Bank Mergers and De Novo Banks: A System Evolutionary Approach

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Abstract

One-stop banking is a method to realize *economies of scope*. However, it is destined to disappear since it satisfies neither a *Nash equilibrium* nor an *ESS* (evolutionary stable strategy) in a simple *evolutionary game* model with *incomplete information*. As a result, achieving *economies of scale* remains a serious challenge, but one which banks must overcome in order to survive and for the banking system at large to evolve. Part of the solution entails a full embrace of *bank mergers* and the proliferation of *de novo banks*. It should duly be noted, however, that there is a danger that emergence of larger banks could give rise to more pronounced "too-big-to-fail" sentiment, thereby complicating the evolutionary process. This paper addresses some of the prerequisite conditions for more rational and stable evolution of the economy.

Key words: one-stop banking, Nash equilibrium, Evolutionary Stable Strategy, economies of scope, economies of scale, evolutionary game with incomplete information

I. Introduction

"Banks are popping up ... at the store, in the mall, and on the street. Major banks are migrating out of their traditional locations and courting consumers where they live, work and shop ... They are transforming existing branches into one-stop shopping venues, where consumers can do daily banking, consult with an estate planner, buy investment products or use the services of a discount brokerage, all under one roof" (Howland, 2000). The banking industry is becoming complex and diverse, and the wave of bank mergers has made the competitive landscape even more complex and led to greater diversity. It is almost impossible to discern a mega-bank with complex operations and the diversity of banks. As a matter of course, these developments could push up the cost of bank management, and consumers might pay dearly. One wonders if the cost problem has something to do with the recent antinomic phenomena of numerous small de novo banks springing up, especially in light of the great bank mergers that are occurring in the U.S.[1, 2] (see Table 1). Are these the ultimate results or end states of bank evolution?

There has been a series of prior studies seeking answers to these questions. The wave of bank mergers might have been justified by the theories of scope and scale economies. However, not a few scholars have been in doubt about their performances: the effects of scope and scale economies are infinitesimal, and diseconomies of scale do exist in large banks (Berger and Humphrey, 1994); a slight effect of scale economies or synergies can be found on the cost side but not on the revenue side (Pulley, Berger, and Humphrey, 1994); the effect of scale economies can be found in small-to-medium sized banks but not in large ones, and there are no scope economies in mega-banks (Rime and Stiroh, 2001); enlarging scale or scope is not desirable to the shareholdersm and only reflects the CEO's private preferences or herd behavior (Milbourn, Boot, and Thakor, 1999); there is no genuine one-stop banking in the global market; in fact, HSBC and ABN Amro are pursuing retail banking, and Deutsche Bank, Chase, Citibank, and ING are pursuing investment banking (Dymski, 2002).

A group of banking specialists and scholars have sought to discover the reasons for the emergence of de novo banks: an increase in the threat of competitive entry (Gilbert, 1974; Hanweck, 1971); good performances of de novo banks (McCall and Peterson, 1977; Rose and Savage, 1983; Hunter and Srinivasan, 1990; DeYoung, 1998); a surplus of bank executives who have been displaced by cost cutting as a result of mergers (Gillan, 1998; Murray, 1998; Zellner, 1998); some benefits of credit allocation such as medium-to-small business lending (Goldberg and White, 1997; DeYoung, Goldberg, and White, 1999; Berger, Bonime, Goldberg, and White, 1999; Seelig and

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1 "De novos take advantage of local conditions that favor entry. They are providing demanded financial services to their customers and establishing their place in the financial services marketplace" (Moore and Skelton 1998, 1). That is, the evolutionary dynamics of the market can spur the creation of new banks more closely aligned with consumers' needs and desires.

2 During the past several years, the number of new charters for banks and thrifts has risen significantly in the US. This has occurred during a period when there has been considerable consolidation in the banking industry. See Seelig and Critchfield (2003)

Critchfield, 2003). However, nearly all of these studies are based on speculations derived from naive empirical fact-findings or statistical tests, as suggested by Seelig and Critchfield (2003).

