined by

$$\max_{a,\,b} \;\; p(b)v\left[x(a) - u^{-1}\left(\frac{a}{p(b)}\right)\right] - C(b). \tag{11}$$

An optimal contract can be a fixed contract, $s(x) = x_0$, satisfying the binding IR condition, where x_0 is a positive constant. Such a contract exists.

The Second-Best Problem under Higher Control

When a and b are uncontractable, incentive conditions must be introduced. Assume that the two parties choose a and b separately in a Nash equilibrium. Then, the IC conditions are

$$IC_a: \;\; p(b)u'[s(x(a))]s'[x(a)]x'(a) = 1, \tag{12}$$

$$IC_b: \;\; p'(b)v[x(a) - s(x(a))] = C'(b). \tag{13}$$

The IR condition is

$$IR: \;\; p(b)u[s(x(a))] \geq a. \tag{14}$$

Hence, the principal's second-best problem is

$$
\begin{aligned}
\max_{a,b,s(\cdot)} \quad & p(b)v\left[x(a)-s(x(a))\right]-C(b) \\
\text{s.t.} \quad & IC_a: \; p(b)u'[s(x(a))]s'[x(a)]x'(a)=1, \\
& IC_b: \; p'(b)v\left[x(a)-s(x(a))\right]=C'(b), \\
& \qquad\; SOCs, \\
& IR: \quad p(b)u[s(x(a))]\geq a.
\end{aligned}
\tag{15}
$$

The IC_b and IR conditions imply that

$$
v\left[x(a)-u^{-1}\left(\frac{a}{p(b)}\right)\right]\leq \frac{C'(b)}{p'(b)}
\tag{16}
$$

We can use condition (16) to replace the IR condition. Further, with the IC_b condition, we eliminate the contract from the objective function. Hence, problem (15) can be rewritten as

$$
\begin{aligned}
\max_{a,b,s(\cdot)} \quad & p(b)\frac{C'(b)}{p'(b)}-C(b) \\
\text{s.t.} \quad & IC_a: \; p(b)u'[s(x(a))]s'[x(a)]x'(a)=1, \\
& IC_b: \; p'(b)v\left[x(a)-s(x(a))\right]=C'(b), \\
& \qquad\; SOCs, \\
& IR: \quad p(b)u\left(x(a)-v^{-1}\left[\frac{C'(b)}{p'(b)}\right]\right)\geq a.
\end{aligned}
\tag{17}
$$

This problem can be solved in two steps. First, the principal chooses (a_h^*, b_h^*) in the following problem:

$$
\begin{aligned}
\max_{a,b} \quad & p(b)\frac{C'(b)}{p'(b)}-C(b) \\
\text{s.t.} \quad & p(b)u\left(x(a)-v^{-1}\left[\frac{C'(b)}{p'(b)}\right]\right)\geq a.
\end{aligned}
\tag{18}
$$

Second, given (a,b), the principal designs a contract to satisfy the two IC conditions and the SOCs.

By the same discussion as in the last paragraph of the previous section, given (a,b), we can easily design a contract $s(x)$ to satisfy the IC conditions and their SOCs. Hence, an optimal contract exists. Again, the focus is on the determination of (a,b) in problem (18) and we have no need to discuss optimal contracts.

3. Analysis

Which control structure, the lower control structure in problem (7) or the higher control structure in problem (15), is more efficient when the organization faces certain challenges? We consider several types of challenges: (1) competition for market share, (2) bureaucracy, (3) weak internal control, and (4) large external uncertainty. To answer the question, we choose some simple functional forms for the underlying functions. This allows us to use parameters to represent some specific factors and discuss the impact of these factors.

3.1. The Solution

Let

$$x(a) = Aa^{\alpha},\ \ c(b) = Bb^{\beta},\ \ C(b) = \gamma Bb^{\beta},\ \ p(b) = \varepsilon b,\ \ u(x) = x,\ \ v(x) = \frac{1}{1-\theta} x^{1-\theta}, \qquad (19)$$

where $A, B, \alpha, \beta, \gamma, \theta$ and ε are constants. Here, $A > 0$ represents the bank's market share. $\alpha \in (0,\ 1)$ measures the productivity of effort a. $B > 0$ describes the difficulty in internal control; hence, 1/B represents the internal control ability. $\beta \geq 1$ is an inverse index of the productivity of the risk control effort b; hence, $1/\beta$ represents the effectiveness of the risk control. γ is a measure of the relative cost when a job is done by the higher manager rather than by the lower manager. Since the higher manager is far away from the client (in terms of hierarchical layers), she does the same job at a higher cost as the lower manager does. Hence, we assume that $\gamma \geq 1$. This higher cost can be due to the loss of information details along the hierarchy, so that a higher cost must be paid to obtain the same amount of information at a higher level of management. Hence, we can consider it as an index of bureaucratic inefficiency. $1-\varepsilon$, with $\varepsilon \in (0,\ 1)$, represents the negative influence of uncontrollable risks from external sources; hence, $1-\varepsilon$ measures the degree of external uncertainty. θ, with $\theta \in (0,\ 1)$, is the constant relative risk aversion of the principal.[6] Finally, by the SOCs for problems (9) and (18), we require that

$$\beta > \frac{1}{1-\alpha}; \qquad (20)$$

that is, the cost function is sufficiently convex.

Two remarks on the choices of the functional forms are necessary. First, the probability function $p(b)$ can be a concave function. This is actually unnecessary since the convexity of the cost function is equivalent to the concavity of $p(b)$. A more concave probability function is equivalent to a more convex cost function. To confirm this intuition, we have tried a concave probability function of the form $p(b) = \varepsilon b^{\rho}$ with $0 < \rho < 1$ in a numerical analysis; indeed, we find that such an extension does not change our conclusions.

Second, the risk-neutrality assumption for the lower manager may be justifiable in reality. In many organizations, the burden of risks tends to lie on the shoulders of top managers. They make business decisions and hence take responsibilities for the outcomes. Also, a top man-

[6] We restrict $\theta < 1$ to avoid a negative utility value. Also, we need $v(0) = 0$ for convenience.

ager’s human capital tends to be specific to the comp1( )5.4(te)-3.5(ndif)-3.,-3.53.1while -5.1(8e co)-7l4(te

Proposition 1 (Lower Control). *Under lower control, the first-best (FB) solution is*

$$a_l^{**} = (\alpha\varepsilon A)^{\frac{\beta}{(1-\alpha)\beta-1}}\left(\frac{1-\alpha\theta}{\theta+\beta-\theta\beta}\frac{1}{\alpha B}\right)^{\frac{1}{(1-\alpha)\beta-1}},$$

$$b_l^{**} = (\alpha\varepsilon A)^{\frac{1}{(1-\alpha)\beta-1}}\left(\frac{1-\alpha\theta}{\theta+\beta-\theta\beta}\frac{1}{\alpha B}\right)^{\frac{1-\alpha}{(1-\alpha)\beta-1}};$$

the second-best (SB) solution is

$$a_l^{*} = (\beta-1)^{\frac{\beta-1}{(1-\alpha)\beta-1}}\left(\frac{A\varepsilon}{\beta}\frac{1+\alpha(1-\theta)\beta}{\theta+\beta-\theta\beta}B^{-\frac{1}{\beta}}\right)^{\frac{\beta}{(1-\alpha)\beta-1}},$$

$$b_l^{*} = (\beta-1)^{\frac{\alpha}{(1-\alpha)\beta-1}}\left(\frac{A\varepsilon}{\beta}\frac{1+\alpha(1-\theta)\beta}{\theta+\beta-\theta\beta}B^{\alpha-1}\right)^{\frac{1}{(1-\alpha)\beta-1}}.$$

We always have $a_l^{*} > a_l^{**}$ *and* $b_l^{*} < b_l^{**}$, *and the SB solution is always inefficient.*

In a decentralized hierarchy, both a and b are controlled by the lower manager. This allows the lower manager to treat the two control variables as substitutes. The overall investment in (a, b) in the SB solution is less than in the FB solution. Since the incentive variable a is more directly related to his income, the lower manager has a tendency to save on investment in the risk variable b. As a result, the lower manager chooses to over-invest in a to compensate for too much reduction in b.

We next present the solution for the case of centralization.

