Does Bank Structure Matter?

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ABSTRACT

This paper addresses the question of whether a mega-bank or monopolistic banking system can lead to a higher steady state level of capital stock. There is substantial evidence of a positive relationship between financial market development and long-term output growth. Little is known, however, about the role played by the market structure of the banking sector on growth. In addition, little work, if any, has attempted to analyze how the degree of information externality affects the relative performance of a monopoly bank and competitive banks.

This paper shows that the optimal bank structure is dependent upon the degree of information externality, associated with financial market development and the stage of economic development. That is, the monopolistic banking system has better perforamance in accumulating capital stock in the under-developed and advanced countries, while the competitive banking system has better in the developing countries. In addition, this paper shows that 승 monopolistic banking system obtains higher steady state level of capital as information externality increases.

This result suggests that not only developing countries but also industrial countries may benefit from a concentrated banking system. Hence, this provides an alternative explanation of the recent deregulation and resulting trends in mergers and acquisitions.

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I. Introduction

This paper addresses the question of whether a monopolistic banking system can lead to a higher steady state level of capital stock. Specifically, this research examines factors that contribute to the promotion of economic growth that comes from a concentrated banking system.

Although several studies have recently addressed the issue of whether a monopoly banking system has better performance in terms of economic growth, there have been theoretical debates over the effects of competition on capital accumulation and real economic activities. Conventional wisdom suggests that competition promotes efficiency. In this view, a monopoly bank would exercise its monopoly power to extract rents by charging higher loan rates and/or by paying lower deposit rates. The resulting decreased supply of funds and the associated higher lending rates would lead to a slower process of capital accumulation. Smith (1998) and Guzman (2000) provide support for conventional wisdom by showing that a competitive banking system performs better in accumulating capital stock.

However, some argue that the literature on efficiency in banking does not consider how the banking industry differs from other industries.[1] For example, Allen and Gale (2000) argue that the standard competitive paradigm is not appropriate for the banking industry. One of the crucial limits of the conventional wisdom is that it is not consistent with historical evidences.[2] Petersen and Rajan (1995), Caminal and Matutes (1997) and Schnitzer (1998) show that a monopoly banking system performs better for promoting economic growth. They show that a monopoly bank can more easily overcome the problem of asymmetric information by close ties with firms.[3] They also show that a monopoly bank benefits from choosing the most profitable projects by reducing adverse selection, and making firms use funds in less risky project by preventing moral hazard.

The above studies have focused on the asymmetric information structure between banks and firms, however, little, if any, work has attempted to explore the effect of information externality[4] on relative performance of a monopoly and a competitive banking system.[5] In addition, little has been said about the policy

1) See Berger and Mester (1997) for the survey of the literature.

2) Cetorelli and Gambera (2001) summarize the effect of concentrated credit market on economic development and industrialization.

3) In addition, as seen in Petersen and Rajan (1995), firms with lower credit quality such as new firms and small firms are able to obtain fund more easily as the number of banks becomes less, since banks have high probability to participate and share the potential future profit of firms. In this view, the loss from extracting rent is compensated by the gain from overcoming the problems associated with asymmetric information and from increasing loan amount to small and new firms.

4) Information externality refers to the fact that once information on firm's credit quality is created, it can be immediately transmitted to other banks.

implications of changes in information externality and market structure. For example, what is the effect of changes in government policy from anti-M&A to pro-M&A?

This paper shows that the presence of information externality together with asymmetric information would explain how an economy with a monopolistic banking system might have a higher steady state level of capital stock than an economy with a competitive banking system. The presence of investment projects subject to a costly state verification is essential to understand how a monopoly bank performs better compared to a competitive bank. It is assumed that the state verification of investment projects (hereafter, I will state it as screening activities) is economically meaningful. That is, the benefits of screening activities exceed the cost.

This paper extends the Cetorelli's (1997) and Bernanke and Gertler (1989) by incorporating several features relevant to the current economic environments. For example, the model allows various degrees of the information externality. Information is treated as both private and public, depending on the degree of the information externality. In addition, this model is more comprehensive one in that it derives and compare the long-run equilibrium of the duopoly banking system and monopolistically competitive banking system as well as competitive banking system and a monopoly banking system. The novelty of this paper is that it provides the framework for analyzing this issue empirically. By performing comparative statics, it is found that the comparative advantage of a monopoly banking system depends on overall income level, the degree of financial market development, the types of financial market system, i.e. bank-based and capital market-based.

The major finding of this paper is that a monopoly banking system might lead to better performance in accumulating capital stock under both a low and a high degree of information externality. This is opposite result to the conventional wisdom, see e.g. Cetorelli's (1997). A monopoly bank benefits from the allocative efficiency associated with screening activities (specifically, screening activities are closely related to the relationship banking) and the absence of a free riding problem associated with information externality.

In addition, this paper shows that the comparative advantage of a monopolistic banking system depends on the degree of information externality as well as the economic development. In other words, as the degree of information externality increases, a monopoly banking system is more likely to achieve a higher level of steady-state capital stock. Moreover, a monopoly banking system may lead a higher steady state level of capital when it is both the low stage of economic development and high stage of economic development. This suggests that industrial countries as well as developing countries may benefit from a concentrated banking system. This result is not found in the existing literature, which has only shown that only

5) Cetorelli (1997) firstly introduces the effect of information externality on this issue. In the paper, however, he does not explain the effect of various degree of information externality since he assumes the perfect information externality.

developing countries may benefit from a concentrated banking system.

This analysis provides an alternative explanation of the recent deregulation and resulting trends in mergers and acquisitions, as well as an explanation for the apparent government policy changes from anti-M&A to pro M&A.

The remainder of the paper proceeds as follows. In section II, the model and its relevant factors are described. Section III analyzes the effect of bank structure on the lending strategy and derives equilibrium in each banking system. Section IV compares the long run equilibrium of capital in the competitive banking system with that in the monopoly banking system. In Section V, comparative static analysis is performed. Section VI concludes this paper and discusses policy implications.

II. The Model

This paper in general employs the model based on the Cetorelli's (1997) by making some amendment and adjustment.[6] This paper employs a standard two-period lived, overlapping generations model with production.[7] Population is assumed to be constant and each generation is composed of a continuum of agents with unit mass.[8] Time is discrete, and indexed by t = 0, 1, 2, ⋯

Every period, there are two generations, the young and the old, and a single good is produced. Young agents are endowed with one unit of labor, which is supplied inelastically at the real wage w_t and endowed with one indivisible investment project. The size of the investment project is assumed to be identical across firms. However, they have no endowment of capital stock or goods.

Young generations are divided into two types, depending on the quality of their endowed investment project, which we label Type 1 (the high-quality) and Type 2 (the low-quality). Young agent knows their own types. Type 1 young agents comprise a fraction $\Phi \in (0,1)$, while Type 2 a fraction $(1-\Phi)$ of the population.[9]

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6) The main differences are as follows. Firstly, this paper uses the standard model to deal with asymmetric information problem. Secondly, this model generalizes the effect of information externality on the comparative advantage of bath banking system, which explains historical evidences better. Thirdly, this model accommodates the oligopoly banking system and the monopolistically competitive banking system. Lastly, it provide the tools for analyzing this issue empirically.

7) The overlapping generations model has the advantage of providing a tractable framework for dynamic general equilibrium analysis, into which heterogeneity among borrowers and lenders is easily incorporated. See Bernanke and Gertler (1989)

8) The assumption of a unit mass of workers implies that we will generally have to handle in per capita basis rather than aggregate basis.

9) In this paper, I will use the heterogeneous agent model. We can use the homogeneous agent model alternatively to incorporate the nature of uncertainty. Both approaches have no difference in its results.

Young agents, both Type 1 and Type 2, are potential firms. They can access to a production technology that has a two-stage process as in Cetorelli (1997); investment and production. In the investment stage, a firm makes an investment to produce physical capitals. The size of the investment project is assumed to be identical across firms. The investment project is such that it transforms one unit of goods at the beginning of period t into one unit of capital at the end of period t.

The outcome of this stage is either success or failure. Type 1 young agents are successful in the investment with probability of $p_I \in [0,1]$ and unsuccessful with probability of $(1-p_I)$, while Type 2 young agents are successful with probability of $p_{II} \in [0,1]$ and unsuccessful with probability $(1-p_{II})$. Without loss of generality, it is assumed that Type 1 agents always succeed in the investment, while Type 2 agents are doomed to fail, so $p_I = 1$ and $p_{II} = 0$.

The production stage produces a single final good by using physical capital and labor. Type 2 young agent will supply their labor into production line that is owned by Type 1 young agents. K units of physical capital and (1+L)[10] units of labor produce *F(K,1+L)* units of the final good, where *F* is a constant returns to scal e[11] production function. Let $f(k) = F(k,1)$ denote a standard neoclassical intensive production function[12], where $k_t = K_t/(1+L_t)$ is the capital-labor ratio. K_t is aggregate stock of physical capital, which is equivalent to successful investment. Labor market clearing requires $L_t = (1-\Phi)/\Phi$ Hence, $k_t = \Phi K_t$. To fix ideas, a Cobb-Douglas production function is employed:

$$y_t = f(k_t) \equiv k_t^{\gamma},\ 0 < \gamma < 1 \tag{1}$$

where y_t and k_t are production per capita[13], capital per capita at time t, respectively, and γ is the degree of capital intensity of production function.

Old agents have no endowment of either labor or good, and they have no access to the investment project. They have saving from the previous period in the form of deposits and equity capital of banks. Both instruments have identical property of risk.[14] A standard arbitrage argument requires for an interior solution that the rate of return on deposit be equal to the rate of return on equity capital, i.e.

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10) Type 1 young agents works for themselves (1) and hire Type 2 young agent (L).

11) Obviously, mergers among banks show scale of economy, according to the results of previous studies. However, to concentrate how the degree of information externality affects relative performance of both a competitive and a monopoly banking system, I assume a constant return to scale. When we assume increasing return to scale, we have a consistent conclusion that a monopoly bank always performs better.

12) It is assumed that $f(k)$ is a smooth, increasing, and strictly concave function with $f(0) = 0$, i.e. $f_k > 0$, $f_{kk} < 0$ and Inada conditions hold.

13) Throughout the paper, "per capita" means "per member of a given generation".

14) The standard arbitrage argument holds when both instruments for savings lie same sphere of risk. In other words, When they have different property of risk, the rate of return of each instrument differ reflecting the risk premium.

$r^d = r^e$. At the end of period, the old consume all they have before dying. It is also assumed that the initial old generations have an aggregate endowment of final goods, $K_0 > 0$, distributed equally among all of them.

Agents' labor supply, consumption and saving behavior are described in a simplest way. For example, labor supplies are fixed[15] and supplied unelastically, so that competitive market wage is determined by w_t. All agents are assumed to be identical with respect to their preferences, and there is no disutility of labor. Utility is derived from consuming the final good both when young and when old. They have identical utility functions of the constant relative risk aversion (CRRA)[16] form.

$$\underset{c_t, c_{t+1}}{Max} \quad U(c_{1,t}, c_{2,t+1}) = c_{1,t}^{\alpha} + \beta c_{2,t+1}^{\alpha}, \quad \alpha < 1 \tag{2}$$

$$s.t \quad c_{1,t} = w_t - s_t$$

$$c_{2,t+1} = s_t r_{t+1}$$

The subscript 1 denotes young, and 2 denotes old generations. Another subscript t refers time. Hence, $c_{1,t}$ denotes the consumption of a young agent at time t, born at period t and $c_{2,t+1}$ refers the consumption of a old agent at time t+1, born at period t. Hence the combination of $c_{1,t}$ and $c_{2,t+1}$ is the lifetime consumption of a agent born at time t. $U(\cdot)$ is a twice differentiable Bernoulli utility function, and β is a discount factor. See Appendix A for derivation of the problem of agent's utility maximization

Banks are institutions owned by old agents as in Cetorelli and Peretto (2000). They intermediate resources between old agents born at t-1 and young agents born at t at the beginning of time t. At the end of time t, banks recover loans from successful young agents and repay principal and interest to old agents. Banks make profits, which are part of the resources that the old use to finance consumption.