In this paper, regarding a bank as an information-processing unit, we will investigate the antinomy and the futures of the banking system or its hierarchical system, specifically from the viewpoint of evolutionary game theory under informational asymmetry. Much of the evolutionary game literature (Kandori, Rob, and Mailath, 1993; N'oldeke and Samuelson, 1994 etc.) has been interested in the refinement of Nash equilibria based on a bounded rationality approach: Bounded rational players are sometimes oblivious to their strategies/attributes programmed already, and are searching for them via learning. Sometimes they are switched by new entrants who are taking actions at random. These kinds of bounded rational players may or may not employ an equilibrium strategy. Hence, they might be on the off-path-equilibrium, in which they play role of mutants drifting along time and space until they can reach to some stable outcomes. The bounded rational players may be banks or their clients. However, it would be natural to assume that banks are confronting their bounded rational customers and that the bounded rationality is a source of the informational asymmetry. We will, therefore, investigate how the hierarchical banking system will evolve in the process of solving the informational asymmetry and serving the customers.

This paper has four parts. Chapter 2 lays out the problematic situation and basic assumptions. Chapters 3 and 4 address a simple dynamic of a banking system and its characteristics. Chapter 5 concludes.

<Table 1> New Institutional Charters and M&As in the U.S.

Year	De Novos	M&A		
		Bank Holding Company Consolidations	Acquisitions	Subtotal
1986	267	130	253	383
1987	220	265	370	635
1988	210	284	389	673
1989	176	220	240	460
1990	143	244	209	453
1991	77	276	239	515
1992	40	218	290	508
1993	52	181	431	612
1994	53	190	468	658
1995	106	302	420	722
1996	150	243	417	660
1997	193	276	449	725
1998	215	194	477	671
1999	262	132	365	497
2000	218	223	312	535
2001	140	157	264	421

Source: FDIC(2003) cited by Seelig and Critchfield(2003).

II. The Model

Let us consider the following game repeated over time. We may, for example, consider a kind of lending-borrowing game or underwriting-issuing game between banks and firms. These banks and firms are assumed to be homogeneous and play a random matching game.

Each firm $f \in \{1,2,\cdots,M\}$ has an innate industrial attribute or calling $i(t) \in \{1,2\}$ at time t. The attribute might not have any practical meaning if it is not connected with its vehicle $j(t) \in \{1,2\}$; e.g., the physical investment plan written in the loan contract submitted to banks. The driving forces of the vehicle are inertia, stochastic learning, or mimicry. That is, each firm can sustain the innate attribute as its investment plan by inertia, while stochastic learning can switch the attribute into any one of a number of different kinds of investment plans. The common corresponding biological terms for the attribute and the vehicle are the gene and phenotype[3]. Every firm may be oblivious to its gene with a small probability $\eta \in (0,1)$, otherwise its gene can be made equal to its phenotype by help of inertia. If the firm forgets its gene, it will learn about the gene at random according to the probability distribution $(\lambda, 1-\lambda)$. $\lambda \in (0,1)$ is the probability that a firm finds its gene to be 1; in other words, it is also the probability that its phenotype happens to be 1 (See Fig-1). η and λ are assumed to be common knowledge, time- and state-independent.

Each bank $b \in \{1,2...M\}$ can only observe the phenotype of the firm. The phenotype plays a signaling role to the bank, but it is a noisy signal in the sense that it cannot transmit the information of the firm's innate attribute exactly; hence, the phenotype may truncate the gene. In these circumstances, each bank should employ a strategy $k(t) \in \{1,2\}$ based upon the DB of the CSS (credit scoring system) or beliefs of CRM (customer relationship management), say $\mu(t)$. Banks have a hierarchical system composed of a head office and many branches and departments in order to grasp and classify various phenotypes of firms and provide appropriate financial services to them. The head office aggregates the DB and beliefs; the branch and department are represented as *information set b.j* (see Fig-1) and *function/strategy* respectively.