Proposition 2 (Higher Control). *Under higher control, the FB solution is*

$$a_h^{**} = \left[\frac{1-\alpha\theta}{(1-\theta)\beta\gamma B}(1-\alpha)^{-\theta}\alpha^{\beta-1}A^{\beta-\theta}\varepsilon^{\beta}\right]^{\frac{1}{\alpha\theta-\alpha\beta-1+\beta}},$$

$$b_h^{**} = \frac{1}{\alpha\varepsilon A}\left[\frac{1-\alpha\theta}{(1-\theta)\beta\gamma B}(1-\alpha)^{-\theta}\alpha^{\beta-1}A^{\beta-\theta}\varepsilon^{\beta}\right]^{\frac{1-\alpha}{\alpha\theta-\alpha\beta-1+\beta}};$$

the SB solution is

$$a_h^{*} = \left(\frac{(\alpha A)^{\beta-\theta}\varepsilon^{\beta}}{(1-\theta)\gamma\beta B}\right)^{\frac{1}{\beta-\alpha\beta+\alpha\theta-1}}\left(\frac{1}{\alpha}-1\right)^{\frac{1-\theta}{\beta-\alpha\beta+\alpha\theta-1}},$$

$$b_h^{*} = (\alpha A)^{\frac{1-\theta}{\beta-\alpha\beta+\alpha\theta-1}}\varepsilon^{\frac{1-\alpha\theta}{\beta-\alpha\beta+\alpha\theta-1}}\left(\frac{1}{(1-\theta)\gamma\beta B}\right)^{\frac{1-\alpha}{\beta-\alpha\beta+\alpha\theta-1}}\left(\frac{1}{\alpha}-1\right)^{\frac{(1-\theta)(1-\alpha)}{\beta-\alpha\beta+\alpha\theta-1}}.$$

We always have $a_h^* < a_h^{**}$ and $b_h^* < b_h^{**}$, and the SB solution is always inefficient.[7]

In a centralized hierarchy, the incentive variable a and the risk variable b are controlled separately by the two managers, implying that the two variables can be used as complements. As a result, both managers underinvest in the SB solution.

Given the SB control variables a_l^* and b_l^* and the principal's payoff V_l^* (which is the total surplus of the project) under lower control, we measure the effects of a parameter x on the solution by the following relevant elasticities:

$$e_{a,x}^l \equiv \left|\frac{\partial \log(a_l^*)}{\partial \log(x)}\right|, \qquad e_{b,x}^l \equiv \left|\frac{\partial \log(b_l^*)}{\partial \log(x)}\right|, \qquad e_{V,x}^l \equiv \left|\frac{\partial \log(V_l^*)}{\partial \log(x)}\right|, \tag{21}$$

where x can be any parameter, including A, B, ε, and γ. Similarly, for control variables a_h^*, b_h^* and payoff V_h^* under higher control, we can also similarly define elasticities $e_{a,x}^h$, $e_{b,x}^h$ and $e_{V,x}^h$ for any parameter x. In the following sections, we analyze the effects of the four parameters on the choice of control structures; the four parameters are: market share A, internal control ability $1/B$, external uncertainty $1-\varepsilon$, and bureaucratic inefficiency γ. These four aspects correspond to four recent challenges to Chinese banks. The question is: will these effects imply a preference for a centralized system?

3.2. Market Share

The first question is whether or not a reallocation of control rights can effectively deal with competition for market share. For example, in the last fifty years, due to banking reforms and the development of financial markets in many countries, the banking sector increasingly faces competition from financial intermediaries and new entrants to the banking sector. The following proposition shows that the reallocation of some control rights can indeed reduce the negative impact from such competition.

Proposition 3 (Market Share).

(a) We always have

$$\frac{\partial a_l^*}{\partial A} > 0, \quad \frac{\partial b_l^*}{\partial A} > 0, \quad \frac{\partial V_l^*}{\partial A} > 0, \quad \frac{\partial a_h^*}{\partial A} > 0, \quad \frac{\partial b_h^*}{\partial A} > 0, \quad \frac{\partial V_h^*}{\partial A} > 0,$$

implying a positive effect of market share on all the effort and welfare variables.

[7] It is normal that the second-best solutions in Propositions 1 and 2 are inefficient since we have uncontractable variables in both the production and probability functions. Notice that our model is not a standard agency model due to its unusual ways of introducing the effort variables.

(b) More importantly, we always have

$$e^{l}_{a,A} > e^{h}_{a,A}, \qquad e^{l}_{b,A} > e^{h}_{b,A}, \qquad e^{l}_{V,A} > e^{h}_{V,A},$$

implying that the effort and welfare variables are less affected by a change in the market share under higher control than under lower control.

Proposition 3(b) indicates that market competition has a smaller effect on the centralized control structure. In other words, centralizing risk control rights can be a response to the competition for market share. When both effort variables are controlled by the opportunistic lower manager, the negative impact of a market shrinkage is larger than when the two effort variables are controlled by separate managers. For the lower manager, the two control variables are strategic substitutes, while for the higher manager, the two control variables are strategic complements. The complementarity of the two variables makes the higher manager less opportunistic, which implies Proposition 3(b).

In the case of Chinese banks, since 2001, private banks and local government-affiliated banks have begun to compete with the state-owned banks (SOBs) for market share. The opening of the full banking market to foreign competition in 2007 creates a further challenge to Chinese banks. According to Proposition 3(b), to reduce the negative effect of the competition for market share, the Chinese banks should move certain control rights upwards. This is indeed what w393 kl6Tw[4ge ir

Figure 1 indicates that the total surplus under higher control is larger than that under lower control when the market share is small. This is due to the tradeoff between the benefit of higher control shown in Proposition 3(b) and a higher cost at the higher level (called bureaucratic inefficiency) as defined by the relative cost $C(b)/c(b)$.

One related line of literature is about competition and financial stability in the banking sector; see surveys by Canoy *et al.* (2001) and Carletti–Hartmann (2003). The question is: when facing increased competition, will banks choose more risky portfolios? The general answer is yes. However, Boyd–De Nicoló (2005) show that, by taking into account the loan market, the general view is incorrect. That is, banks become less risky as their markets become more competitive. Also, Matutes–Vives (2000) study the relationship between risk-taking incentives and competition for deposits. They conclude that the welfare performance of the market and the appropriateness of alternative regulatory measures depend on the degree of rivalry and the deposit insurance regime. Finally, Allen–Gale (2004) consider a variety of different models of competition and financial stability. These models include general equilibrium models of financial intermediaries and markets, agency models, spatial competition models, Schumpeterian competition, and contagion. They indicate that there is a wide range of theoretical possibilities for the relationship between competition and financial stability. In some cases, there is a tradeoff between the two; but in other cases, there is no tradeoff.

Our approach is quite different; we argue that banks can use an organizational approach in dealing with increased competition by adjusting the allocation of control rights within the banks' hierarchies. The focus is different: the existing literature focuses on a policy issue, such as how much concentration in the banking sector is optimal, while we focus on banking strategies.

Many analysts claim that the U.S. commercial banking sector suffered from competition for market share with nonblank financial intermediaries in the last 20 to 30 years. Interestingly, during this period, there were intensive merger and acquisition activities in the banking sector. Such an activity can be considered as a form of centralization in control rights, which is consistent with our theory.

3.3. Bureaucracy

Decision making in a hierarchy can be adversely affected by bureaucratic chains. Besides, when decisions are made at different levels, there is an added negative impact of the separation of decisions from incentives. In our model, we use parameter γ to measure the relative degree of bureaucratic inefficiency between higher control and lower control. A larger γ means a higher degree of bureaucratic inefficiency in the hierarchy. We wonder if a decrease in γ implies a preference for a centralized control structure.

Proposition 4 (Bureaucracy).

(a) We always have

$$\frac{\partial a_l^*}{\partial \gamma} = \frac{\partial b_l^*}{\partial \gamma} = \frac{\partial V_l^*}{\partial \gamma} = 0, \qquad \frac{\partial a_h^*}{\partial \gamma} < 0, \qquad \frac{\partial b_h^*}{\partial \gamma} < 0, \qquad \frac{\partial V_h^*}{\partial \gamma} < 0.$$

That is, a higher degree of bureaucratic inefficiency reduces efforts and surplus under higher control.

(b) More importantly, we always have

$$e_{a,}^{h} \qquad e_{a,}^{l}\ , \qquad e_{b,}^{h} \qquad e_{b,}^{l}\ , \qquad e_{V,}^{h} \qquad e_{V,}^{l}\ ,$$

There is a small literature on organizational bureaucracy. One line of studies examines the relationships among organizational culture, leadership style and bureaucratic hierarchy. In a study for the U.S. Department of Defense, Hannon–Baxter (2000) find that the organization is full of misunderstandings, primarily caused by parties filtering interactions through their own narrow perspectives. In another study on developing economies, Kilby (1962) argues that organizational inefficiency may be an important cause for under-development. A third line of studies focuses on the relationship between turnover rates and organizational efficiency; see, for example, Staw–Oldham (1978), Dalton et al. (1979, 1981), Muchinsky–Morrow (1980), and Staw (1980). It is shown that some degree of turnover tends to be healthy for an organization. Turnover infuses "new blood", fresh ideas, and keeps the organization from becoming stagnant. At a moderate level of turnover, this benefit can outweigh the operational cost of turnover. Our approach to organizational efficiency is unique; we show that a reallocation of control rights can improve efficiency under certain situations.