The loan contract between a bank and a firm is assumed to follow standard single period debt contracts as in Sharpe (1990). A single-period debt contract consists of a gross real interest rate on loans, R_t^L, and the corresponding repayment schedule,

$$\begin{cases} l_t R_t^L & \text{if } Type1 \\ \nu & \text{if } Type2 \end{cases} \tag{3}$$

15) As in Bernanke and Gertler (1989), the author focuses only on explaining investment fluctuations rather than employment fluctuations. Extensions of the results to the various employment cases are straight forward in principle.

16) Given a twice differentiable Bernoulli utility function u(.), the coefficient of relative risk aversion at c is $r_R(c, u) = -cu''(c)/u'(c)$. Models with constant relative risk aversion are encountered often in finance theory, where they lead to considerable analytical simplicity. Under this assumption, no matter how the wealth of the economy and its distribution across individuals evolves over time, the consumption and saving decisions of individuals do not vary as long as the interest rate on deposits remain same. See Mas-Colell, Whinston and Green (1995) p.194

where l_t is the size of the loan, equivalent to the indivisible project size chosen by a firm at time t, and ν refers to either the residual values of a investment or the penalties levied to unsuccessful young agents. The final goods used in investment are assumed to be completely depreciated as in Bernanke and Gertler (1989). Type 2 agents, hence, will default as in Azariadis (1993).

Definition 1: Let $\theta^2_P(\nu)$ and $\theta^2_{NP}(\nu)$ be the Type 2 young agents' expected income when they start investment project and they do not engage investment project, respectively.

Proposition 1: There exists a critical level of penalty, ν^*, such that $\theta^2_P(\nu^*) = \theta^2_{NP}(\nu^*)$ for Type 2 young agents, and $\theta^2_P(\nu) \geq \theta^2_{NP}(\nu)$ for $\nu \leq \nu*$ and $\theta^2_P(\nu) < \theta^2_{NP}(\nu)$ for $\xi > \xi^*$.

Proof : Appendix B

It is also assumed that no penalty is levied to assure that a bank plays an important role in this model economy.[17)]

Banks do not know the types of an individual agent. They know, however, aggregate measure of the proportion of Type 1 agents of the population.[18)] It is also assumed that banks can access the screening technology[19)] that enables them to distinguish Type 1 from Type 2 agents with certainty before they provide credit. The screening technology is assumed to be economically meaningful. That is, the benefit from screening is greater than the screening cost. The screening cost is assumed to be proportional to the amount lent.[20)] Note that banks lend all available funds. Hence, screening cost is proportional to savings, i.e. $b=(1-\mu)s_t$ where μ is the measure of the level of development of the screening technology.[21)] The benefit of

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17) The critical level of penalty, $\nu*$ is positively correlated with the type 2 young agents' probability of success in investment project. In the case of some penalties levied to unsuccessful agents, i.e. $\nu > \nu*(=0)$, we have a separating equilibrium in this model. That is, Type 1 agents borrow a credit to fund an investment, while Type 2 agents do not. In this case, screening activities of banks are not important.

18) This follows the standard methodology for handling asymmetric information problem between banks and firms. We can use an alternative setting that both agents and banks do not know the probability of success of a project. Both approaches have any effect on the quality of result.

19) The screening activities consist of three functions: consulting, monitoring (ex ante) and auditing (ex post). In this economy, hence, banks play two important roles as in Diamond (1984). First, they collect savings and give a credit to firms, thus achieving diversification of idiosyncratic risk. Second, banks possess economies of scale with respect to gathering information and monitoring firms. From screening technology, banks produce valuable information about quality of entrepreneurs. It is used either only by screen-preformed bank or by all banks, depending on degree of information externality.

20) The advantage of this one is that it makes screening cost depend upon size of banks.

21) Screening technology reflects the developments of financial intermediary. Numerous theoretical models suggest that financial intermediaries can lower the cost of researching potential investments, exerting corporate control, managing risk, mobilizing savings, and

screening is to reduce investment loss from giving credit to low quality firms, i.e. $(1-\Phi)s_i$. Hence, $\mu > \Phi$.

Definition 2: Let $\eta(i) \in (H, D)$ be the perfect information of the agent's Type, where $\eta = H$ if investment is successful and $\eta = D$ if investment is failed.

Definition 3: Let $\tilde{\eta}(i) \in (\tilde{H}, \tilde{D})$ be the noisy signal of $\eta(i) \in (H, D)$.[22]

When a bank is engaged in screening (called a "screening bank"), she can observe a specific agent's Type at the cost of b, while a bank not engaged in screening (called a "outside bank"), she can observe only a noisy signal, $\tilde{\eta}(i) \in (\tilde{H}, \tilde{D})$. All "outside" banks are assumed to observe the same outcome of that signal.[23]

Suppose the conditional distribution function is given by

$$P_r(\tilde{\eta} = \tilde{H}/H) = P_r(\tilde{\eta} = \tilde{D}/D) = (1+\xi)/2$$
$$P_r(\tilde{\eta} = \tilde{H}/D) = P_r(\tilde{\eta} = \tilde{D}/H) = (1-\xi)/2 \quad (4)$$

where $\xi \in [0,1]$ refers to degree of information externality. For example, If $\xi = 0$, i.e. no information externality, then outside banks do not have any clues to distinguish high from low quality firms. If $\xi = 1$, i.e. perfect information externality, outside banks know the firm's quality that is exactly same as a screening bank does.

The assumption of the degree of information externality, except for perfect information externality implies asymmetric outcome observability between screening banks and outside banks, and in turn, it makes banks have to expend some minimum level of resources to make sure they choose high quality projects. In the process of screening, the screening banks learn more about the success of the firm's investment than outside banks do. How degree of information externality affects banks' optimal strategies for screening decision will be investigated in the next section.

conducting exchanges. In addition, the level of financial intermediary development influences savings and allocation decisions in ways that may alter long-run growth rates. See, for example Levine, Loayza, and Beck (2000), Greenwood and Jovanovic (1990), Bencivenga and Smith (1991).

22) The basic idea for noisy signal comes from Type I and II error in statistics. Type I error refers that bank rejects providing credit to high quality firms, i.e. $\Pr(\tilde{\eta} = \tilde{L}/H)$, and Type II error implies that banks accept a loan application and give a credit to low quality firms, i.e. $\Pr(\tilde{\eta} = \tilde{H}/L)$.

23) It is assumed that a firm that rejected previously by one bank will not submit a loan application to other banks. Allowing a subsequent application leads to the "Winners Curse" in that the pool of loan applicants all banks faced is systematically worsening. If a lender has a close tie with a borrower, winners curse problem will be mitigated. See Shaffer (1998)

III. Equilibrium in the Banking System

Consider an economy with N banks, where N is an exogenous number. Setting N=1 allows us to consider a monopoly banking system, and N>1 a competitive banking system.[24] Define $S_t = \int_0^1 s_t^i d_i$ be equilibrium level of aggregate saving of young agents, where s_t^i is saving of young agent i. Note that $S_t = s_t$ with a unit mass as every young agent chooses same amount of savings. The total saving is distributed equally among banks. Hence, a bank receives a saving of $s_{b,t}^j = S_t/N$ where another subscript b denotes bank.

Consider a bank's choices. If a bank engages in screening, he makes a safe loan regardless of what other banks do and of the degree of information externality. However, if the bank does not screen, two outcomes are possible. First, in the case of a high information externality, a bank can learn a firm's quality and makes a safe loan without sustaining the screening cost if one of the other banks screens the firm. Second, if there is a low information externality, or if no other banks screen the firm, a bank makes a risky loan whose expected payoff depends on the unconditional distribution of high quality projects, Φ

To get some useful insight for comparative advantage of each banking system, we need to compare the aggregate credit and physical capital between screening equilibrium and no screening equilibrium.

Definition 4: Let X_t^N, X_t^S be aggregate credits provided to all firms under no screening and under full screening, respectively. In addition, let X_t^R be aggregate credits provided to all firms when banks screen firms with probability $q_t \in (0,1)$.

Definition 5: Let x_t^N, x_t^S be credits provided to an individual firm under no screening, and under full screening, respectively. In addition, let x_t^R be credits provided to an individual firm when banks engage in screening firms with probability $q_t \in (0,1)$.

Proposition 2: For the aggregate credit to all firms by banks, $X_t^N > X_t^R > X_t^S$ holds. However, for the credit to an individual firm, $x_t^S > x_t^R > x_t^N$ holds.

Proof. See Appendix B

Proposition 2 shows that when a bank participates in screening activities, total credit to firms would be reduced because of the costs of screening, however, the credits supplied to firms are completely recoverable as only high quality firms are recipients of loans.

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24) The result of oligopoly banking system converges to that of a competitive banking system. For example, in symmetric, non-cooperative Nash equilibrium, oligopoly banks choose "no screening" as their optimal strategies in the case of high information externality, while choose "screening" in the case of low information externality. The Nash equilibrium for duopoly banks is attached in Appendix C.

1. The Competitive Banking System

The competitive banks are assumed to be simultaneous-move, Nash-competitors. In other words, all banks choose strategies at the same time, which give them maximum payoffs, taking other banks' strategies given.

A bank $j \in N$ chooses a strategy Z_j^m where superscript m refers to a set of strategies, and subscript j denotes a bank j. A set of strategies, m, consists of no-screening(NS) and screening (S). Let "NS=1" and "S=2". For example, Z_j^1 denotes strategy of bank j, which is no screening, and Z_j^2 denotes a strategy of bank j, which is screening. A bank chooses its optimal strategies, either no screening or screening simultaneously, considering other banks' strategies and corresponding payoffs.[25)]

In the Nash equilibrium, each bank has symmetric payoffs. In other words, the payoffs of a bank under a strategy bundle (Z_1^1, Z_2^2) equal that of other bank under a strategy bundle (Z_1^2, Z_2^1). The optimal strategies and payoffs for a competitive bank vary, depending upon the degree of information externality, ξ

Definition 6: Let a competitive bank's profit be denoted by $\pi_c^S(\xi)$ under screening equilibrium, and by $\pi_c^{NS}(\xi)$ under no screening equilibrium, respectively.

Proposition 3: There exists a critical degree of information externality, ξ^* such that $\pi_c^S(\xi^*) = \pi_c^{NS}(\xi^*)$ for competitive banks, and $\pi_c^S(\xi) > \pi_c^{NS}(\xi)$ for $\xi < \xi^*$ and $\pi_c^S(\xi) < \pi_c^{NS}(\xi)$ for $\xi > \xi^*$.

Proof. See Appendix B.

Proposition 4: The screening banks are getting higher payoffs as the financial market advances.