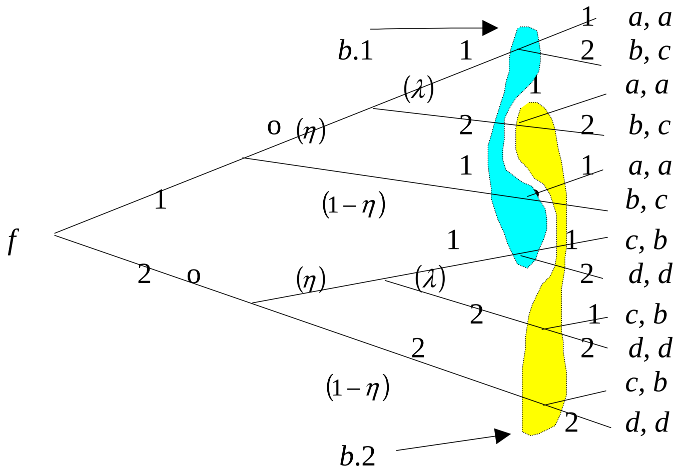
Omitting the time variable t for a notational convenience, the payoffs of a firm and a bank can be represented as $u^f(i,k)$ and $u^b(i,k)$ respectively; that is, a firm's gene *i* and a bank's strategy *k* are assumed to be key factors that determine their payoffs as follows:

bank / firm	***k*=1**	***k*=2**
***i*=1**	***a, a***	***b, c***
***i*=2**	***c, b***	***d, d***

3 The combination of a gene and phenotype, i.e., *ij(.)*, is called a *genotype*.

Then, we can easily check that the well-matching outcomes (*a*, *a*) and (*d*, *d*) are the pure strategy Nash equilibrium provided that $a > c$ and $d > b$. We assume $a > c$ and $d > b$ throughout this paper.

<Figure 1> Game Tree: 1 period



Let $Z \equiv (z_1, z_2)$ and $Y \equiv (y_1, y_2)$ be the distributions of genes and phenotypes respectively, where $Z_i \equiv (0, M)^4$ is the total number of gene $i \in \{1,2\}$ and $y_i \in [0, M]$ is that of phenotype $j \in \{1,2\}$ satisfying

$$\sum_{i=1}^{2} z_i = M \quad \forall t$$

$$y_j = \sum_{b=1}^{M} I_{b.i}\,,\ \sum_{j=1}^{2} y_i = M \quad \forall t\,,$$

where $I_{b.j}$ is 1 if the $b.j$ th branch observes the phenotype *j*, but 0 otherwise. In fact, y_j is incomplete because it identifies the phenotype of gene *i* with that of gene $i'(\neq i)$. This is the very reason that the phenotype truncates the gene. And let $X \equiv (x_{j.k})_{j,k\in\{1,2\}} = (x_{1.1}, x_{1.2}, x_{2.1}, x_{2.2})$ be the distribution of bank branch, where $x_{j.k}$ is the total number of branches that employ some strategy *k* against the phenotype *j* satisfying

$$\sum_{k=1}^{2} x_{i.k} = y_j\,,\ \sum_{k=1}^{2}\sum_{j=1}^{2} x_{j.k} = M \quad \forall t.$$

4 Except the initial condition $Z_i(t=0) \in (0, M)$.

Then, the banking system and industrial structure can be characterized by the frequency or probability distribution $B(t) \equiv \{\hat{p}(t);(\hat{q}(t))\}_t$ and $F(t) \equiv \{p(t)\}_t$:

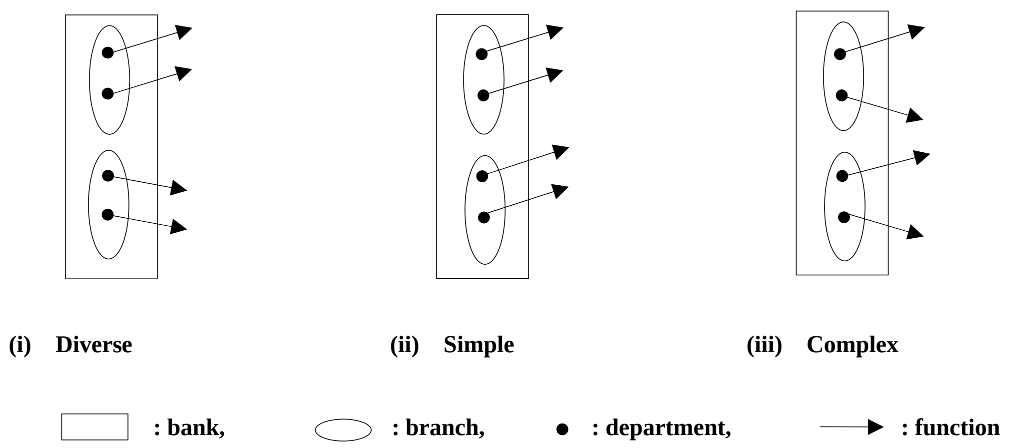
$$\hat{p}(t) \equiv (\hat{p}_1(t), \hat{p}_2(t))$$