3.4. Internal Control

One important consideration of a superior control structure is the firm's internal control ability. We wonder which control structure is better if a firm's internal control ability is weak. In our model, we use the parameter $1/B$ to measure the firm's internal control ability.

Proposition 5 (Internal Control).

(a) We always have

$$\frac{\partial a_l^*}{\partial B} < 0, \quad \frac{\partial b_l^*}{\partial B} < 0, \quad \frac{\partial V_l^*}{\partial B} < 0, \quad \frac{\partial a_h^*}{\partial B} < 0, \quad \frac{\partial b_h^*}{\partial B} < 0, \quad \frac{\partial V_h^*}{\partial B} < 0,$$

implying a positive impact of internal control ability (as measured by $1/B$) on effort and surplus.

(b) More importantly, we always have

$$e_{a,B}^l > e_{a,B}^h, \qquad e_{b,B}^l > e_{b,B}^h, \qquad e_{V,B}^l > e_{V,B}^h,$$

implying that a change in internal control ability has a bigger impact on effort and payoffs under lower control than under higher control.

Proposition 5(b) suggests that, when a firm's internal control ability weakness, it should choose higher control, since under higher control the negative impact of weak internal control is smaller. Intuitively, when a firm's internal control is weak, it makes sense not to allocate many control rights at one level (the lower level). At each level, the manager will take measures to reduce the negative impact. The separation of control to different levels allows double-hedging against the problem at all levels, which is likely to reduce the overall negative impact of weak internal control.

Figure 3 further indicates that centralization is more efficient when the internal control ability is weak (a large B). The tradeoff is between the benefit of higher control in Proposition 5(b) and the bureaucratic inefficiency of higher control.

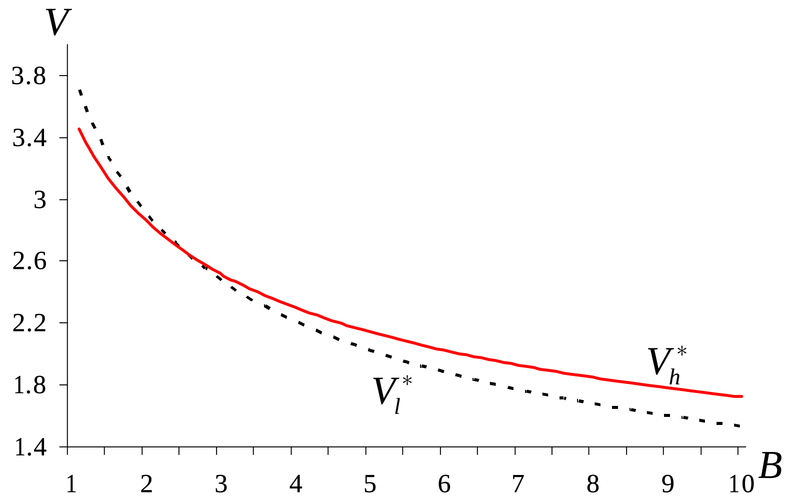


Figure 3. The Effect of the Internal Control Ability on the Choice of Control Structures

In the case of Chinese banks, there was extensive financial fraud during 2000–2005 and the situation worsened quickly until 2004. This was a sign of internal control weakness. Proposition 5(b) suggests that, in a period of weakness in internal control, banks should move some control rights upwards. This happens to be what we observe in reality.

There is a large literature on corporate control; see, for example, Glassman–Rhoades (1980), Morck–Shleifer–Vishny (1989), Baradwaj–Fraser–Furtado (1990), Jensen–Murphy (1990), Byrd–Hickman (1992), Prowse (1995), and Gorton–Rosen (1995). Traditional topics in the study of corporate control include incentive contracts (such as stock options), market discipline, takeover threats, mergers and acquisitions, and monitoring by the board of directors and large investors. One line of research, in particular, focuses on the position of the chairman of the board of directors (COB). Should the COB be the CEO or an outsider? Palmon–Wald's (2002) empirical study indicates that the answer depends on the size of the firm.

However, many of these studies focus on the top manager, but not on allocating control rights among different levels of management. The study by Inderst–Müller (2003) is an exception. They compare a centralized structure by which the headquarters raise funds on behalf of multiple projects with a decentralized structure by which each project raises funds separately from the capital market. The benefit of centralization is that the headquarters can use excess liquidity from high cash-flow projects to buy continuation rights for low cash-flow projects. The cost is that the headquarters may pool cash flows from several projects and self-finance follow-up investments without having to return to the capital market. Absent any capital market discipline, it is more difficult to force the headquarters to make repayments, which tightens financing constraints ex ante. Indeed, their empirical study implies that conglomerates have a lower average productivity than stand-alone firms have.

Existing studies do not say much about corporate control in banks even though the banking sector is of dominant importance in the financial market. Corporate control in the banking sector is unique. The banking sector tends to be overly regulated. For example, significant restrictions are traditionally imposed on takeovers in the banking sector so that takeovers cannot play an important role in disciplining banks. Many researchers emphasize the agency problem of deposit insurance, which causes banks to take too much risk. Also, some (such as Byrd–Hickman 1992) find that outside directors have larger stakes in nonfinancial firms than in banks. Others (such as Gorton–Rosen 1995) claim that US commercial banks suffered from corporate control problems in the 1980s. They show both theoretically and empirically that, if outside control becomes costly when the top manager has a modest equity share in the bank, the manager may take too much risk when the banking industry is unhealthy and the manager may take too little risk when the banking industry is healthy. Our approach is quite different from the traditional approaches. We look at a unique angle of a bank's internal control.

3.5. External Uncertainty

A firm may face an unexpected temporary increase in external uncertainty. We wonder if an adjustment in control rights allocation can cope with such a situation. In our model, we use the parameter $1-\varepsilon$ to measure the degree of external uncertainty (which is the credit risk in the case of a bank). The question is: if external uncertainty is increasing, which control structure is better?

Proposition 6 (External Uncertainty).

(a) We always have

$$\frac{\partial a_l^*}{\partial \varepsilon} > 0, \quad \frac{\partial b_l^*}{\partial \varepsilon} > 0, \quad \frac{\partial V_l^*}{\partial \varepsilon} > 0, \quad \frac{\partial a_h^*}{\partial \varepsilon} > 0, \quad \frac{\partial b_h^*}{\partial \varepsilon} > 0, \quad \frac{\partial V_h^*}{\partial \varepsilon} > 0,$$

implying that all the efforts and payoffs are decreasing in external uncertainty (as measured by $1-\varepsilon$*).*

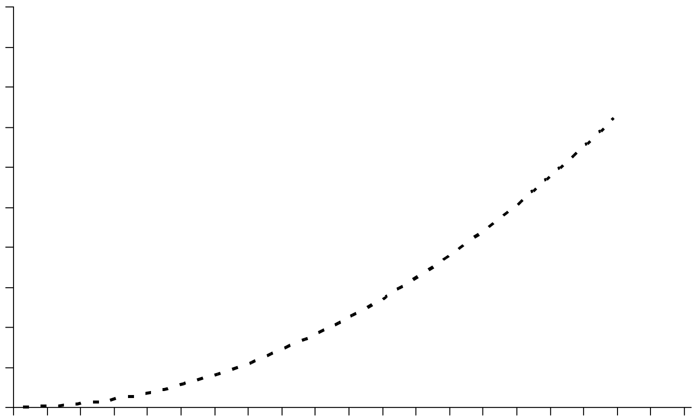
(b) More importantly, we always have

$$e_{a,\varepsilon}^l > e_{a,\varepsilon}^h, \qquad e_{b,\varepsilon}^l > e_{b,\varepsilon}^h, \qquad e_{V,\varepsilon}^l > e_{V,\varepsilon}^h,$$

implying that external uncertainty has a larger effect on efforts and payoffs under lower control than under higher control.

Proposition 6(b) indicates that increasing external uncertainty increases the relative efficiency of a centralized control structure. Hence, when external uncertainty increases, a bank should choose control at the higher level. One reason for this conclusion is that, since the higher manager is risk averse, she is more willing to expend effort in dealing with risk. The second reason is that the incentive and risk variables are no longer substitutable under higher control. Under lower control, the lower manager tends to emphasize the incentive variable and treat the incentive and risk variables as substitutes, which is confirmed by the over-investment in the incentive variable in Proposition 1.

Further, Figure 4 shows that centralization is more efficient when external uncertainty is high (a small ε). The tradeoff is between the benefit indicated by Proposition 6(b) and the bureaucratic inefficiency under higher control.



However, Canoy *et al.* (2001) find that many forms of competition do not endanger financial stability and, in cases in which competition does affect financial stability, proper regulation and sound corporate governance may safeguard financial stability. Carletti-Hartmann (2003) point out that a wide variety of approaches are taken across countries, with some countries giving a stronger role to prudent supervisors than to competition authorities and other countries doing it the other way around. They also find that the widely accepted tradeoff between competition and stability does not generally hold.