Proof. See Appendix B.

Definition 7: A strategy profile $Z^* = (Z_1^{m*}, Z_2^{m*}, \ldots, Z_N^{m*})$ constitutes a Nash equilibrium for the competitive banks if for every j=1, 2, . ., N, , $\pi_j = 0$ and $\pi(Z_j^{m*}, Z_{-j}^{m*}) \geq \pi(Z_j^{m'}, Z_{-j}^{m*})$ for all $Z_j^{m'} \in Z_j$.

Proposition 5(No screening Equilibrium): The unique Nash equilibrium of the competitive banks is $Z_j^* = Z_j^1$ for every j=1, 2, . ., N if $\xi > \xi^*$.

Proof. See Appendix B.

Proposition 5 shows that competitive banks have no incentive to be engaged in screening activities in the case of substantially higher degree of information externality. Instead, they want to diversify risk by lending all firms indiscriminately.

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25) The payoffs for a bank are its profits. Profits equal the revenue minus funding and screening cost. The revenue of a bank is determined by the interest rates on lending, R_{t+1}^L, multiplied by the successful physical capital. The cost of funds for a bank is determined by the interest rates on deposit (or the return on equity capital), r_{t+1}, multiplied by total saving. The cost of screening is proportional to savings, as mentioned.

Hence, of the lending assets (st), lending to only high quality firms (Φ) turns out to be successful (physical capital), i.e. $K_{t+1} = \Phi s^j_t$. Hence the equilibrium capital-labor ratio is given by

$$k_{t+1} = \Phi K_{t+1} = \Phi^2 s^j_t. \tag{5}$$

Rewritten (5) for the entire banking system, we can obtain following relations

$$s_t = \Phi^{-2} k_{t+1} \tag{6}$$

A bank's expected return, hence, will be $R^L_{t+1} \times \Phi s^j_t$ where Φ is the time-invariant proportion of high quality firms. In aggregate, total return of banks will be $R^L_{t+1} \times \Phi s^j_t$. From zero profit condition for the competitive banks,

$$R^L_{t+1} \Phi s_t = r_{t+1} s_t \tag{7}$$

where r_{t+1} is the cost of funds and R^L_{t+1} is the interest rate on loans. R^L_{t+1} and r_{t+1} are well defined demand and supply schedules of capital . Hence, the rental rate for successful physical capital, R^L_{t+1}, and real wage w_t are defined by

$$R^L_{t+1} = \gamma k^{\gamma-1}_{t+1} \tag{8}$$

$$w_{t+1} = (1-\gamma) k^{\gamma}_{t+1} \tag{9}$$

Young agents choose s_t to maximize lifetime consumption. Plugging the optimal amount of saving at time t, s^*_t into CRRA utility function, we can derive r_{t+1}.

$$r^{C1}_{t+1} = (\frac{1}{\beta})^{\frac{1}{\alpha}} [\frac{w_t - s^*_t}{s^*_t}]^{\frac{\alpha-1}{\alpha}} \tag{10}$$

where superscript C1 refers to a competitive banking system with high information externality. By plugging (6) and (9) into (10), we have

$$r^{C1}_{t+1} = (\frac{1}{\beta})^{\frac{1}{\alpha}} [\Phi^2 (1-\gamma) k^{\gamma}_t k^{-1}_{t+1} - 1]^{\frac{\alpha-1}{\alpha}} \tag{10-1}$$

By substitution (6), (8), and (10-1) into (7) and rearrangement, we can derive the following relation which shows equilibrium law of motion for the per capita capital stock, k under high information externality, i.e. $\xi > \xi^*$.

$$\Phi \gamma k^{\gamma-1}_{t+1} = (\frac{1}{\beta})^{\frac{1}{\alpha}} \left(\frac{[\Phi^2 (1-\gamma) k_t{}^{\gamma} k^{-1}_{t+1} - 1]}{[\Phi^2 (1-\gamma) k_t{}^{\gamma} k^{-1}_{t+1} - 1]^{\frac{1}{\alpha}}} \right) \tag{11}$$

Proposition 6(Screening Equilibrium): The unique Nash equilibrium of the competitive banking industry is $Z^*_j = Z^2_j$ for every j=1, 2, . ., N if $\xi < \xi^*$.

Proof. See Appendix B.

As all banks are engaged in screening activities, only high quality firms will receive loans as $p_I = 1$, $p_{II} = 0$. Then, an individual bank can lend a maximum of $\mu s^j_t (= s^j_t - b)$ and all of those credits will be turned into productive capital, i.e. $K_{t+1} = \mu s_t$ in aggregate, and the equilibrium capital-labor ratio is given by

$$k_{t+1} = \Phi\mu s_t \tag{12}$$

Similarly, we can derive deposit interest rates, r_{t+1}.

$$r_{t+1}^{C0} = \left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}}[\Phi\mu(1-\gamma)k_t^{\gamma}k_{t+1}^{-1} - 1]^{\frac{\alpha-1}{\alpha}} \tag{13}$$

where the superscript C0 refers to a competitive banking system with low information externality.[26] Similarly, we can derive the equilibrium law of motion for per capita capital stock, k under low information externality, i.e. $\xi < \xi^*$.

$$\mu\gamma k_{C0}^{\gamma-1} = \left(\frac{1}{\beta}\right)^{-\frac{1}{\alpha}}\left(\frac{\Phi\mu(1-\gamma)k_{C0}^{\gamma-1} - 1}{[\mu\Phi(1-\gamma)k_{C0}^{\gamma-1} - 1]^{-\frac{1}{\alpha}}}\right) \tag{14}$$

2. Monopoly Banking Industry

In this economy, there is only one bank, a monopoly bank. A monopoly bank tries to maximize her profits.

Proposition 7: The unique Nash equilibrium of a monopoly bank is "screening", regardless of the degree of information externality.

Proof. See Appendix B.

Same as the full screening equilibrium in the competitive banking system, $K_{t+1} = \mu s_t$ and $k_{t+1} = \Phi\mu s_t$. The profit maximization problem of a monopoly bank is:

$$\underset{\{s_t\}}{Max} \quad \mu R_{t+1}^{L} s_t - r_{t+1} s_t \tag{15}$$

This is identical to the problem of competitive market under $\xi < \xi^*$. The main difference between monopoly problem and competition with screening problem is how the deposit interest rate is determined. A monopoly bank decides it to maximize its own profit, while a competitive bank chooses it to make zero profit. Similarly, we can derive the equilibrium law of motion in the monopoly credit market.

$$\gamma^2 k_M^{\gamma-1} = \left(\frac{1}{\beta}\right)^{-\frac{1}{\alpha}}\left(\frac{\frac{\Phi(1-\gamma)k_M^{\gamma-1}}{\alpha} - \mu^{-1}}{[\mu\Phi(1-\gamma)k_M^{\gamma-1} - 1]^{-\frac{1}{\alpha}}}\right) \tag{16}$$

(See Appendix B)

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26) Throughout the paper, the screening equilibrium in the competitive banking system is called as equilibrium in the monopolistically competitive banking system. In the economy with incomplete, asymmetric information, banks satisfies the assumption of monopolistically competitive market. For example, it has the property of monopoly market in that a bank has a monopoly power for the firms that she contacts. While it has the property of competitive market in that the number of bank is sufficiently large to assure no excess margin and it is free to enter and/or exit in the market.

IV. Comparison of Steady Level of Capital

Now, the long-run equilibrium of capital obtained in a competitive banking system and in a monopoly banking system will be compared.

Definition 8: Let k_{C1}, k_{C0} and k_M be a steady state level of capital for an economy with a competitive banking system(high information externality), a monopolistically competitive banking system (low information externality) and a monopoly banking system, respectively, such that

$$\Phi\gamma k_{C1}^{\gamma-1}=\left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}}\left(\frac{\Phi^2(1-\gamma)k_{C1}^{\gamma-1}-1}{[\Phi^2(1-\gamma)k_{C1}^{\gamma-1}-1]^{\frac{1}{\alpha}}}\right)\ (\xi>\xi^*) \tag{17}$$

$$\mu\gamma k_{C0}^{\gamma-1}=\left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}}\left(\frac{\Phi\mu(1-\gamma)k_{C0}^{\gamma-1}-1}{[\mu\Phi(1-\gamma)k_{C0}^{\gamma-1}-1]^{\frac{1}{\alpha}}}\right)\ (\xi<\xi^*) \tag{18}$$

$$\gamma^2 k_M^{\gamma-1}=\left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}}\left(\frac{\frac{\Phi(1-\gamma)k_M^{\gamma-1}}{\alpha}-\mu^{-1}}{[\mu\Phi(1-\gamma)k_M^{\gamma-1}-1]^{\frac{1}{\alpha}}}\right) \tag{19}$$

The left-hand side of each equation denotes the marginal revenue (MR), while the right-hand side refers to the marginal cost (MC) of lending assets for a bank. Each equation shows that in equilibrium, marginal revenue will be equal to the marginal cost.

Proposition 8: All economies converge to unique steady state levels of capital.

Proof. See Appendix B.

Proposition 9: Under the competitive banking system, the steady state level of capital decreases as information externality increases, i.e. $k_{C0}>k_{C1}$ as ξ increases.

Proof. See Appendix B.

Proposition 9 supports the conventional wisdom in that market equilibrium in general is inefficient in the presence of externalities.[27] Hence, this result implies that the competitive equilibrium may not be a pareto-optimal as the information technology advances.

Proposition 10: In the case of low information externality, i.e. $\xi<\xi^*$, the steady state level of capital in the (monopolistically) competitive banking system is strictly higher than that in the monopoly banking system if $\mu>\gamma$.

Corollary 1: The monopoly banking system has strictly higher steady state level of capital than the monopolistically competitive banking system only if $\mu\ll\gamma$.

Proof. See Appendix B.

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27) When there is an information externality and if banks fail to internalize the externality, banks invest less, which implies "no screening" in this paper. Mergers and acquisitions are suggested as one of the solutions for the externalities problem. For the details, see Coase (1960) and Hendricks and Porter (1996).

Intuitively, if both competitive banks and a monopoly bank are participating in screening activities, then the advantage of allocative efficiency in monopoly banking system will be washed away. In this case, the loss in output associated with typical rent extraction activities of a monopoly bank generally leads to inefficiency of economy.

Low information externality, however, implies that there is low level of financial market development and no credit pooling system to share the credit information among financial intermediaries. Considering the condition of low information externality, hence, Corollary 1 is more appropriated, which implies that given the capital intensive production technology, γ the monopoly banking system may perform better.[28] Both the under-developed countries and developing countries might satisfy this condition.

Proposition 11: In the case of high information externality, i.e. $\xi > \xi^*$, the monopoly banking system has strictly higher steady state level of capital than the competitive banking system if $\Phi < \gamma$.

Corollary 2: The steady state level of capital in the competitive banking system is strictly higher only if $\Phi \gg \gamma$.

Proof. See Appendix B.

Intuitively, it is clear. Given the capital intensive production technology, γ the loss in output associated with lending capital to lower quality firms would be high when the proportion of high quality firms were lower, i.e. high credit risk. Then the value added by screening activities would be large enough to compensate the loss in output associated with the typical rent extraction activity of the monopoly.

28) The condition $\gamma \gg \mu$ is a necessary condition, not sufficient. The sufficient condition is that the marginal cost in the monopoly banking system, MC_M is strictly lower than that in the competitive banking system, MC_{C0}. The economic intuition for $\gamma \gg \mu$ to be necessary condition is that even if the financial sector is under-developed, there is still a room to benefit from the competitive banking structure.