$$\hat{q}(t) \equiv (\hat{q}_1(t), \hat{q}_2(t))$$

$$p(t) \equiv (p_1(t), p_2(t))$$

where $\left(\hat{p}_1(t) \equiv \frac{x_{1.1}(t)}{y_1(t)}, \hat{p}_2(t) \equiv \frac{x_{1.2}(t)}{y_1(t)}\right)$, $\left(\hat{q}_1(t) \equiv \frac{x_{2.1}(t)}{y_2(t)}, \hat{q}_2(t) \equiv \frac{x_{2.2}(t)}{y_2(t)}\right)$ are the population of the branch *b*.1 and *b*.2 respectively for all *b*. Figure 2, for example, shows that every branch *b.j* employs a phenotype-contingent strategy *k*=*j* without regard to the difference of its department when and only when $\hat{p}_2(t)=0, \hat{q}_1(t)=0$ in equilibrium (see Figure 2(i)). $\left(p_1(t) \equiv \frac{z_1(t)}{M}, p_2(t) \equiv \frac{z_2(t)}{M}\right)$ is the population of the gene. $\hat{p}_1(t)+\hat{p}_2(t)$, $\hat{q}_1(t)+\hat{q}_2(t)$, and $p_1(t)+p_2(t)$ are equal to 1 respectively.

<Figure 2> Banking System



DEFINITION 1

A banking system is diverse if both $\hat{p}_2(t)$ and $\hat{q}_1(t)$ converge to 0; complex if both $\hat{p}_2(t)$ and $\hat{q}_1(t)$ do not converge to 0; simple if $\hat{p}_1(t)$ or $\hat{q}_2(t)$ converge to 1. An industrial structure is simple if $p_1(t)$ converges to 1 or 0, diverse otherwise.

In the diverse banking system, one bank has many (two in this paper) functions, but there are no redundant branches in the sense that every branch has its own function or plays a unique function compared to each other; hence, *a diverse banking system* might be related with *economies of scope under one bank's roof.* In the simple banking system, one bank has only one function, and there exist redundant branches in the sense that every branch plays the same function; hence, *a simple banking system* might be related with *economies of scale*. On the other hand, in the complex banking system, one branch has many (i.e., two) functions; hence, *a complex banking system* might be related with *economies of scope under one branch's roof*[5]. Needless to say, there is very little variety in industrial genes in the *simple industrial structure*.

All of our interest is in the dynamic distribution of banks' branches and firms' genes while they continue to make myopic best responses over time. We are not interested in the dynamics of the phenotype, not only because firms are not assumed to change their phenotypes actively in this paper, but because the phenotype itself might not have any practical meaning in the real world[6].

III. The Evolution of Banking Systems and Industrial Structures

Given the payoff structure, the probabilities of inertia (η) and stochastic learning (λ), each bank employs a strategy $k(t)\in\{1,2\}$ to maximize its expected payoff $Eu^b(i,k)$ at each branch b.j, which can be represented as

$$Max\ \left[a(\mu_1+\mu_2)+b\mu_3, c(\mu_1+\mu_2)+d\mu_3\right] \quad \text{at} \quad b.1$$

$$Max\ \left[a\mu_1'+b(\mu_2'+\mu_3'), c\mu_1'+d(\mu_2'+\mu_3')\right] \quad \text{at} \quad b.2,$$

where the 1st and the 2nd terms in the two brackets are the expected payoffs of the branch *b.j* $(j=1,2)$ when it takes *k*=1 and *k*=2 respectively. And $\mu\equiv\mu(t)\equiv(\mu_1(.),\mu_2(.),\mu_3(.))$ and $\mu'\equiv\mu'(t)\equiv(\mu_1'(.),\mu_2'(.),\mu_3'(.))$ are the DB or beliefs of *b*.1 and *b*.2, respectively, which are defined by the conditional probabilities

$$\mu_1\equiv\Pr[\{i=1\}\cap\{o\}\,|\,\{j=1\}],\ \mu_2\equiv\Pr[\{i=1\}\,|\,\{j=1\}],\ \mu_3\equiv\Pr[\{i=2\}\cap\{o\}\,|\,\{j=1\}]$$

$$\mu'_1\equiv\Pr[\{i=1\}\cap\{o\}\,|\,\{j=2\}],\ \mu'_2\equiv\Pr[\{i=2\}\cap\{o\}\,|\,\{j=2\}],\ \mu'_3\equiv\Pr[\{i=2\}\,|\,\{j=2\}]$$

where $\{o\}$ represents the event of oblivion.