A third line looks at a bank's responses to changing uncertainty. For example, Baum–Caglayan–Ozkan (2004) argue that "as uncertainty increases, the cross–sectional dispersion of loan–to–asset ratios should narrow as greater economic uncertainty hinders banks' ability to foresee the investment opportunities (returns from lending). Contrarily, when uncertainty is lower, returns will be more predictable leading to a more unequal distribution of lending across banks as managers take advantage of more precise information about different lending opportunities." Indeed, they found empirical evidence to support this argument.

Finally, a fourth line looks at banks that are associated with holding companies. For example, a recent study by Ashcraft (2008) finds that a bank affiliated with a multi-bank holding company is significantly safer than a standalone bank. A holding company is a form of centralization of control rights. Hence, Ashcraft's (2008) empirical finding is consistent with our theory.

3.6. The Most Important Challenge

In the above, we have shown that centralization of control rights can be used to deal with certain challenges. One further interest is the relative importance of the challenges. Some challenges may have a larger impact on a firm than do others. Which challenge is the most important?

We first define a measure of importance. Take the market share A as an example. When $e_{V,A}^{l} > e_{V,A}^{h}$, we argue that, by reallocating risk control rights upward, the firm's profitability is less affected by competition for market share. That is, reallocating control rights is a strategy to shield the negative impact of the competition for market share. Hence, when the value of $e_{V,A}^{l} - e_{V,A}^{h}$ is larger, the market share is a more important reason for a control-rights reallocation. By this, we define the importance of the challenge by the difference $\left|e_{V,A}^{l} - e_{V,A}^{h}\right|$ of the effects (as defined by elasticities) on different control structures (lower control vs. higher control). Given a percentage change in market share, the gain is larger if the difference of the two elasticities is larger. For example, if a 1% decrease in A causes a 10% decrease in payoff under lower control but only a 3% decrease in payoff under higher control, then switching from lower control to higher control reduces the loss by 7% to the firm. That is, instead of 10% loss, the firm has only 3% loss after the switch (implying a 7% increase in payoff). Hence, the bigger the difference, the more profitable it is to switch.

The importance measures for other challenges are similarly defined. The following proposition shows the ranking of the four types of challenges based on their importance.

Proposition 7 (The Dominant Challenge). *Either market share or bureaucracy is the most important challenge. Specifically,*

(a) For variables A, B *and* ε, *we always have*

$$\left|e^l_{a,A} - e^h_{a,A}\right| > \left|e^l_{a,\varepsilon} - e^h_{a,\varepsilon}\right| > \left|e^l_{a,B} - e^h_{a,B}\right|,$$
$$\left|e^l_{b,A} - e^h_{b,A}\right| > \left|e^l_{b,\varepsilon} - e^h_{b,\varepsilon}\right| > \left|e^l_{b,B} - e^h_{b,B}\right|,$$
$$\left|e^l_{V,A} - e^h_{a,A}\right| > \left|e^l_{V,\varepsilon} - e^h_{V,\varepsilon}\right| > \left|e^l_{V,B} - e^h_{V,B}\right|,$$

implying that market share is more important than external uncertainty, which in turn is more important than internal control abw[o7p3Tms4(c)-57(o)13n)-6(t)-20rol a)-63bw[o72h)-27.9l)-7.3h)]T 0 there has been serious financial fraud in Chinese banks since 2000. Lastly, there is also a serious problem of non-performing loans (NPLs).

How do Chinese banks cope with these challenges? Interestingly, one major recent change is the reallocation of control rights. Specifically, the SOBs moved certain control rights, mainly the right of credit extension (a risk control right), upwards in their hierarchies, from municipal branches to provincial branches or to the headquarters. After this change, a manager at the lower level no longer had the right to determine to whom and how much to lend; instead, his responsibility was reduced to recommending large projects to the higher level. This is the so-called "strong headquarters-weak branch" management structure. In fact, this form of centralization is widespread in almost all commercial banks in China, including joint share commercial banks (JSCBs) and non-bank financial institutions. Interestingly, this reaction is consistent with our theory during such a period.

More specifically, Figure 5 shows competition for market share. The trend of a substantial decline in market share for the SOBs begun in 2000. According to Proposition 3(b), centralization of risk control rights can be a measure to deal with such a situation. Indeed, after the decline in market share became persistent for two to three years, the SOBs began to centralize their control rights. ABC was the first to centralize in 2003; the other three banks, BOC, CCB and ICBC, did so in 2004. Interestingly, the timing of the SOBs' centralization coincide with when the JSCBs began to control a substantially larger market share in 2003. It seems that it was the JSCBs' strong gain in market share that finally triggered the reaction by the SOBs.

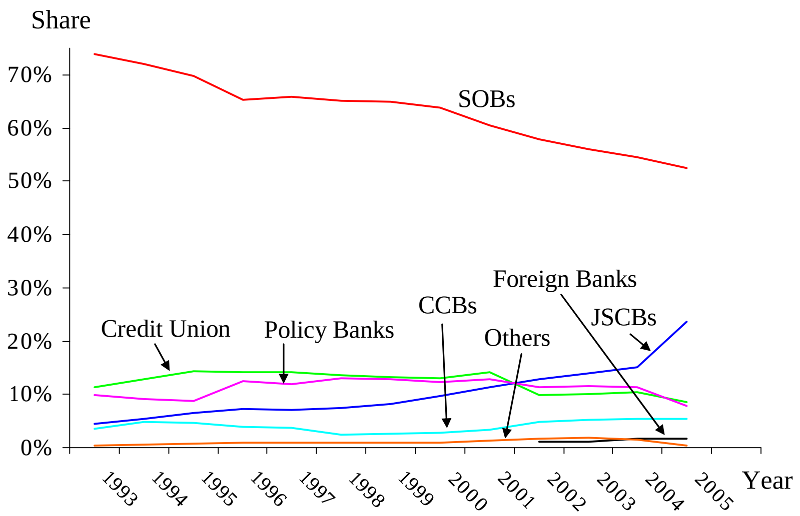


Figure 5. Market Shares for Banking Institutions (1993-2005)[8]

A key factor in Chinese banks' going public is to fight bureaucracy. Zhou (2005a), the governor of the Chinese Central Bank, points out that, going public transforms a government bank from a government agency operating within the government's bureaucratic system to a

[8] Source: García-Herrero et al. (2006) and Almanac of China's Finance and Banking (1994–2006).

typical company operating under market principles. Figure 6 shows the relationship between the timing of centralization and privatization. CCB was the first to go public in November 2005; BOC went pubic in June 2006; ICBC went public in October 2006; and ABC is expected to go public in 2008. Figure 6 indicates that centralization seems just one-step ahead of privatization, as if centralization is in preparation for privatization. This is consistent with the argument that, before going pubic, measures need to be taken to reduce bureaucracy and to make a bank more like a company operating under market principles. This is also consistent with our theory in Proposition 4(b) indicating that a centralized control system benefits more from a reduction in bureaucracy than does a decentralized system.

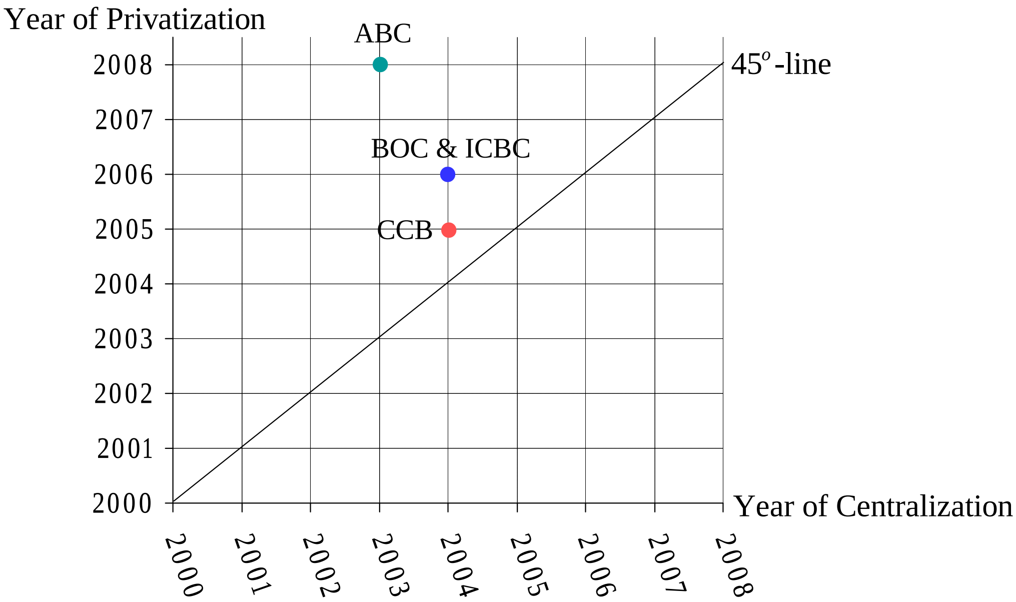


Figure 6. Timing of Centralization and Privatization

Figure 7 indicates the problem of banking fraud in terms of value and numbers. The severity of financial fraud peaked in 2002–2003. The Chinese banks' move to centralize risk control rights during that period is consistent with our theory in Proposition 5(b) indicating that a centralized control system is less vulnerable to weaknesses in internal control than is a decentralized system. Figure 7 seems to confirm this fact; the timing of centralization coincides well with the timing of the severity of financial fraud.