V. Comparative Statics

To analyze the effect of information externality on comparative advantage of each market system, let us define $\breve{\xi}$ as a critical level of information externality, which equates the payoffs in the monopoly banking system to that in the competitive banking system.

Definition 9: Let $k_M(\xi)$, $k_C(\xi)$ be the steady state level of capital in the monopoly banking system and in the competitive banking system, respectively.

Proposition 12: There exists a critical level of information externality, $\breve{\xi}$ such that, for any $\alpha, \beta, \Phi, \gamma, \mu$ in their admissible ranges, $k_M(\breve{\xi}) = k_C(\breve{\xi})$ and $k_M(\xi) > k_C(\xi)$ for $\xi > \breve{\xi}$ and $k_M(\xi) < k_C(\xi)$ for $\xi < \breve{\xi}$ if and only if $\mu > \gamma > \Phi > 0$.

Proof. See Appendix B.

Proposition 12 implies that as the information externality increases, a concentrated banking system may lead to a higher output for the economy. To see this, the author performs the comparative static analysis. Comparative static analysis gives us insights for how the equilibrium condition varies as the other parameters of the economy change.

1. Low Information Externality

Here we can compare equation (18) and (19) to perform comparative static. From Proposition 10 and Corollary 1, we know that the comparative advantage between the competitive and the monopoly banking system may vary as the degree of financial market developments.

Definition 10: Let μ^* be a critical value of the level of financial market developments, which equates the steady state level of capital stock in the monopoly banking system to that in the competitive banking system.

Proposition 13: There exists a μ^* such that, for any $\alpha, \beta, \Phi, \gamma, \mu$ in their admissible ranges, $k_M(\mu^*) = k_C(\mu^*)$ and $k_M(\mu) > k_C(\mu)$ for $\mu > \mu^*$ and $k_M(\mu) \le k_C(\mu)$ for $\mu < \mu^*$ if and only if $\gamma > \mu^* \in (0,1)$.

Proof. From Proposition 10 and Corollary 1, we can easily prove above Proposition.

Proposition 13 implies that as the financial markets advance, the competitive banking system may produce a higher output in the case of lower information externality. Intuitively, competitive banks can easily access information on firm's quality without screening as financial markets advance. Then, the advantage of allocative efficiency in the monopoly banking system will be diminishing. Instead, the loss in output associated with typical rent extraction activities of a monopoly bank leads to inefficiency of economy. However, if the financial markets are under-developed, a monopoly bank has a competitive advantage in acquiring and processing information on firm's quality.

To explore the effect of changes in parameters on the relative advantage between monopolistic and competitive banking system, let me define the difference function, Δ_1 as follows: $\Delta_1 = k_M - k_{C0}$.[29] Let $k_1^* = k_M^{\gamma-1}(\mu^*) = k_{C0}^{\gamma-1}(\mu^*)$. Then, $\Delta_1(\mu^*, k_1^*, \alpha, \beta, \gamma, \Phi)$ can be rewritten by

$$\Delta_1(\mu^*, k_1^*, \alpha, \beta, \gamma, \Phi) = (\gamma - \mu^*)\gamma k_1^* - \left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}} \left[\frac{\Phi(1-\gamma)k_1^*(\frac{1}{\alpha} - \mu^*) - (\frac{1}{\mu^*} - 1)}{(\Phi\mu^*(1-\gamma)k_1^* - 1)^{\frac{1}{\alpha}}} \right] = 0$$

(1) The Effect of Φ on μ^*

Now let us explore that how the critical level of screening technology changes as the proportion of high quality firms increases. In other words, I investigate how μ^* varies as Φ changes, i.e. $\partial\mu^*/\partial\Phi$. As μ^* is not written explicitly as a function of Φ, I derive the effect by applying the implicit function theorem on Δ_1. That is,

$$\frac{\partial\mu^*}{\partial\Phi} = -\frac{\partial\Delta_1/\partial\Phi}{\partial\Delta_1/\partial\mu^*} = -\frac{\Delta_{1\Phi}}{\Delta_{1\mu^*}}$$

The sign of $\partial\mu^*/\partial\Phi$ is strictly positive under a certain condition(See Appendix B). That is, the critical level of degree of financial markets development increases as the proportion of high quality firm increases in the case of low information externality. The economic meaning for a higher critical level of financial markets development is that an economy will benefit more from a monopolistic banking system. It is due to the inefficiency from over-investment of information system and severe competition among competitive banks.

(2) The Effect of Degree of Capital Intensity, γ on μ^*

Next let us explore that how the critical level of financial markets development varies as the degree of capital intensity of technology γ changes. Note that the degree of capital intensity of technology can be interpreted by an indicator of the elasticity of capital demand. From this analysis, hence, I will answer the following question: Is a competitive banking system better for capital-intense countries (mainly industrial countries) or labor-intense countries (mainly developing countries)? Moreover, which banking system performs better if a country has a high (low)

29) We know from Proposition 10 and Corollary 1 that $\Delta_1 > 0$ as $\gamma \gg \mu$ and $\Delta_1 < 0$ as $\mu > \gamma$. In order for the difference function, Δ_1 to be continuous function in μ, hence, $\gamma > \mu^*$ must be held.

elasticity of capital demand?

To investigate how μ^* varies as γ changes, i.e. $\partial\mu^*/\partial\gamma$, I also apply the implicit function theorem on Δ_1.

$$\frac{\partial\mu^*}{\partial\gamma} = -\frac{\partial\Delta_1/\partial\gamma}{\partial\Delta_1/\partial\mu^*} = -\frac{\Delta_{1,\gamma}}{\Delta_{1,\mu^*}}$$

The sign of $\partial\mu^*/\partial\gamma$ is strictly negative if $\mu^* > 2\gamma$. Let us take a considering the condition of $\mu^* > 2\gamma$, which implies that a monopoly banking system is more likely to lead to higher steady state level of capital stock. Hence, it implies that the comparative advantage of the monopoly banking system will be diminishing as the economy has higher elasticity of capital demand. Intuitively, the negative repercussion on capital formation, associated with rent extraction activity in the monopolistic banking system, becomes worse as an economy has higher elasticity of capital demand. This result is consistent with historical evidence.

This is the case of the combination of the low information externality, i.e. under-developed in financial sector and high growth in real sector. The ASEAN countries might be a example of being classified to this category. Hence, those countries can promote economic growth if they set up financial system more competitively.

Countries with bank-based financial markets system such as Japan and Germany and those with market-based financial system such as United States and United Kingdom might have a different property on the elasticity of capital demand. For example, bank-based countries might have lower elasticity of capital demand than market-based countries, in general. Hence, this result gives some empirical implications about whether the effect of a concentrated banking system on real economic activities will differ among countries with different financial markets system.

2. High Information Externality

In the case of high information externality, we can compare equation (17) and (19) to perform comparative static. From Proposition 11 and Corollary 2, we know that the comparative advantage between the competitive and the monopoly banking system varies as the proportion of high quality firms in the economy changes.

Definition 11: Let Φ^* be a critical value of the proportion of high quality firms, which equate the steady state level of capital stock in the monopoly banking system to that in the competitive banking system.

Proposition 14: There exists a Φ^* such that, for any $\alpha, \beta, \Phi, \gamma, \mu$ in their admissible ranges, $k_M(\Phi^*) = k_C(\Phi^*)$ and $k_M(\Phi) > k_C(\Phi)$ for $\Phi < \Phi^*$ and $k_M(\Phi) \le k_C(\Phi)$ for $\Phi > \Phi^*$ if and only if $\gamma < \Phi^* \in (0,1)$.

Proof. From Proposition 11 and Corollary 2, we can easily prove the Proposition.

Proposition 14 implies that as the proportion of high quality firms increases, the competitive banking system may produce a higher output for the economy. Intuitively, the advantage of allocative efficiency in the monopoly banking system will be diminishing as high quality firm increases. In this case, the loss in output associated with typical rent extraction activities of a monopoly bank dominates the advantage of allocative efficiency. This, in turn leads to inefficiency of economy.

To explore the effect of changes in parameters on the relative advantage between monopolistic and competitive banking system, let me define the difference function, Δ_2 as follows: $\Delta_2 = k_M - k_C$.[30] Let $k_2^* = k_M^{\gamma-1}(\Phi^*) = k_C^{\gamma-1}(\Phi^*)$. Then, $\Delta_2(\Phi^*, k_2^*, \alpha, \beta, \gamma, \mu)$ can be rewritten by

$$\Delta_2(\Phi^*, k_2^*, \alpha, \beta, \gamma, \mu) = (\gamma - \Phi^*)\gamma k_2^* - \left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}} \left[\frac{\frac{\Phi^*(1-\gamma)}{\alpha} k_2^* - \mu^{-1}}{(\Phi^* \mu(1-\gamma)k_2^* - 1)^{\frac{1}{\alpha}}} - \frac{\Phi^{*2}(1-\gamma)k_2^* - 1}{(\Phi^{*2}(1-\gamma)k_2^* - 1)^{\frac{1}{\alpha}}} \right] = 0$$

Similarly, we can explore that how the critical level of high quality firm's ratio changes as the financial markets advance and as production technology changes. In other words, I investigate how Φ^* varies as μ and γ changes, respectively.

As $\Phi^*$is not written explicitly as a function of μ and γ I derive the effect by applying the implicit function theorem on Δ_2. That is,

$$\frac{\partial \Phi^*}{\partial \mu} = -\frac{\partial \Delta_2 / \partial \mu}{\partial \Delta_2 / \partial \Phi^*} = -\frac{\Delta_{2\mu}}{\Delta_{2\Phi^*}} \quad \text{and} \quad \frac{\partial \Phi^*}{\partial \gamma} = -\frac{\partial \Delta_2 / \partial \gamma}{\partial \Delta_2 / \partial \Phi^*} = -\frac{\Delta_{2\gamma}}{\Delta_{2\Phi^*}}$$

The results of the comparative statics are as follows.

First, $(\partial \Phi^* / \partial \mu) > 0$ if the steady state level of capital level of capital is more than a certain level. In other words, the critical level of high quality firm's ratio increases as the financial markets advance. The economic meaning for higher critical level of high quality firm's ratio is that the economy benefits more from a monopoly banking system. Hence, the monopoly banking system has a better performance in reaching higher steady state level of capital as the financial markets advances.

Second, $(\partial \Phi^* / \partial \gamma) < 0$ if $\Phi^* > 2\gamma$ and the steady state level of capital level of capital is more than $[\Phi^* \mu (1-\gamma)]^{-1}$. The condition of $\Phi^* > 2\gamma$ implies that the monopolistic banking system has more likely to lead to higher steady state level of capital stock. Hence, we can conclude that the negative repercussion on capital formation, associated with rent extraction activity in the monopolistic banking system becomes worse as an economy has a higher elasticity of capital demand. This result is consistent with historical evidences.

30) We know from Proposition 11 that $\Delta_2 > 0$ as $\gamma > \Phi$ and $\Delta_2 < 0$ as $\Phi \gg \gamma$. In order for the difference function, Δ_2 to be continuous function in Φ hence, $\gamma < \Phi^*$must be held.