Using *Bayes* rule, we can calculate μ and μ' as a function of industrial structure $F(t)\equiv\{p(t)\}$:

$$\mu_1+\mu_2=\frac{[\eta\lambda+(1-\eta)]p_1}{\eta\lambda+(1-\eta)p_1},\quad \mu_3=\frac{\eta\lambda p_2}{\eta\lambda+(1-\eta)p_1}$$

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5 There might also exist redundant branches in the complex banking system because some branches play the same function as each other; hence, it might also be related with economies of scale in the whole banking system.

6 In fact, key factors that determine the payoff are assumed to be a firm's gene and bank's strategy in this paper. All that is important for us is not "What are you like?" but "Who are you?"

$$\mu'_1 = \frac{\eta(1-\lambda)p_1}{\eta(1-\lambda)+(1-\eta)p_2}, \quad \mu'_2+\mu'_3 = \frac{(1-\eta\lambda)p_2}{\eta(1-\lambda)+(1-\eta)p_2}$$

and find that the expected payoffs of a bank are concave to p_1 with ease. We can also find that the critical levels of p_1 that make the bank indifferent to the two strategies can be represented as p_1^o and $p_1'^o$

$$p_1^o \equiv \frac{\theta(d-b)}{\delta(a-c)+\theta(d-b)} \quad \text{at} \quad b.1 \tag{1}$$

$$p'^o_1 \equiv \frac{(1-\theta)(d-b)}{(1-\delta)(a-c)+(1-\theta)(d-b)} \quad \text{at} \quad b.2,$$

where $\delta \equiv 1-\eta(1-\lambda)$, $\theta \equiv \eta\lambda$. In other words, the critical levels of the industrial structure, say $F^o \equiv \left(p_1^o, p_1'^o\right)$, satisfy

$$Eu^b\left(F^o, k=1\right) = Eu^b\left(F^o, k=2\right) \tag{2}$$

Then, from equation (2), we can derive the *dynamics of the banking system* $B(t) \equiv \{\hat{p}(t); \hat{q}(t)\}$ satisfying the following *Darwinian* property:

$$Sign\left[Eu^b(i, k(t)=1) - Eu^b\left(F^o, k=1\right)\right] \tag{3}$$

$$\equiv Sign\left[\sum_{b=1}^{M} I_{b.j}\left(k(t+1)\right) - \sum_{b=1}^{M} I_{b.j}\left(k(t)\right)\right]$$

$$= Sign\ \left[\hat{p}_1(t+1) - \hat{p}_1(t)\right] \quad \text{for} \quad j=1$$

$$Sign\ \left[\hat{q}_1(t+1) - \hat{q}_1(t)\right] \quad \text{for} \quad j=2$$

Similarly, each firm employs a strategy $i(t) \in \{1,2\}$ in order to maximize its expected payoff

$$Eu^f(i,k) \equiv \sum_{j=1}^{2}\sum_{k=1}^{2} u(i,k)\Pr(j|i)\Pr(k|j),$$

where $\Pr(j|i)$ is the likelihood of the phenotype *j* when the gene was *i*, and $\Pr(k|j)$ is the likelihood that the bank employed the strategy *k* when it observed the phenotype *j*. The firm's expected payoff can also be represented as a function of the banking system $B(t) \equiv \{\hat{p}(t); \hat{q}(t)\}$:

$$Max\left[b+(a-b)\{\delta(1-\hat{p}_2)+(1-\delta)\hat{q}_1\},\ d-(d-c)\{\theta(1-\hat{p}_2)+(1-\theta)\hat{q}_1\}\right],$$

which is linear to $\hat{p}(t),\hat{q}(t)$. The 1st and the 2nd term in the bracket are the expected payoffs of the firm when it employs *i*=1 and *i*=2, respectively. We can also find that the very critical levels of $\hat{p}_2(t),\hat{q}_1(t)$ that make banks indifferent to the two strategies of the firm can be represented as $\hat{p}_2{}^o, \hat{q}_1{}^o$ satisfying