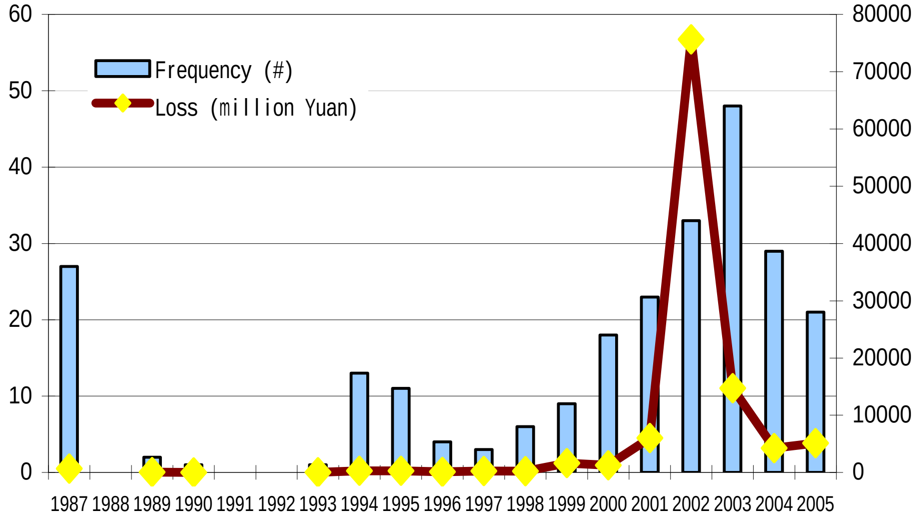


Figure 7. Financial Fraud in the Chinese SOBs (1987–2005)[9]

Figure 8 shows the problem of non-performing loans (NPLs) in value and in percentage. At their peak, the NPLs accounted for about 40% of the SOBs' total loans in 2001. Our theory in Proposition 6(b) indicates that a centralized control system is less affected by negative external shocks than is a decentralized system. Hence, the NPLs may also explain the recent centralization of control rights in the SOBs.

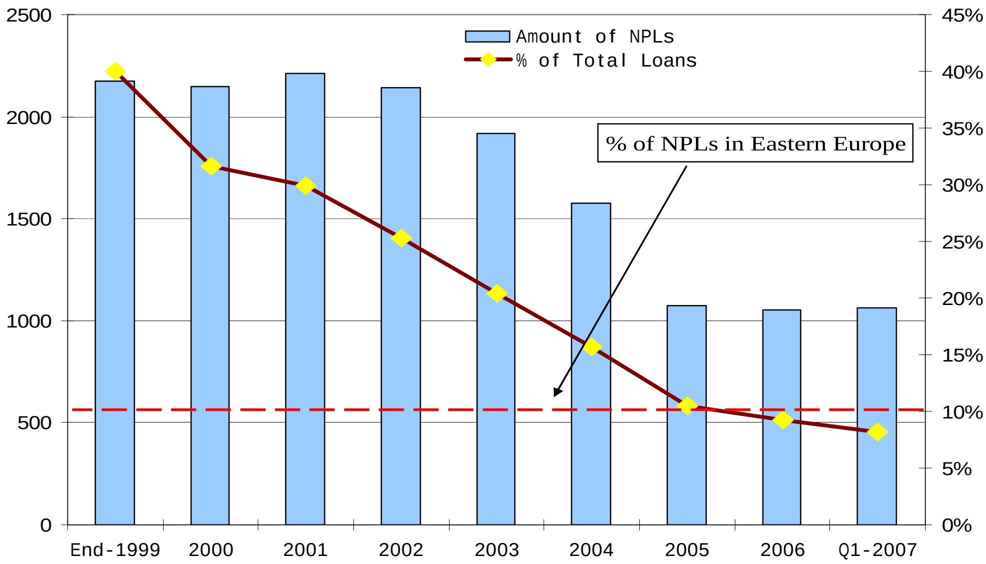


Figure 8. NPLs in the Chinese SOBs[10]

All four cases seem to be consistent with our theory. However, we do not know which cases or if all the cases are the real reasons. By Proposition 7, market share or privatization is

[9] Source: Zhang (2004) and Sheng (2005).

[10] Source: Cui (2006), Xiao (2006), García-Herrero *et al.* (2006), and annual reports of the China Banking Regulatory Commission.

the mostly likely reason. Unfortunately, due to a short period since the reforms, there is not enough data to conduct an empirical study.

One more piece of evidence in support of our theory is from some public statements from the government on the underlying rationale for the reforms. When referring to the reforms, Zhou (2005b), the governor of the Chinese Central Bank, stated that “the main task of all Chinese banks, as well as the primary goal of the current banking reforms, is to improve the banks’ corporate governance and risk management, particularly the design of a sound system for credit approval, risk control, asset disposition, and internal supervision.” He mentioned two key tasks: to improve *risk control* and *corporate governance*. Here, going public is considered as a major step toward improving corporate governance.

A further piece of information is that the Chinese banks’ response in reallocating control rights is actually widespread, involving all banks. This suggests that the banks’ reaction is likely to be a response to aggregate shocks.

Finally, our theory also suggests an improvement in profitability after centralization of control rights. Figure 9 shows the financial performance of the four SOBs measured by the risk-proof profitability indicator called CAR. Indeed, Figure 9 indicates a clear improvement in profitability after centralization of control rights.

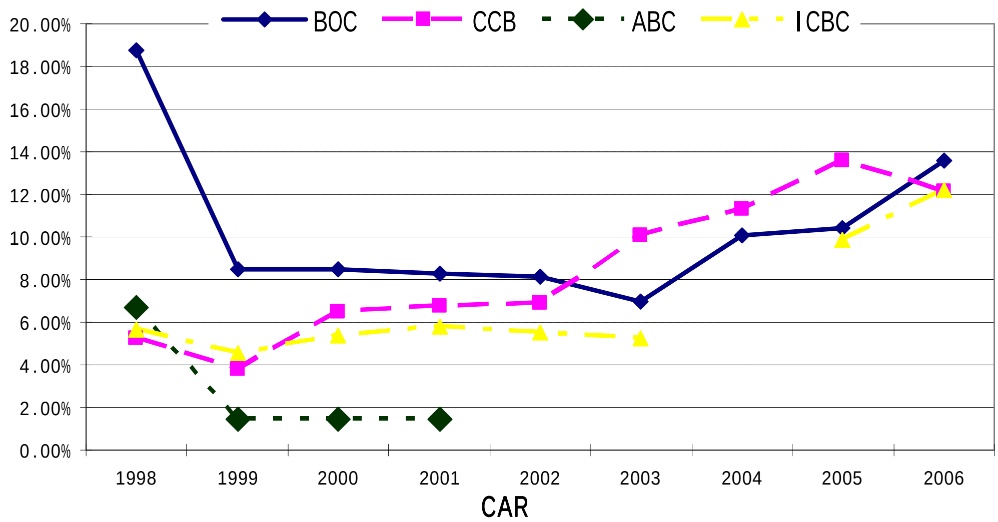


Figure 9. A Performance Indicator for the SOBs[11]

[11] Source: Almanac of China’s Finance and Banking, 1995–2006; Annual reports of the SOBs. Data before 2001 are from Bank in China.

5. Concluding Remarks

We show in theory that centralization of risk control rights can potentially be an effective measure in dealing with certain challenges in the corporate setting. We also show in theory that either the competition for market share or an improvement in bureaucracy is the most justifiable reason for such centralization. The recent reactions of the Chinese SOBs to the challenges they face turn out to be consistent with our theory.

Such a theory has not been seen in the existing literature. However, this theory has many potential applications. For example, recently, in developed economies, some policy decisions, such as monetary and trade policies, tended to be moved to higher levels of government, while other policies, such as health and education policies, tended to be moved to lower levels. We wonder what is the intention of these changes and what effects these changes have on the economy. Our theory may be applicable to these questions.