VI. CONCLUSION AND POLICY IMPLICATIONS

This paper explores the effect of banking market structure on capital accumulation under different degree of the information externality. Specifically, it explores how the degree of information externality affects the bank's decision on screening activities and resulting long-run equilibrium of capital stock

This paper shows that allocative efficiency from screening activity and efficient provision of screening from free riding problem are major factors for a monopoly banking system to reach a better performance in accumulating capital. In addition, it shows that a monopoly banking system might have better performance as the information technology advances and the financial markets develop

In addition, this paper suggests that there appears to be some relationship between economic development and optimal market structure in banking industry. It also suggests that there is relationship between information externality and market structure. For example, in an early stage of economic development, a monopolistic banking system might be more effective to achieve higher steady state level of capital and economic growth. In this stage, both financial market development (μ) and the proportion of high quality firms (Φ) are likely to be low. Hence, the following conditions, $\mu < \gamma$ and/or $\Phi < \gamma$ will be easily satisfied, as shown in the Proposition 11 and Corollary 1.

The competitive banking system might be better in the middle stage of economic development, where real sector starts to improve but financial sectors are still under-developed. However, as financial markets advance, information externality becomes increase, which suggests that a monopolistic banking system regains its comparative advantage for accumulating capital.

The results of comparative static also show that a monopoly banking system has a comparative advantage as financial markets advance and the credit risk is lower. However, a competitive banking system has a comparative advantage as an economy shows a high elasticity of capital demand. This result gives us empirical questions whether the effect of concentrated banking system on real economic activities will differ among countries with different financial systems and different economic conditions.

This result provides an alternative explanation for the recent deregulation and resulting trends in merger and acquisition both in the industrial countries and in the developing countries. Hence, this result can provide a theoretical foundation to support the policy change from anti-M&A to pro-M&A observed in different countries.

As we have seen from empirical evidence, banks have made a huge investment on networking and computerization to respond to the strategic uncertainty. As keeping the information technology "in-house" is a way to keep future options open and diversify across possible areas of future focus[31], a competitive banking system leads to overinvestment on information technology. Hence, a concentrated banking system through the mergers and acquisitions can be beneficial to the economy since it gives an economy of scale as well as the synergy effect from information sharing.

This paper should be considered as a first step in incorporating the level of economic development, financial markets development and information externality into the analysis of the effect of the banking market structure on the economic growth. Accordingly, there are a number of possible extensions.

First, in this model there is only a single good, there is no government sector, and banks are not regulated. Exploring the desirability of regulatory intervention, and allowing some scope for fiscal and monetary policy to affect the operation of the financial system would be important topics for further investigation. For example, in this paper, I assume that banks are owned by old agents. This assumption makes it simply to analyze. However, when we incorporate new agents, bank owner and bank regulator, into this model, we can analyze bank manager's incentive and policy implication of bank regulator.

Second, this paper analyzes the equilibrium law of motion for capital stock under different banking market structures. Exploring the transitional dynamics under different banking market structure would be interesting for future project, too. Third, whereas this paper assumes that banks and firms are identical in size among themselves, it would be more realistic to introduce bank and firm size as a source of asymmetry into the model. Asymmetric bank and firm size gives the larger bank and firm a higher degree of monopoly power at the occurrence of transaction, which in turn, influences strategic interaction among banks and/or among firms. Pecorino (2001) analyzes the effect of changes in industry structure on the ability to maintain a cooperative equilibrium in a repeated game setting. He allows size difference among firms and finds the following results. When the market share of the largest firm rises holding the size distribution of firms within the "fringe", the changes in cooperation level among firms is not determined. However, when the number of identical firms in the fringe increases, cooperation becomes more difficult.

It is also interesting to model endogenous meager which depends on the degree of information externality. There is empirical evidence that the relationship between the number of banks and social welfare is an inverted U-shape. This implies that neither competitive banking system nor monopoly banking system are not pareto-dominant. Although the result in this paper suggests that it depends on information externality, it could be interesting if the number of banks gets to be chosen depending on the degree of information externality.

31) This argument comes from the theory developed by Boot et al (1998). In this context, the enormous premia that have been paid in M&A would be rationalized in part by the large projected savings in information technology expenses by the merging banks. See Thakor (1999)

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Appendix A
Agents' Utility Maximization Problem

Young agents derive utility from consuming final goods both when they are young and when old. Let $c_{1,t}$ denote consumption of young agent at time t, and let $c_{2,t+1}$ denote consumption of old agent at time t+1. An agents is assumed to care about his lifetime consumption.

A Type 1 young agent wants to maximize his own utility. As a young agent has preference for operating his own business, a Type 1 young agent makes an investment to produce physical capital. To make investment, he borrows from banks. His investment turns out to be success and he obtains physical capital. A Type 1 young agent produces final good using physical capital and labor and then pays back loans to banks. So he has following disposable income.

$$DI_t^1 = F(l_t, 1+L_t) - w_t L_t - R_t^L l_t \qquad \text{(A.1)}$$

where superscript 1 refers to Type 1 (high productivity) young agents, $F(l_t, 1+L_t)$ is production using physical capital ($l_t = K_t$) and labor ($1+L_t$). R_t^L is the gross interest rate on loans A young agent makes a decision how much he consumes at current period and how much he consumes at next period. Hence, $c_{1,t}^1$ and $c_{2,t+1}^1$ are given as follows.

$$c_{1,t}^1 = DI_t^1 - s_t^1, \quad c_{2,t+1}^1 = r_{t+1} s_t^1 \qquad \text{(A.2)}$$

The utility maximization problem of a Type 1 young agent, hence, is as follows.

$$\max \quad U(c_{1,t}^1, c_{2,t+1}^1) = (c_{1,t}^1)^\alpha + \beta (c_{2,t+1}^1)^\alpha \qquad \text{(A.3)}$$

$$s.t \;\; c_{1,t}^1 = F(l_t, 1+L_t) - R_t^L l_t - w_t L_t - s_t^1$$

$$c_{2,t}^1 = r_{t+1} s_t^1$$

As mentioned, young agents save for future consumption in the form of deposits (d_t) and equity capital of banks (e_t), i.e. $s_t = d_t + e_t$. Let r_{t+1}^D be deposit interest rates and let r_{t+1}^E be rate of returns on equity capital. No arbitrage condition guarantees that revenue from deposits is exactly same as revenue from equity capital, i.e. $r_{t+1}^D = r_{t+1}^E = r_{t+1}$.

The competitive markets for capital and labor guarantee the following demand schedules:

$$R_t^L = \frac{\partial F(l_t, 1+L_t)}{\partial l_t} = F_1(l_t, 1+L_t) = F_1(K_t, 1+L_t) \qquad \text{(A.4)}$$

$$w_t = F_2(K_t, 1+L_t) \qquad \text{(A.5)}$$

as $l_t = K_t$.

By applying Euler's Theorem, (A.1) can be rewritten as

$$
\begin{aligned}
DI_t^1 &= F(l_t, 1+L_t) - w_t L_t - R_t^L l_t \\
&= l_t F_1(l_t, 1+L_t) + (1+L_t) F_2(l_t, 1+L_t) - w_t L_t - R_t^L l_t \\
&= l_t R_t^L + (1+L_t) w_t - w_t L_t - R_t^L l_t = w_t
\end{aligned}
\qquad \text{(A.6)}
$$

Hence,

$$c_{1,t}^1 = w_t - s_t^1, \quad c_{2,t+1}^1 = s_t^1 r_{t+1} \qquad \text{(A.7)}$$

A Type 2 young agent also wants to maximize his own utility subject to resource constraints. As young agents have preference for operating their own business, a Type 2 young agent makes an investment to produce physical capital in the case of no penalty for default. To make investment, he also borrows credit from banks. His investment turns out to be failure, however. Thus, he is doomed to default. He will supply his labor in successful lines of production and receive competitive real wages, w_t.

Similarly, $c_{1,t}^2$ and $c_{2,t+1}^2$ are given as follows.

$$c_{1,t}^2 = w_t - s_t^2, \quad c_{2,t+1}^2 = s_t^2 r_{t+1} \qquad \text{(A.8)}$$

where superscript 2 refers to Type 2 (low productivity) young agents.
Hence, the utility maximization problem of a Type 2 young agent is as follows.

$$
\begin{aligned}
\max \quad & U(c_{1,t}^2, c_{2,t+1}^2) = (c_{1,t}^2)^\alpha + \beta (c_{2,t+1}^2)^\alpha \qquad \text{(A.9)} \\
s.t \quad & c_{1,t}^2 = w_t - s_t^2 \\
& c_{2,t}^2 = r_{t+1} s_t^2
\end{aligned}
$$

Note that net profits derived from borrowing and investing a physical capital is zero as loan interest rate equals marginal productivity of capital in production function. As both types of young agents have same productivity of labor, Type 1 young agents have same wage income as Type 2 young agents, which is marginal productivity of labor.

As both Type 1 and Type2 young agents have same preference, they will save same amount of real good for the next period consumption. Hence, each agent has identical bundle of consumption at time t and time t+1.

$$c_{1,t}^1 = c_{1,t}^2 = c_{1,t} = w_t - s_t \qquad \text{(A.10)}$$

$$c_{2,t+1}^1 = c_{2,t+1}^2 = c_{2,t+1} = r_{t+1} s_t$$

$$s_t^1 = s_t^2 = s_t = w_t \nu(r_{t+1}) \text{ where } \nu(r_{t+1}) \text{ is } \left(1 + [\beta r_{t+1}{}^{\alpha}]^{\frac{1}{\alpha - 1}}\right)^{-1}.$$

Appendix B.
Proofs

1. Proposition 1

The expected income of Type 2 is $w_t - \nu$ when they make a investment and w_t when they do not. Hence, the critical level of penalty $\nu*$ is zero. If there is a penalty levied on the Type 2, Type 2 young agents do not make a project, while invest a project when there is no penalty.

2. Proposition 2

First, I will show $X_t^N > X_t^R > X_t^S$.

If no banks screen, the total saving from old agents becomes loans supplied to firms, i.e. $X_t^N = S_t$. However, if all banks screen, because of the screening cost, the total credit available credit will be $X_t^S = N(s_{b,t} - (1-\mu)s_{b,t}) = \mu N s_{b,t} = \mu S_t$. When the probability of screening is considered, the total available credit is $X_t^R = q_t X_t^S + (1-q_t) X_t^N = [1-q_t(1-\mu)]S_t$ since the fraction of firms that are screened, $q_t \in (0,1)$. Hence, $X_t^N > X_t^R > X_t^S$

Next, I will show $x_t^S > x_t^R > x_t^N$.

To compare the size of credit for an individual firm, we need the number of firms that receive credit. If there is no screening, all the firms are credit recipients. With mass unit of entrepreneurs, $x_t^N = S_t = s_t$. If all banks screen, only high quality firms (Φ) have access to credit. Hence, x_t^S = $\mu S_t / \Phi = (\mu / \Phi) * S_t$ since $\mu > \Phi$ by definition. When randomizing with probability $q_t \in (0,1)$, the number of firms that have access to credit is $(1-q_t) + q_t \Phi = 1 - q_t(1-\Phi)$. Therefore, the expected credit for an individual firm, $x_t^R = [1-q_t(1-\mu)]S_t / [1-q_t(1-\Phi)]$. Hence, $x_t^S > x_t^R > x_t^N$.