$$\Phi\left(1-\hat{p}_2{}^o\right)+\Psi\hat{q}_1{}^o=d-b, \qquad (4)$$

where $\Phi \equiv \delta(a-b)+\theta(d-c), \Psi \equiv (1-\delta)(a-b)+(1-\theta)(d-c)$. In other words, the critical levels of a banking system, say $B^o \equiv \left(\hat{p}_2{}^o, \hat{q}_1{}^o\right)$, satisfy

$$Eu^f\left(i=1, B^o\right) \equiv Eu^f\left(i=2, B^o\right) \qquad (5)$$

From equation (5), we can derive *the dynamics of the industrial structure* $F(t) \equiv \{p(t)\}$ satisfying the following *Darwinian* property:

$$Sign\left[Eu^f\left(i(t)=1,k\right)-Eu^f\left(i=1,B^o\right)\right] \qquad (6)$$

$$\equiv Sign\ \left[z_1(t+1)-z_1(t)\right]$$

$$= Sign\ \left[p_1(t+1)-p_1(t)\right]$$

PROPOSITION 1

(i) A banking system can be diverse only when the industrial structure remains in certain range of diversity.
(ii) An industrial structure can maintain its diversity without regard to the patterns of a banking system only when $\Phi = \Psi$.

Proof:
(i) We can show $p_1''^o > p_1{}^o$ from equation (1) and the assumption *a* > *c, d* > *b*. And from (2) and (3), we can derive

$$p_1(t) > p_1''^o \Rightarrow \left(\hat{p}_2(\tau)\downarrow, \hat{q}_1(\tau)\uparrow\right)_{\tau \geq t+1} \qquad (7)$$

$$p_1{}^o \leq p_1'(t) \leq p_1''^o \Rightarrow \left(\hat{p}_2(\tau)\downarrow, \hat{q}_1(\tau)\downarrow\right)_{\tau \geq t+1}$$

$$p_1(t) < p_1{}^o \Rightarrow \left(\hat{p}_2(\tau)\uparrow, \hat{q}_1(\tau)\downarrow\right)_{\tau \geq t+1,}$$

where the down-arrows and the up-arrows represent decreases and increases with respect to time. At (7), $p_1{}^o \leq p_1(t) \leq p_1''^o$ means that the industrial structure remains in a certain range of diversity compared with the other two cases, and $\left(\hat{p}_2(\tau)\downarrow, \hat{q}_1(\tau)\downarrow\right)_{\tau \geq t+1}$ means that the banking system is being diversified monotonically as time passes. However, if the diversity of the industrial structure exceeds or falls below some critical levels, i.e., $p_1(t) > p_1''^o$ or $p_1(t) < p_1{}^o$, the banking system will become complex or simple because $\left(\hat{q}_1(\tau)\uparrow\right)_{\tau \geq t+1}$ or $\left(\hat{p}_1(\tau)\uparrow\right)_{\tau \geq t+1}$ will be satisfied.

(ii) From (4) ~(6), we can derive the following relations:

$$(\hat{p}_2(t), \hat{q}_1(t)) \in \left\{(\hat{p}_{2,}\hat{q}_1) \middle| \Phi(1-\hat{p}_2) + \Psi\hat{q}_1 > d - b\right\} \Rightarrow p_1(t)\uparrow \quad (8)$$

$$(\hat{p}_2(t), \hat{q}_1(t)) \in \left\{(\hat{p}_{2,}\hat{q}_1) \middle| \Phi(1-\hat{p}_2) + \Psi\hat{q}_1 < d - b\right\} \Rightarrow p_1(t)\downarrow$$

Suppose $(\hat{p}_2(t), \hat{q}_1(t))$ satisfy (4). Then

$$\Phi(1-\hat{p}_2(t+1)) + \Psi\hat{q}_1(t+1)$$

$= d - b + (\Psi - \Phi)\varepsilon$ if banking system approaches a diverse one[7]

$= d - b + (\Phi - \Psi)\varepsilon$ otherwise[8]

for any arbitrary $\varepsilon \in (0,1)$. Hence, for any $\tau(\geq t+1)$ and *t*, $p_1(\tau)$ would not be changed if $\Phi = \Psi$, which means that an industrial structure can sustain its diversity or initial pattern without regard to the banking system. However, $p_1(\tau)$ would increase (or decrease) monotonically if $\Psi > \Phi$ (or $\Psi < \Phi$). This means that the diversity of the industrial structure vanishes. **Q.E.D.**