A reallocation of control rights is different from a complete reorganization. A control rights adjustment is a simple, costless, and fast way to cope with a changing environment. A reallocation of control rights can be considered to be an adjustment on a path to a steady state, while a complete reorganization can be considered to be a move from one steady state to another. When facing a short-term challenge, a simple adjustment of control rights can be a cost-saving solution. Further, under uncertainty and disinformation, a sequence of adjustments of control rights can be a Bayesian-learning convergent sequence to a final solution. Also, the history and the existing structure of an organization can be constraints to a possible change. Hence, a reallocation of control rights can be a better solution than a complete reorganization, at least in the presence of a temporary shock.

Finally, in this paper, we have only allowed risk control to be allocatable. An obvious extension is to allow the effort variable or both to be allocatable. Such a model can be applied to a different set of applications, which is beyond the scope of this paper.

Appendix

A.1 An Optimal Contract and the SOCs

The Optimal Contract

Given (a,b), for the contract in (10) and for an x_0 satisfying $x_0 < x(a)$, the two IC conditions imply that

$$\begin{aligned} IC_a: \quad & p(b)u'\left[\rho(x(a)-x_0)\right]\rho x'(a) = 1, \\ IC_b: \quad & p'(b)u\left[\rho(x(a)-x_0)\right] = c'(b), \end{aligned}$$

implying

$$\rho(x(a)-x_0)=u^{-1}\left[\frac{c'(b)}{p'(b)}\right], \qquad p(b)u'\left\{u^{-1}\left[\frac{c'(b)}{p'(b)}\right]\right\}\rho x'(a)=1.$$

Hence, given (a_l^*, b_l^*), we find

$$\rho=\left(p(b_l^*)x'(a_l^*)u'\left\{u^{-1}\left[\frac{c'(b_l^*)}{p'(b_l^*)}\right]\right\}\right)^{-1},$$

$$x_0=x(a_l^*)-p(b_l^*)x'(a_l^*)u'\left\{u^{-1}\left[\frac{c'(b_l^*)}{p'(b_l^*)}\right]\right\}u^{-1}\left[\frac{c'(b_l^*)}{p'(b_l^*)}\right].$$

This x_0 is consistent with our initial assumption that $x_0 < x(a_l^*)$. Therefore, an optimal contract of the form in (10) exists.

The SOCs

With the contract in (10), when $x_0 < x(a)$, the utility functions in (1) and (2) respectively become

$$U=p(b)u[\rho x(a)]-a-c(b),$$
$$V=p(b)v\big[(1-\rho)x(a)\big].$$

Obviously, if utility function $u(x)$ is concave in x and output function $x(a)$ is concave in a, then U is concave in a. Also, if $p(b)$ is concave in b, then V is concave in b. Since the optimal solution a_l^* satisfies the condition $x_0 < x(a)$, the SOCs are satisfied. Therefore, the first-order approach used in our agency model is valid.

A.2. Proof of Proposition 1

Lower Control, FB

The first-best problem (3) is

$$V_l^{**}\equiv\max_{a,b}\ \frac{b\varepsilon}{1-\theta}\left(Aa^{\alpha}-\frac{a}{b\varepsilon}-\frac{B}{\varepsilon}b^{\beta-1}\right)^{1-\theta}.$$

The FOCs are

$$\frac{\varepsilon}{1-\theta}\left(Aa^{\alpha}-\frac{a}{b\varepsilon}-\frac{B}{\varepsilon}b^{\beta-1}\right)^{1-\theta}+b\varepsilon\left(Aa^{\alpha}-\frac{a}{b\varepsilon}-\frac{B}{\varepsilon}b^{\beta-1}\right)^{-\theta}\left(\frac{a}{b^2\varepsilon}-(\beta-1)\frac{B}{\varepsilon}b^{\beta-2}\right)=0,$$

$$\alpha Aa^{\alpha-1}-\frac{1}{b\varepsilon}=0.$$

The first FOC can be simplified to

$$A\varepsilon a^{\alpha}-\big[1+(1-\theta)(\beta-1)\big]Bb^{\beta-1}-\theta\frac{a}{b}=0. \tag{23}$$

The second FOC implies that

$$a = (\alpha A b \varepsilon)^{\frac{1}{1-\alpha}}. \tag{24}$$

Substituting (24) into (23) eliminates a and yields

$$\left(\frac{1}{\alpha} - \theta\right)(\alpha \varepsilon A)^{\frac{1}{1-\alpha}} b^{\frac{\alpha}{1-\alpha}} = \left[1 + (1-\theta)(\beta - 1)\right] B b^{\beta-1},$$

which implies b_l^{**} and then a_l^{**} in Proposition 1. The social welfare is

$$V_l^{**} \equiv p(b^{**}) v \left[x(a^{**}) - u^{-1}\left(\frac{a^{**} + c(b^{**})}{p(b^{**})} \right) \right].$$

Notice that, since $p(b) = b\varepsilon$ is a probability, we need $b_l^{**}\varepsilon \leq 1$, which means a condition on the parameters. This condition is indeed ensured in the numerical calculations of Figures 1–4.

Lower Control, SB

The second-best problem (9) is

$$\begin{aligned} \max_{a,b} \quad & \frac{\varepsilon b}{1-\theta}\left(A a^{\alpha} - \frac{\beta B}{\varepsilon} b^{\beta-1}\right)^{1-\theta} \\ \text{s.t.} \quad & a \leq (\beta - 1) B b^{\beta}. \end{aligned} \tag{25}$$

By introducing a Lagrange multiplier λ, the FOCs are

$$\varepsilon b \left(A a^{\alpha} - \frac{\beta B}{\varepsilon} b^{\beta-1}\right)^{-\theta} \alpha A a^{\alpha-1} - \lambda = 0, \tag{26}$$

$$\frac{\varepsilon}{1-\theta}\left(A a^{\alpha} - \frac{\beta B}{\varepsilon} b^{\beta-1}\right)^{1-\theta} - b\left(A a^{\alpha} - \frac{\beta B}{\varepsilon} b^{\beta-1}\right)^{-\theta} \beta B(\beta-1) b^{\beta-2} + \lambda(\beta-1)\beta B b^{\beta-1} = 0; \tag{27}$$

and the Kuhn-Tucker condition is

$$\lambda\left[(\beta-1) B b^{\beta} - a\right] = 0. \tag{28}$$

Equation (26) implies that $\lambda > 0$. By (28), we know that the constraint in (25) is binding. This implies that the second-best solution cannot achieve efficiency. Substituting (26) into (27) eliminates λ and yields

$$\varepsilon A a^{\alpha} = \beta B\left[(1-\theta)(\beta-1) + 1\right] b^{\beta-1} - \alpha \varepsilon A a^{\alpha-1}(1-\theta)(\beta-1)\beta B b^{\beta}. \tag{29}$$

Using the binding constraint to replace the term $(\beta-1)Bb^{\beta}$ by a in (29) yields

$$\varepsilon A\left[1 + \alpha(1-\theta)\beta\right] a^{\alpha} = \beta B\left[(1-\theta)(\beta-1) + 1\right] b^{\beta-1}.$$

Using the binding constraint again to eliminate a in (29) yields

$$\varepsilon A\left[1 + \alpha(1-\theta)\beta\right](\beta-1)^{\alpha} B^{\alpha} b^{\alpha\beta} = \beta B\left[(1-\theta)(\beta-1) + 1\right] b^{\beta-1},$$

which implies b_l^{*} and then a_l^{*} in Proposition 1. The social welfare is

$$V_l^* \equiv p(b_l^*)v\left[x(a_l^*) - u^{-1}\left(\frac{c'(b_l^*)}{p'(b_l^*)}\right)\right]. \tag{30}$$

Notice that, since $p(b) = b\varepsilon$ is a probability, we need to require $b_l^*\varepsilon \leq 1$, which means a condition on the parameters.

The SB Solution is Inefficient

The following lemma is from Beckenbach–Bellman (1983, p.13).

Lemma 1. For $x,\ y \geq 0$ and $\alpha \in (0,\ 1)$, we have

$$x^\alpha y^{1-\alpha} \leq \alpha x + (1-\alpha)\, y.$$

The inequality is reversed if $\alpha < 0$. The equality holds iff $x = y$. ■

Given the solutions, $b_l^* < b_l^{**}$ means

$$\left[\frac{\beta - 1}{\alpha(\theta + \beta - \theta\beta)}\right]^\alpha \left(\frac{1}{1-\alpha\theta}\right)^{1-\alpha} < \frac{\beta}{1 + \alpha(1-\theta)\beta}. \tag{31}$$

By Lemma 1, we have

$$\left[\frac{\beta - 1}{\alpha(\theta + \beta - \theta\beta)}\right]^\alpha \left(\frac{1}{1-\alpha\theta}\right)^{1-\alpha} \leq \alpha \frac{\beta - 1}{\alpha(\theta + \beta - \theta\beta)} + (1-\alpha)\frac{1}{1-\alpha\theta}.$$

Hence, for (31) to hold, we only need

$$\frac{\beta - 1}{\theta + \beta - \theta\beta} + \frac{1-\alpha}{1-\alpha\theta} < \frac{\beta}{1 + \alpha(1-\theta)\beta}.$$

By $(1-\alpha)\beta > 1$ in (20), this inequality becomes

$$1 + \alpha(1-\theta)\beta < \theta + \beta - \theta\beta,$$

which always holds by the assumption $(1-\alpha)\beta > 1$ again. Hence, we do have $b_l^* < b_l^{**}$.