Table 1. Comparison of Credit and Capital

	Full Screening	Randomizing	No Screening
Total Credit	μS_t	$[1-q_t(1-\mu)]S_t$	S_t
Credit per Firms	$(\mu/\Phi)s_t$	$\frac{[1-q_t(1-\mu)]}{[1-q_t(1-\Phi)]}s_t$	s_t
Physical Capital	μS_t	$[\mu q_t + (1-q_t)\Phi]S_t$	ΦS_t

3. Proposition 3

If a bank is engaged in the screening activity, she has to bear following screening costs, $(1-\mu)s_t$. If not, she has the expected profit, calculated as follows: The probability of accept for loan application conditioned that only noisy information is available is

$$(P_r(Loan)) = P_r(\tilde{\eta} = H/H) * P_r(H) + P_r(\tilde{\eta} = H/L) * P_r(L).$$

That is,

$$P_r(Loan) = (1+\xi)\Phi/2 + (1-\xi)(1-\Phi)/2 = (1-\xi+2\Phi\xi)/2$$

As the high quality firms are able to pay back their loan with interest rate, the repayment ratio($P_r(H/Loan)$ of no-screen banks is

$$P_r(H/Loan) = P_r(\tilde{\eta} = H/H)/P_r(Loan) = (1+\xi)\Phi/(1-\xi+2\Phi\xi).$$

Hence, the expected revenue of no-screen banks is

$$P_r(H/Loan) * s_t = (1+\xi)\Phi s_t/(1-\xi+2\Phi\xi).$$

By definition, we can derive the critical level of information externality.

$$\xi^* = \frac{\mu - \Phi}{\Phi + \mu - 2\mu\Phi} \qquad \text{(B.1)}$$

In view of positivity condition of $\xi \in (0,\ 1)$, we can find the range of each variable: $\Phi \in (1/2,\ 1)$ and $\mu \in (1/2,\ 1)$. Under this range of these variables, ξ^* has a range of $0 < \xi^* < 1$.

Hence, if $\xi < \xi^*$, screening gives a bank higher payoff, and vice versa.

However, in a competitive banking system, banks will retreat from engaging in screening activities as the degree of information externality increases, shown in Proposition 2.

4. Proposition 4

By reviewing (B.1), the critical level of information externality converges to zero as the level of screening technology is close to the proportion of high quality firms. Given the proportion of high quality firms, the critical level of information externality increases as screening technology advances, suggesting that screening equilibrium has higher payoffs as financial markets advance.

5. Proposition 5

First, it is shown that $Z_j^* = Z_j^1$ for every j=1, 2,⋯, N is equilibrium. If all banks choose $Z_j^* = Z_j^1$ i.e., "No Screening", the total revenue will be $\Phi R_{t+1}^L s_t$, as they recover loans only for high quality firms. Given the zero-profit condition for the competitive banks, we can derive deposit interest rate, r_{t+1}, which is ΦR_{t+1}^L.

Suppose that a bank j deviates and decides to screen. Since the information about screened high quality firms is revealed to outside banks immediately, and thus outside banks make a better offer to the firms. Of course, as the screened, high quality firms want to borrow at the lowest cost, they make a contract with a bank that offers lowest lending rates. Hence, a screening bank j cannot recover screening cost and makes a loss, i.e. $\pi_j < 0$. There, thus, is no incentive for any banks to deviate from the optimal strategy, i.e. $Z_j = NS$ for every j=1,2,⋯,N. Therefore, $Z_j^* = NS$ is equilibrium.

Next, it is shown that $Z_j^* = NS$ is unique equilibrium. Suppose $Z_{j'} \neq Z_j^1$ is an equilibrium. Then, a bank $j \in j'$ will be subject to free riding and will suffer a net loss as shown $Z_{j'} \neq Z_j^1$ above. If this bank decides to deviate and choose NS, it will benefit from free riding and will make at least zero profits. Therefore, $Z_{j'} \neq NS$ is not equilibrium.

6. Proposition 6

Similarly, it is shown first that $Z_j^*=Z_j^2$, i.e. "Screening", for every j=1,2,⋯,N is equilibrium. If all banks choose to screen, the total revenue will be $\mu R_{t+1}^L s_t$, which is greater than the payoffs of no screening, $\Phi R_{t+1}^L s_t$. Given the zero-profit condition, the deposit interest rate r_{t+1} is μR_{t+1}^L if screened, and ΦR_{t+1}^L if not. Therefore, $Z_j^*=Z_j^2$ is an equilibrium for every j=1,2,⋯,N. Similarly, $Z_j^*=Z_j^2$ is a unique equilibrium.

7. Proposition 7

The expected revenue for a monopoly bank is $\mu R_{t+1}^L s_t$ when she engages in screening activities. That is $\Phi R_{t+1}^L s_t$ when she does not engage in screening activities. By the assumption of $\mu > \Phi$, a monopoly bank screens rain or shine.

8. Profit Maximization Problem for a Monopoly Bank

Objective function : $\mu R_{t+1}^L s_t - r_{t+1}^M s_t$

Subject to: $R_{t+1}^L = \gamma k_{t+1}^{\gamma-1}$, $w_{t+1} = (1-\gamma) k_{t+1}^{\gamma}$, $k_{t+1} = \Phi \mu s_t$

$$r_{t+1}^M = \left(\frac{1}{\beta}\right)^{-\frac{1}{\alpha}} \left[\frac{w_t - s_t}{s_t}\right]^{-\frac{\alpha-1}{\alpha}}$$

Plugging constraints into objective function,

$$\underset{\{k_{t+1}\}}{\mathrm{Max}} \ \Phi^{-1}\gamma k_{t+1}^{\gamma} - \left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}} [\Phi\mu(1-\gamma)k_t^{\gamma}k_{t+1}^{-1} - 1]^{\frac{\alpha-1}{\alpha}} (\Phi\mu)^{-1} k_{t+1}$$

Differentiating with respect to k_{t+1},

$$\frac{\partial \pi}{\partial k_{t+1}} = \Phi^{-1}\gamma^2 k_{t+1}^{\gamma-1} - \left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}} \Phi^{-1}\mu^{-1}[\Phi\mu(1-\gamma)k_t^{\gamma}k_{t+1}^{-1} - 1]^{\frac{\alpha-1}{\alpha}}$$

$$- \left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}} \Phi^{-1}\mu^{-1}k_{t+1}\left(\frac{\alpha-1}{\alpha}\right)[\Phi\mu(1-\gamma)k_t^{\gamma}k_{t+1}^{-1} - 1]^{\frac{-1}{\alpha}}[-\Phi\mu(1-\gamma)k_t^{\gamma}k_{t+1}^{-2}] = 0$$

By rearranging terms,

$$\gamma^2 k_{t+1}^{\gamma-1} - \left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}} \left[\frac{\Phi(1-\gamma)}{\alpha} k_t^{\gamma}k_{t+1}^{-1} - \mu^{-1}\right][\Phi\mu(1-\gamma)k_t^{\gamma}k_{t+1}^{-1} - 1]^{\frac{-1}{\alpha}} = 0$$

Hence,

$$\gamma^2 k_{t+1}^{\gamma-1} - \left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}} \left\{ \frac{\left[\frac{\Phi(1-\gamma)}{\alpha} k_{t+1}^{-1}k_t^{\gamma} - \mu^{-1}\right]}{[\Phi\mu(1-\gamma)k_{t+1}^{-1}k_t^{\gamma} - 1]^{\frac{1}{\alpha}}} \right\} = 0$$

9. Proposition 8

The marginal revenue of each equation (17), (18) and (19) are linearly increasing in $k_{C1}^{\gamma-1}$, $k_{C0}^{\gamma-1}$ and $k_M^{\gamma-1}$, respectively. The marginal cost of (17), (18) and (19) have a vertical asymptote for $k_{C1}^{\gamma-1} = 1/[\Phi^2(1-\gamma)]$ $k_{C0}^{\gamma-1} = 1/[\mu\Phi(1-\gamma)]$ and $k_M^{\gamma-1} = 1/[\mu\Phi(1-\gamma)]$, respectively. Those are converging to zero as $k_{C1}^{\gamma-1} \to \infty$, $k_{C0}^{\gamma-1} \to \infty$, $k_M^{\gamma-1} \to \infty$, respectively. Thus, in all cases, there is unique long run equilibrium, $k_{C1}^{\gamma-1}$, $k_{C0}^{\gamma-1}$, and $k_M^{\gamma-1}$.

10. Proposition 9

Figure I compares equation (17) and (18). Note that $\mu > \Phi$. Therefore, the vertical asymptote for MC_{C0} is strictly lower than that with MC_{C1}. Hence, every point of MC_{C1} is strictly to the right of MC_{C0}. The slope of $k_{C0}^{\gamma-1}$ in MR_{C0} is also steeper than that of $k_{C1}^{\gamma-1}$in MR_{C1}, which implies $k_{C1}^{\gamma-1} > k_{C0}^{\gamma-1}$. Note that as $\gamma < 1$, $k_{C0} > k_{C1}$.

11. Proposition 10 and Corollary 1

Figure II compares the equation (18) with equation (19). From equation (18) and (19), we know that MC_{C0} is strictly lower than MC_M Hence, every point of MC_M is strictly to the right of MC_{C0}. If $\mu > \gamma$, the slope of $k_{C0}^{\gamma-1}$ in MR_{C0} is steeper than that of $k_M^{\gamma-1}$ in MR_M which implies that $k_{C0}^{\gamma-1} < k_M^{\gamma-1}$. Note that since $\gamma < 1$, $k_M < k_{C0}$. However, if γ is much greater than μ i.e. $\gamma \gg \mu$, then the slope of $k_M^{\gamma-1}$ in MR_M is much steeper than that of $k_{C0}^{\gamma-1}$ in MR_{C0}, which may obtain the result that $k_{C0}^{\gamma-1} > k_M^{\gamma-1}$. Note that since $\gamma < 1$, $k_M > k_{C0}$.

12. Proposition 11 and Corollary 2

It is straightforward. Figure III compares the equation (17) and (19). From (17) and (19). We know that every point of MC_{C1} is strictly to the right of MC_M If $\gamma > \Phi$, the slope of $k_M^{\gamma-1}$ in MR_M is steeper than that of $k_{C1}^{\gamma-1}$ in MR_{C1}, which implies that $k_M^{\gamma-1} < k_{C1}^{\gamma-1}$. Note that as $\gamma < 1$, so $k_M > k_{C1}$.

13. Proposition 12

It is straightforward. From Proposition 10 and Proposition 11, we show that the relative performance in each banking system depends on the degree of information externality. That is, in the case of low information externality, competitive banking system has a comparative advantage in general to have high steady state level of capital stock, while monopoly banking system has a comparative advantage in the case of high information externality.

14. The Effect of Φ on μ^*

First, let me differentiate the difference function Δ_1 with respect to Φ then

$$\frac{\partial \Delta_1}{\partial \Phi} = -\left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}} \left[\frac{(1-\frac{1}{\alpha})\mu^*(1-\gamma)k_1^* \left(\Phi(1-\gamma)k_1^*(\frac{1}{\alpha}-\mu^*)+1 \right)}{\{\Phi\mu(1-\gamma)k_1^*-1\}^{\frac{1+\alpha}{\alpha}}} \right]$$

The sign of $\partial\Delta_1/\partial\Phi > 0$ is positive as $\alpha \in (0,1)$. Recall that α denote the shape of saving supply schedule. For example, $\alpha = 1$ means horizontal supply schedule and $\alpha = 0$ means vertical supply schedule.[32] It is obvious, intuitively. If the saving supply is inelastic, the negative effect of rent extraction becomes smaller. In this case, the relative advantage of a monopoly bank is enlarged as the proportion of high quality firm increases.