Also, $a_l^{**} < a_l^*$ is equivalent to

$$\left[\frac{\alpha(\theta + \beta - \theta\beta)}{\beta - 1}\right]^{\frac{\beta-1}{\beta}} (1-\alpha\theta)^{\frac{1}{\beta}} < \frac{1 + \alpha(1-\theta)\beta}{\beta}. \tag{32}$$

By Lemma 1 again, we have

$$\left[\frac{\alpha(\theta + \beta - \theta\beta)}{\beta - 1}\right]^{\frac{\beta-1}{\beta}} (1-\alpha\theta)^{\frac{1}{\beta}} < \frac{\beta - 1}{\beta}\frac{\alpha(\theta + \beta - \theta\beta)}{\beta - 1} + \frac{1-\alpha\theta}{\beta}.$$

Since

$$\frac{\beta-1}{\beta}\frac{\alpha(\theta+\beta-\theta\beta)}{\beta-1}+\frac{1-\alpha\theta}{\beta}=\frac{1+\alpha(1-\theta)\beta}{\beta},$$

(32) always holds. Hence, $a_l^{**} < a_l^{*}$.

A.3. Proof of Proposition 2

Higher Control, FB

The first-best problem in (11) is

$$\max_{a,b} \frac{1}{1-\theta} b\varepsilon\left(Aa^{\alpha}-\frac{a}{b\varepsilon}\right)^{1-\theta}-\gamma Bb^{\beta}.$$

The FOCs are

$$\alpha Aa^{\alpha-1}=\frac{1}{b\varepsilon},$$
$$\frac{\varepsilon}{1-\theta}\left(Aa^{\alpha}-\frac{a}{b\varepsilon}\right)^{1-\theta}+b\varepsilon\left(Aa^{\alpha}-\frac{a}{b\varepsilon}\right)^{-\theta}\frac{a}{b^{2}\varepsilon}=\beta\gamma Bb^{\beta-1}.$$

The first FOC implies that

$$b=\frac{1}{\alpha\varepsilon A}a^{1-\alpha}. \tag{33}$$

Using (33), the second FOC implies

$$\frac{1}{1-\theta}\left(\varepsilon Aa^{\alpha}-\alpha\varepsilon Aa^{\alpha}\right)+\alpha\varepsilon Aa^{\alpha}=\beta\gamma B\left(\alpha\varepsilon Aa^{\alpha-1}\right)^{1-\beta}\left(Aa^{\alpha}-\alpha Aa^{\alpha}\right)^{\theta},$$

which implies a_h^{**} and then b_h^{**} in Proposition 2. The social welfare is

$$V_h^{**}\equiv\frac{\varepsilon}{1-\theta}b_h^{**}\left(A(a_h^{**})^{\alpha}-\frac{a_h^{**}}{\varepsilon b_h^{**}}\right)^{1-\theta}-\gamma B(b_h^{**})^{\beta}.$$

Higher Control, SB

The second-best problem in (18) is

$$\max_{a,b} b^{\beta}$$
$$\text{s.t. } Aa^{\alpha}b\varepsilon-\varepsilon\left[(1-\theta)\frac{\gamma\beta B}{\varepsilon}\right]^{\frac{1}{1-\theta}}b^{\frac{\beta-\theta}{1-\theta}}\geq a.$$

By introducing a Lagrange multiplier $\lambda\geq 0$, the FOCs are

$$0=\beta b^{\beta-1}+\lambda\left[Aa^{\alpha}\varepsilon-\varepsilon\left[(1-\theta)\frac{\gamma\beta B}{\varepsilon}\right]^{\frac{1}{1-\theta}}\frac{\beta-\theta}{1-\theta}b^{\frac{\beta-1}{1-\theta}}\right], \tag{34}$$

$$0=\lambda\left(\alpha A a^{\alpha-1} b\varepsilon-1\right). \tag{35}$$

The Kuhn-Tucker condition is

$$\lambda\left[A a^{\alpha} b\varepsilon-\varepsilon^{-\frac{\theta}{1-\theta}}\left[(1-\theta)\gamma\beta B\right]^{\frac{1}{1-\theta}} b^{\frac{\beta-\theta}{1-\theta}}-a\right]=0. \tag{36}$$

If $\lambda=0$, then (34) implies $b=0$, which cannot possibly be a maximum solution. Hence, we must have $\lambda>0$. Then, equation (35) implies that

$$b=\frac{1}{\alpha\varepsilon A} a^{1-\alpha}, \tag{37}$$

and (36) implies a binding constraint:

$$A a^{\alpha} b\varepsilon-\varepsilon^{-\frac{\theta}{1-\theta}}\left[(1-\theta)\gamma\beta B\right]^{\frac{1}{1-\theta}} b^{\frac{\beta-\theta}{1-\theta}}-a=0. \tag{38}$$

Substituting (37) into (38) yields

$$\left(\frac{1}{\alpha}-1\right)a-\varepsilon^{-\frac{\beta}{1-\theta}}\left[(1-\theta)\gamma\beta B\right]^{\frac{1}{1-\theta}}\left(\frac{1}{\alpha A}\right)^{\frac{\beta-\theta}{1-\theta}} a^{\frac{(\beta-\theta)(1-\alpha)}{1-\theta}}=0,$$

which implies a_h^* and then b_h^* in Proposition 2. The social welfare is

$$V_h^* \equiv \gamma B(\beta-1)(b_h^*)^{\beta}. \tag{39}$$

The SB Solution is Inefficient

Given the solutions, $a_h^{**}>a_h^*$ means that

$$\left[\frac{1-\alpha\theta}{(1-\theta)\beta\gamma B}(1-\alpha)^{-\theta}\alpha^{\beta-1}A^{\beta-\theta}\varepsilon^{\beta}\right]^{\frac{1}{\alpha\theta-\alpha\beta-1+\beta}}>\left(\frac{(\alpha A)^{\beta-\theta}\varepsilon^{\beta}}{(1-\theta)\gamma\beta B}\right)^{\frac{1}{\beta-\alpha\beta+\alpha\theta-1}}\left(\frac{1}{\alpha}-1\right)^{\frac{1-\theta}{\beta-\alpha\beta+\alpha\theta-1}}. \tag{40}$$

Condition (20) implies $\beta-1+\alpha\theta-\alpha\beta>0$, by which (40) is equivalent to

$$(1-\alpha\theta)(1-\alpha)^{-\theta}>(1-\alpha)^{1-\theta},$$

or $\theta<1$, which is true. Hence,hcw q 1 0 0 1 374100 0 11.04 94 \ i g ' ' a ‡" i g ' 3 A I H `0 À ð

By (30), we have

$$
\begin{aligned}
V_l^* &= \frac{\varepsilon b_l^*}{1-\theta}\left[A\left(a_l^*\right)^{\alpha} - \frac{B\beta}{\varepsilon}\left(b_l^*\right)^{\beta-1}\right]^{1-\theta} \\
&= \frac{\varepsilon}{1-\theta} A^{\frac{\theta+\beta-\theta\beta}{(1-\alpha)\beta-1}} \left(\frac{\varepsilon}{\beta}\frac{1+\alpha(1-\theta)\beta}{\theta+\beta-\theta\beta}\right)^{\frac{1+\alpha\beta(1-\theta)}{(1-\alpha)\beta-1}} (\beta-1)^{\frac{\alpha+\alpha(\beta-1)(1-\theta)}{(1-\alpha)\beta-1}} B^{\frac{\alpha\theta-1}{(1-\alpha)\beta-1}} \left[1-\frac{1+\alpha(1-\theta)\beta}{\theta+\beta-\theta\beta}\right]^{1-\theta}.
\end{aligned}
\tag{41}
$$

Hence,

$$\frac{A}{V_l^*}\frac{\partial V_l^*}{\partial A} = \frac{\theta+\beta-\theta\beta}{(1-\alpha)\beta-1} > 0.$$

Similarly, by (39) and Proposition 2, we find

$$\frac{A}{V_h^*}\frac{\partial V_h^*}{\partial A} = \frac{\beta(1-\theta)}{(1-\alpha)\beta+\alpha\theta-1} > 0.$$

Hence,

$$
\begin{aligned}
e_{a,A}^l &= \frac{\beta}{(1-\alpha)\beta-1} > \frac{\beta-\theta}{(1-\alpha)\beta+\alpha\theta-1} = e_{a,A}^h, \\
e_{b,A}^l &= \frac{1}{(1-\alpha)\beta-1} > \frac{1-\theta}{(1-\alpha)\beta+\alpha\theta-1} = e_{b,A}^h, \\
e_{V,A}^l &= \frac{\theta+\beta-\theta\beta}{(1-\alpha)\beta-1} > \frac{\beta(1-\theta)}{(1-\alpha)\beta+\alpha\theta-1} = e_{V,A}^h.
\end{aligned}
\tag{42}
$$

A.5. Proof of Proposition 4

By Proposition 2, we have

$$\frac{\gamma}{a_h^*}\frac{\partial a_h^*}{\partial \gamma} = -\frac{1}{(1-\alpha)\beta+\alpha\theta-1} < 0, \qquad \frac{\gamma}{b_h^*}\frac{\partial b_h^*}{\partial \gamma} = -\frac{1-\alpha}{(1-\alpha)\beta+\alpha\theta-1} < 0.$$

By (39) and Proposition 2, we have

$$\frac{\gamma}{V_h^*}\frac{\partial V_h^*}{\partial \gamma} = -\frac{1-\alpha\theta}{(1-\alpha)\beta+\alpha\theta-1} < 0.$$

Hence,

$$
\begin{aligned}
e_{a,\gamma}^h &= \frac{1}{(1-\alpha)\beta+\alpha\theta-1} > 0 = e_{a,\gamma}^l, \qquad e_{b,\gamma}^h = \frac{1-\alpha}{(1-\alpha)\beta+\alpha\theta-1} > 0 = e_{b,\gamma}^l, \\
e_{V,\gamma}^h &= \frac{1-\alpha\theta}{(1-\alpha)\beta+\alpha\theta-1} > 0 = e_{V,\gamma}^l.
\end{aligned}
\tag{43}
$$

A.6. Proof of Proposition 5

By Propositions 1 and 2, we have

$$\frac{B}{a_l^*}\frac{\partial a_l^*}{\partial B} = -\frac{1}{(1-\alpha)\beta - 1} < 0, \qquad \frac{B}{b_l^*}\frac{\partial b_l^*}{\partial B} = -\frac{1-\alpha}{(1-\alpha)\beta - 1} < 0,$$

$$\frac{B}{a_h^*}\frac{\partial a_h^*}{\partial B} = -\frac{1}{(1-\alpha)\beta + \alpha\theta - 1} < 0, \qquad \frac{B}{b_h^*}\frac{\partial b_h^*}{\partial B} = -\frac{1-\alpha}{(1-\alpha)\beta + \alpha\theta - 1} < 0.$$

By (39), (41) and Proposition 2, we have

$$\frac{B}{V_l^*}\frac{\partial V_l^*}{\partial B} = -\frac{1-\alpha\theta}{(1-\alpha)\beta - 1} < 0, \qquad \frac{B}{V_h^*}\frac{\partial V_h^*}{\partial B} = -\frac{1-\alpha\theta}{(1-\alpha)\beta + \alpha\theta - 1} < 0.$$

Hence,

$$\begin{aligned} e_{a,B}^l &= \frac{1}{(1-\alpha)\beta - 1} > \frac{1}{(1-\alpha)\beta + \alpha\theta - 1} = e_{a,B}^h, \\ e_{b,B}^l &= \frac{1-\alpha}{(1-\alpha)\beta - 1} > \frac{1-\alpha}{(1-\alpha)\beta + \alpha\theta - 1} = e_{b,B}^h, \\ e_{V,B}^l &= \frac{1-\alpha\theta}{(1-\alpha)\beta - 1} > \frac{1-\alpha\theta}{(1-\alpha)\beta + \alpha\theta - 1} = e_{V,B}^h. \end{aligned} \tag{44}$$

A.7. Proof of Proposition 6

By Propositions 1 and 2, we have

$$\frac{\varepsilon}{a_l^*}\frac{\partial a_l^*}{\partial \varepsilon} = \frac{\beta}{(1-\alpha)\beta - 1} > 0, \qquad \frac{\varepsilon}{b_l^*}\frac{\partial b_l^*}{\partial \varepsilon} = \frac{1}{(1-\alpha)\beta - 1} > 0,$$

$$\frac{\varepsilon}{a_h^*}\frac{\partial a_h^*}{\varepsilon} = \frac{\beta}{(1 \quad \alpha)\beta \quad \alpha\theta \quad 1} > 0, \qquad \frac{\varepsilon}{b_h^*}\frac{\partial b_h^*}{\varepsilon} = \frac{1-\alpha\theta}{(1 \quad \alpha)\beta \quad \alpha\theta \quad 1} > 0.$$

A.8. Proof of Proposition 7

By (42), we find

$$e_{a,A}^{l}-e_{a,A}^{h}=\frac{\theta(\beta-1)}{[(1-\alpha)\beta-1][(1-\alpha)\beta+\alpha\theta-1]},\quad e_{b,A}^{l}-e_{b,A}^{h}=\frac{\theta(1-\alpha)(\beta-1)}{[(1-\alpha)\beta-1][(1-\alpha)\beta+\alpha\theta-1]}.$$

By (43), we have

$$e_{a,\gamma}^{h}-e_{a,\gamma}^{l}=\frac{1}{(1-\alpha)\beta+\alpha\theta-1},\quad e_{b,\gamma}^{h}-e_{b,\gamma}^{l}=\frac{1-\alpha}{(1-\alpha)\beta+\alpha\theta-1}.$$

By (44), we have

$$e_{a,B}^{l}-e_{a,B}^{h}=\frac{\alpha\theta}{[(1-\alpha)\beta-1][(1-\alpha)\beta+\alpha\theta-1]},\quad e_{b,B}^{l}-e_{b,B}^{h}=\frac{\alpha\theta(1-\alpha)}{[(1-\alpha)\beta-1][(1-\alpha)\beta+\alpha\theta-1]}.$$

By (45), we have

$$e_{a,\varepsilon}^{l}-e_{a,\varepsilon}^{h}=\frac{\alpha\theta\beta}{[(1-\alpha)\beta-1][(1-\alpha)\beta+\alpha\theta-1]},\quad e_{b,\varepsilon}^{l}-e_{b,\varepsilon}^{h}=\frac{\theta(1-\alpha)\alpha\beta}{[(1-\alpha)\beta-1][(1-\alpha)\beta+\alpha\theta-1]}.$$

Hence,

$$e_{a,A}^{l}-e_{a,A}^{h}>e_{a,\varepsilon}^{l}-e_{a,\varepsilon}^{h}>e_{a,B}^{l}-e_{a,B}^{h},\qquad e_{b,A}^{l}-e_{b,A}^{h}>e_{b,\varepsilon}^{l}-e_{b,\varepsilon}^{h}>e_{b,B}^{l}-e_{b,B}^{h}.$$

Further, for factor γ, if $\theta>1-\frac{\alpha\beta}{\beta-1}$, we have

$$e_{a,A}^{l}-e_{a,A}^{h}>e_{a,\gamma}^{h}-e_{a,\gamma}^{l},\qquad e_{b,A}^{l}-e_{b,A}^{h}>e_{b,\gamma}^{h}-e_{b,\gamma}^{l};$$

and if $\theta<1-\frac{\alpha\beta}{\beta-1}$, we have

$$e_{a,A}^{l}-e_{a,A}^{h}<e_{a,\gamma}^{h}-e_{a,\gamma}^{l},\qquad e_{b,A}^{l}-e_{b,A}^{h}<e_{b,\gamma}^{h}-e_{b,\gamma}^{l}.$$

By (42), (43), (44) and (45), we also have

$$e_{V,A}^{l}-e_{V,A}^{h}=\frac{\theta(\beta-1)(1-\alpha\theta)}{[(1-\alpha)\beta-1][(1-\alpha)\beta+\alpha\theta-1]},\quad e_{V,\gamma}^{h}-e_{V,\gamma}^{l}=\frac{1-\alpha\theta}{(1-\alpha)\beta+\alpha\theta-1},$$

$$e_{V,B}^{l}-e_{V,B}^{h}=\frac{\alpha\theta(1-\alpha\theta)}{[(1-\alpha)\beta-1][(1-\alpha)\beta+\alpha\theta-1]},\quad e_{V,\varepsilon}^{l}-e_{V,\varepsilon}^{h}=\frac{\alpha\theta\beta(1-\alpha\theta)}{[(1-\alpha)\beta-1][(1-\alpha)\beta+\alpha\theta-1]}.$$

We immediately have

$$e_{V,A}^{l}-e_{a,A}^{h}>e_{V,\varepsilon}^{l}-e_{V,\varepsilon}^{h}>e_{V,B}^{l}-e_{V,B}^{h}.$$

Also, iff $\theta>1-\frac{\alpha\beta}{\beta-1}$, we have

$$e_{V,A}^{l}-e_{V,A}^{h}>e_{V,\gamma}^{h}-e_{V,\gamma}^{l}.$$

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