Next, differentiating Δ_1 with respect to μ^*, we have

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32) From equation (10), we can easily derive the elasticity of saving supply. Let $\varepsilon_{r,s} = (\partial s/\partial r)(r/s)$. Then $\varepsilon_{r,s} = (\alpha/(1-\alpha))((w-s)/s)$. Hence, $\varepsilon_{r,s} \to \infty$ as $\alpha \to 1$ and $\varepsilon_{r,s} \to 0$ as $\alpha \to 0$

$$\frac{\partial \Delta_1}{\partial \mu^*} = -\gamma k_1^* - \left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}} \left[\frac{-\Phi^2(1-\gamma)^2\left(\mu^* + \frac{1}{\alpha}(\frac{1}{\alpha} - \mu^*)\right)k_1^{*2} + \Phi(1-\gamma)\left(1 + \frac{1}{\mu^*} + \frac{1}{\alpha}(\frac{1}{\mu^*} - 1)\right)k_1^* - \frac{1}{\mu^{*2}}}{\{\Phi\mu(1-\gamma)k_1^* - 1\}^{\frac{1+\alpha}{\alpha}}} \right]$$

Let $C = \Phi(1-\gamma)(\mu^* + \alpha^{-1}(\alpha^{-1} - \mu^*))$ and $F = \Phi(1-\gamma)(1 + \mu^{*^{-1}} + \alpha^{-1}(\mu^{*^{-1}} - 1))$. Note that C>0 and F>0. Then, above equation can be rewritten as

$$\frac{\partial \Delta_1}{\partial \mu^*} = -\gamma k_1^* - \left(\frac{1}{\beta}\right)^{\frac{1}{\alpha}} \left[\frac{-C\Phi(1-\gamma)k_1^{*2} + Fk_1^* - \frac{1}{\mu^{*2}}}{\{\Phi\mu(1-\gamma)k_1^* - 1\}^{\frac{1+\alpha}{\alpha}}} \right].$$

It is strictly negative if

$$\frac{F - \sqrt{F^2 - \frac{4C\Phi(1-\gamma)}{\mu^{*2}}}}{2C\Phi(1-\gamma)} < k^* < \frac{F + \sqrt{F^2 - \frac{4C\Phi(1-\gamma)}{\mu^{*2}}}}{2C\Phi(1-\gamma)}.$$

Intuitively, it is obvious. As shown in the previous section, in the case of low information externality, the competitive advantage of monopolistic banking system is diminishing as the financial markets advance. This is consistent with historical evidences. For example, see e.g. Cetorelli (1997).

Hence, $\frac{\partial \mu^*}{\partial \Phi} > 0$ if $\frac{F - \sqrt{F^2 - \frac{4C\Phi(1-\gamma)}{\mu^{*2}}}}{2C\Phi(1-\gamma)} < k^* < \frac{F + \sqrt{F^2 - \frac{4C\Phi(1-\gamma)}{\mu^{*2}}}}{2C\Phi(1-\gamma)}$.

Appendix C.
Duopoly Banking Industry

In this economy, it is assumed that there are N>1banks. Suppose N=2 (Duopoly). The duopoly (N=2) model can be extended to the oligopoly (N>2) model. The results of the duopoly model are the same in quality as that of the oligopoly model. See Cetorelli and Peretto (2000). Both banks are assumed to be Bertrand competitors. In Bertrand competition, each bank chooses its price (i.e., interest rates on deposits and loans) both simultaneously and non-cooperatively. A Nash equilibrium in prices -sometimes referred to as a Bertrand equilibrium- is a pair of prices such that each bank's price maximize that bank's profit given other bank's price. Consider a two stage game. In stage one, the banks decide whether to screen or not. In stage two, they choose the price at the market clearing loan amount. Recall that they lend all available credit.

Let R^L_{t+1} be the loan interest rates charged by bank i. By symmetry, bank i's reaction function is $\Upsilon_i(R^L_j) = R^{L^*}_i$ and bank j's reaction function is $\Upsilon_j(R^L_i) = R^{L^*}_j$. The Nash (Bertrand) equilibrium satisfies $R^{L^*}_i = \Upsilon_i(R^{L^*}_j)$, and $R^{L^*}_j = \Upsilon_j(R^{L^*}_i)$. Note that savings are distributed evenly between banks. This implies that both banks offer the same deposit interest rate. Hence, each bank gathers half of total savings. In this economy, banks are identical both in cost and revenue function. And they have same screening technology. Therefore, there is no incentive for saver to prefer one bank to another bank.

1. No Screening Equilibrium

No duopoly banks will be engaged in screening if the degree of information externality is greater than the critical level of information externality in the banking industry, as mentioned. Note also that high information externality implies that both banks may suffer a free riding problem. Therefore, the bank i's gross profit depends on what other bank do. The profit profile for bank i is:

Π_1: $\pi^{S,S}_i = R^L_{t+1}(x_i - b) - r_{t+1}x_i = R^L_{t+1}(\frac{\mu s_t}{2}) - r_{t+1}\frac{s_t}{2}$ if (both) screen

Π_2: $\pi^{N,S}_i = R^L_{t+1}x_i - r_{t+1}x_i = R^L_{t+1}\frac{s_t}{2} - r_{t+1}\frac{s_t}{2}$ if not screen but other bank screens

Π_3: $\pi^{S,N}_i = R^L_{t+1}\Phi(x_i - b) - r_{t+1}x_i = R^L_{t+1}(\frac{\Phi\mu s_t}{2}) - r_{t+1}\frac{s_t}{2}$ if screen but others not

Π_4 : $\pi^{N,N}_i = R^L_{t+1}\Phi x_i - r_{t+1}x_i = R^L_{t+1}\frac{\Phi s_t}{2} - r_{t+1}\frac{s_t}{2}$ if both do not screen

Proposition C-1: The following relationship holds: $\Pi_2 > \Pi_1 > \Pi_4 > \Pi_3$.

Proof: First, I will show $\Pi_2 > \Pi_1$. In the case of Π_2 (No Screening, Screening), bank i does not screen, but he can recognize high quality firms because another bank screens the firms and the information about the quality of firms are publicized immediately. Hence, bank i can use his all available fund to lend to only screened high quality firms. In the case of Π_1 (Screening, Screening), bank i can recognize high quality firms with cost of screening. Therefore, the amount of loan is less than that in case Π_2. Therefore, $\Pi_2 > \Pi_1$.

Next, I will show $\Pi_4 > \Pi_3$. In the case of Π_4 (No Screening, No Screening), bank i lends to all firms indiscriminately. Hence, he can recover $\Phi s^i_{b,t}$. However, in the case of Π_3 (Screening, No Screening), bank i does screen and distinguish high quality firms but bank j lends to screened high quality firm. Instead, bank i lends to both high and low quality firms indiscriminately. Hence he can recover $\Phi \mu s^i_{b,t}$. Hence, $\Pi_4 > \Pi_3$. By assumption, we know that $\Pi_1 > \Pi_4$. Therefore $\Pi_2 > \Pi_1 > \Pi_4 > \Pi_3$ holds.

Suppose a duopoly bank is engaged in screening and hence discriminates in favor of high quality firms at the expense of paying the screening cost, b. As soon as the high quality firms are revealed, an outside bank observes the result immediately as the information externality is high. Then, an outside bank offers a lower lending rate to the screened, high quality firms. Of course, as the screened, high quality firms want to borrow at the lowest cost, they contract with the outside bank, which offers lower lending rates. Hence, the screening bank cannot recover screening cost and will have a loss.

In this situation, the optimal strategy of a duopoly bank is to wait and see the outcomes of the other bank's screening activities, just as it was in a similar situation with competitive banks. In Nash equilibrium, hence, a duopoly bank has no incentive to be engaged in screening activities, and wants to diversify risk by lending to as many firms as possible. In other words, a duopoly bank faces the free riding problem and it, in turn, leads to no screening equilibrium.

Definition C-1: A strategy profile $z^* = (z_1^{m^*}, z_2^{m^*})$ constitutes a Nash equilibrium for duopoly banks if for every j=1,2., $\pi_j = 0$ In Bertrand competition, each bank charges the competitive price, i.e. $R^{L^*}_{i,t+1} = R^{L^*}_{j,t+1} = r_t / \Phi$. Hence, in equilibrium, banks do not make profits and $\pi(z_j^{m^*}, z_{-j}^{m^*}) \geq \pi(z_j^{m'}, z_{-j}^{m^*})$ for all $z_j^{m'} \in Z_j$.

Proposition C-2: The unique Nash equilibrium of the duopoly banking industry is $z^* = (z_1^1, z_2^1)$ if $\xi > \xi^*$, i.e. no banks are engaged in screening activities.

Proof: It is straightforward. From Table C-1, we can easily find the best response for bank i is {No screening} regardless of bank j's strategies, and vice verse. $BR_i = N$ & $BR_j = N$ Hence, Nash equilibrium is no bank screens, i.e. (NS, NS)

Table C-1 shows the payoff of bank i, j given their own stage one strategy. If both banks screen, the payoffs of both banks Π_1, If bank1 (bank2) screens but bank2 (bank1) does not screen, bank2 (bank1) benefit from information externality. Then, the payoffs of bank1 (bank2) and bank2 (bank1) are Π_3, Π_2, respectively. However, if both banks do not screen, their payoffs are same to Π_4.

Table C-1. Payoffs of Banks

		Bank 2	
		Screen	No-Screen
Bank 1	Screen	Π_1, Π_1	Π_3, Π_2
	No-Screen	Π_2, Π_3	Π_4, Π_4

The Nash equilibrium in the duopoly banking system is identical to that in the competitive banking system. This result can be extended to the oligopoly (N>2) model.

2. Screening Equilibrium

In Nash equilibrium, all duopoly banks participate in screening activities if $\xi < \xi^*$ as the screening cost is less than the investment loss from not screening. As the payoffs of duopoly banks are higher when they engage in screening activities, the best strategy for duopoly banks is to screen all firms in the case of a low information externality. The point is that the banks do not suffer free riding problem if information externality in the banking industry is less than the critical level of the information externality.

Proposition C-3: The unique Nash equilibrium of the duopoly bank is $z^* = (z_1^2, z_2^2)$ if $\xi < \xi^*$.

Proof. It is straightforward. From Table C-2, we can easily find the best response for bank i is {Screening} regardless of bank j's strategies, and vice verse. $BR_i = S$ & $BR_j = S$. Hence, Nash equilibrium is no bank screens, i.e. (S, S)

Table C-2 shows the payoff of bank i, j given their own stage one strategy. If a bank screens, the payoffs of the bank is Π_1, while a bank does not screen, the payoffs is Π_4. As Π_1 is greater than Π_4. a bank's best strategy is screening.

Table C-2. Payoffs of Banks

		Bank 2	
		Screen	No-Screen
Bank 1	Screen	Π_1, Π_1	Π_1, Π_4
	No-Screen	Π_4, Π_1	Π_4, Π_4

As with the no screening equilibrium, the Nash equilibrium in the duopoly banking system is identical to that in the competitive banking system. In addition, this result will be extended to the oligopoly model, too. Hence, the duopoly model converges to competitive model. In this context, setting N>1 allows us to consider a competitive banking system. Note that although the Nash equilibrium of duopoly banks is no screening, they know that full screening equilibrium is better. Hence, if they commit to coordination for getting screening equilibrium, in aggregate, their payoffs converge to .full screening equilibrium. For example, if one bank deviates and is not engaged in screening activity, the payoffs of whole banking industry is $\Pi_2 + \Pi_3$, which is less than $2\Pi_1$. This result can also be extended to N>2 banks oligopoly model. For the details, see Cetorelli and Peretto (2000).

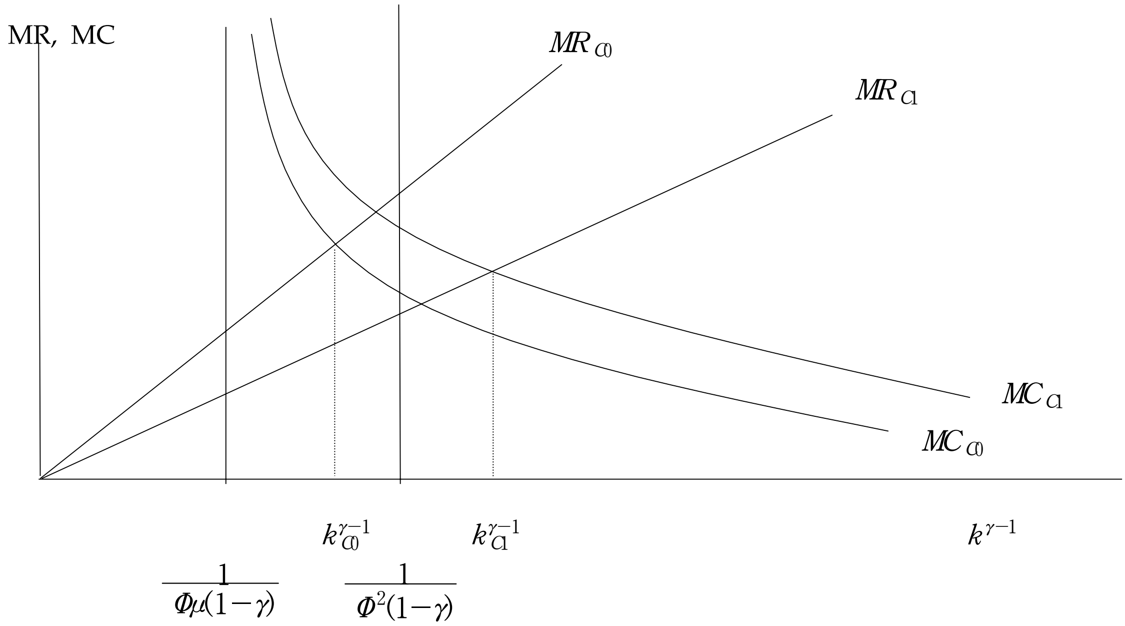
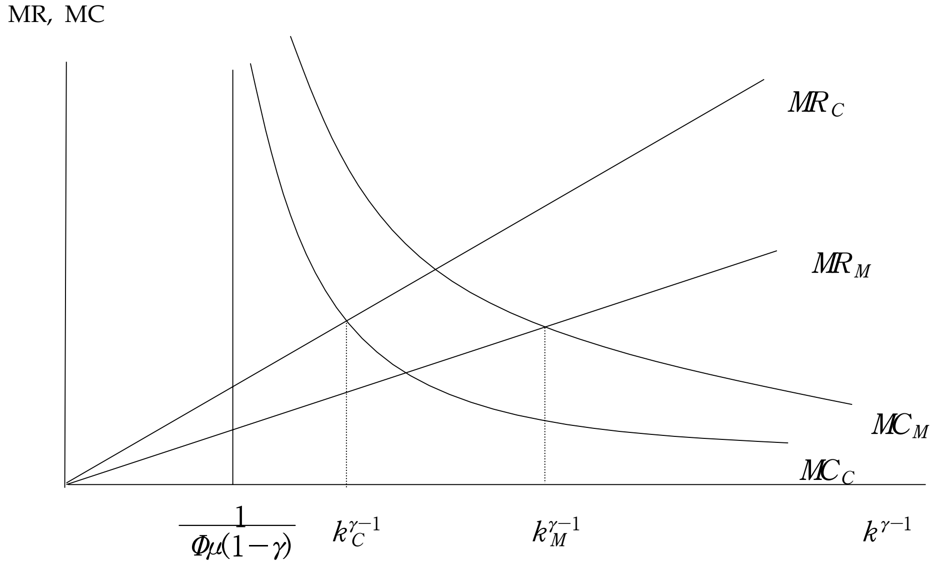


Figure I. Equilibrium Level of Capital - Competitive Banking System with Information Externality

① $\mu > \gamma$ **(Developed Financial Markets)**



② $\mu \ll \gamma$ **(Under-developed Financial Market)**

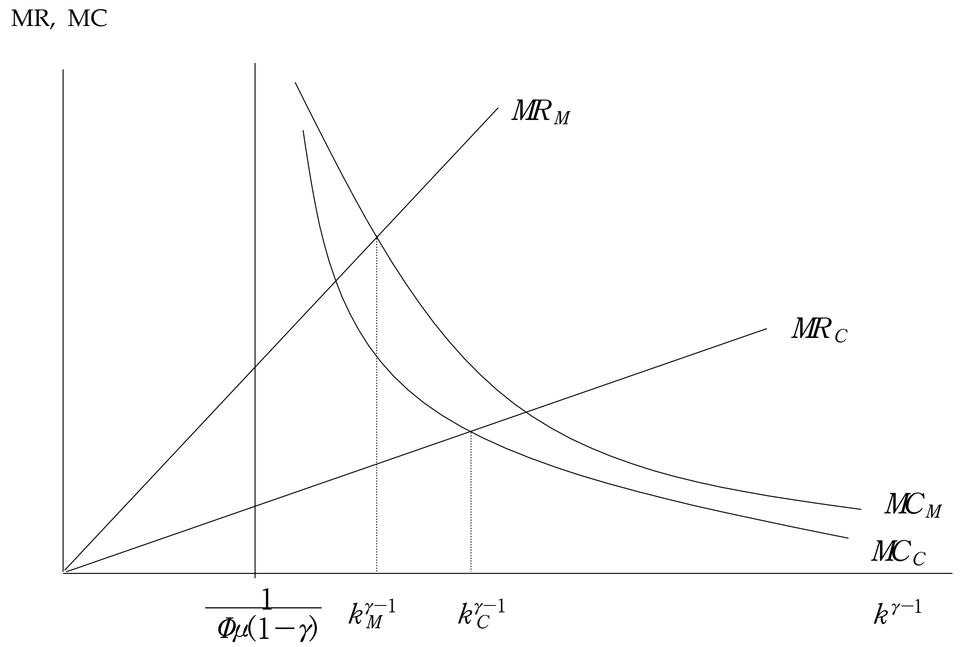
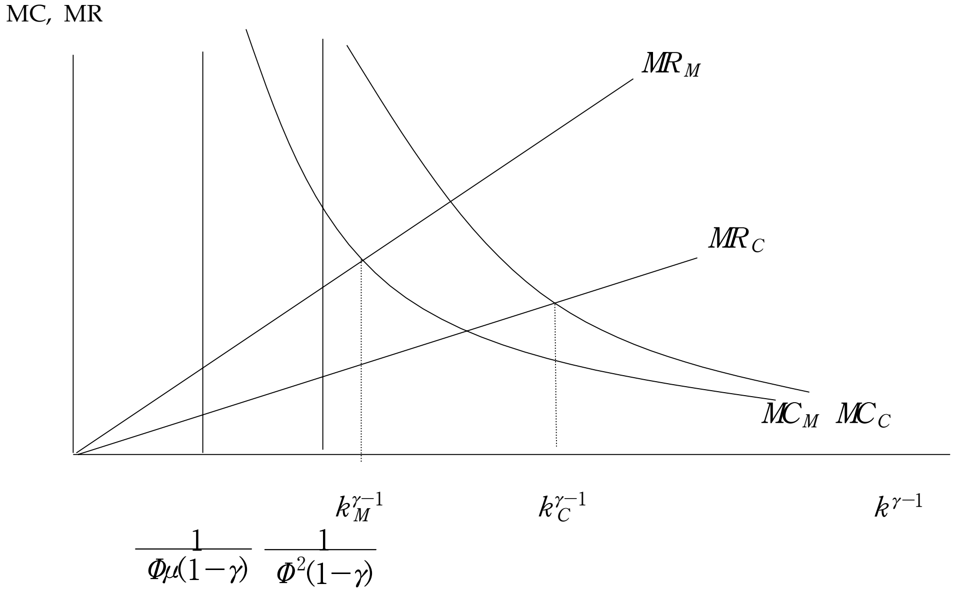


Figure II. Equilibrium Level of Capital - Monopoly and Competitive Banking System with Low Information Externality

① $\Phi < \gamma$ **(High Credit Risk)**



② $\Phi \gg \gamma$ **(Low Credit Risk)**

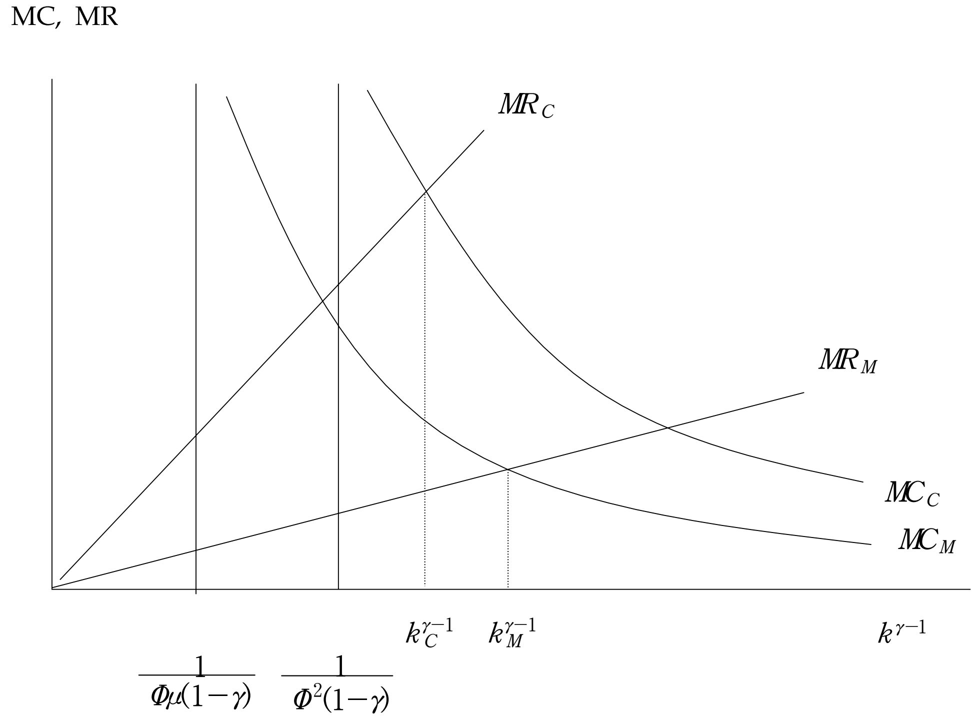


Figure III. Equilibrium Level of Capital - Monopoly and Competitive Banking System with High Information Externality