$\hat{p}_2(t)$ and $\hat{q}_1(t)$ might be used as measures of informational asymmetry. And banks might be compelled to maintain redundant branches or departments in order to rectify the informational asymmetry. Informational asymmetry would, therefore, make the banking system more costly. Proposition 1(i), however, says that a diverse industrial structure can lower costs of the banking system provided that each bank can realize *economies of scope* under one bank's roof. It is not because the diversity of industrial structure resolves informational asymmetry itself fundamentally but because it can mitigate malfunctions stemming from informational asymmetry such as adverse selection. How can this be? Suppose the economy has a diverse industrial structure. In this case, there would not be enough attraction to pull the *drifting industrial genes* toward a certain one. Hence, there might be very few hybrids who mimick the fascinating industrial gene, which would make it easier for

7 That is, $\hat{p}_2(t+1) = \hat{p}_2(t) - \varepsilon$, $\hat{q}_1(t+1) = \hat{q}_1(t) - \varepsilon$

8 That is, $\hat{p}_2(t+1) = \hat{p}_2(t) + \varepsilon$, $\hat{q}_1(t+1) = \hat{q}_1(t) + \varepsilon$

banks to discern their customers. It should be noted, however, that banks cannot discern so many borrowing firms crowded around them with ease during times when a certain industry such as IT (Informational Technology) or BT (Biotechnology) is expanding rapidly and is beset by investment mania. This reason for this is that there may be too many imitators and all that glitters may not be gold.

Next, let us consider the meaning of proposition 1(ii). For this purpose, we should interpret the meaning of $\Phi = \Psi$. $\Phi = \Psi$ denotes *perfect oblivion* (i.e., $\eta = 1$) and *equal opportunity of vocational education* (i.e., $\lambda = \frac{1}{2}$), which is obvious from the fact that $\Phi = \Psi$ is equivalent to $\delta = \theta = \frac{1}{2}$. $\Phi = \Psi$ is realized under the conditions of *perfect recall* (i.e., $\eta = 0$) and *symmetric cost of adverse selection* (i.e., $a - b = d - c$), for $\Phi = a - b$ and $\Psi = d - c$ are satisfied if and only if $\eta = 0$ [9] Here, the cost of adverse selection can be defined by the opportunity cost that a firm might suffer from a bank's misjudgment; i.e., $\left| u^f(i, k = i) - u^f(i, k = j) \right|$ $\forall i, j (\neq i)$ [10]. Hence the symmetric cost of adverse selection means that $\left| u^f(i,k=i) - u^f(i,k=j) \right| = \left| u^f(j,k=j) - u^f(j,k=i) \right|$ is satisfied $\forall i, j(\neq i)$. This problem would be mitigated if the payoff structure is symmetric or all firms are growing in a well-balanced fashion. However, these conditions can only be satisfied with measure zero, so that they are in fact too restrictive to be satisfied. This suggests that maintaining a diverse industrial structure is very difficult.

COROLLARY

Maintaining a diverse banking system is difficult as the diversity of the industrial structure vanishes.

We can acquire the corollary as a natural consequence of proposition 1(i) and 1(ii). Though we do not know whether the diversity of the industrial structure is vanishing, this thesis might serve as a warning against the recent trends in the banking system; not a few banks have attempted to expand their business by establishing one-stop shopping systems and realizing economies of scope under one roof. It seems tragic in the sense that the management costs of a bank may increase and its consumers may depart from the bank in fear of having cover those costs[11]. Is this, therefore, the

9 It is notable that perfect recall reduces the influence of vocational education.

10 Precisely speaking, the reciprocals of $a - b$ and $d - c$ are the losses. In other words, it can be seen as a mismatching cost.

11 Of course, if the consumer is a big firm, a bank might not have enough bargaining power to transfer the cost to that firm. In this case, maintaining the hierarchical system of a bank itself would become impossible.

inevitable destiny of the banking system? And how can we explain the proliferation of de novo banks? The next chapter will answer these questions.

IV. Properties of the Evolutionary Equilibrium

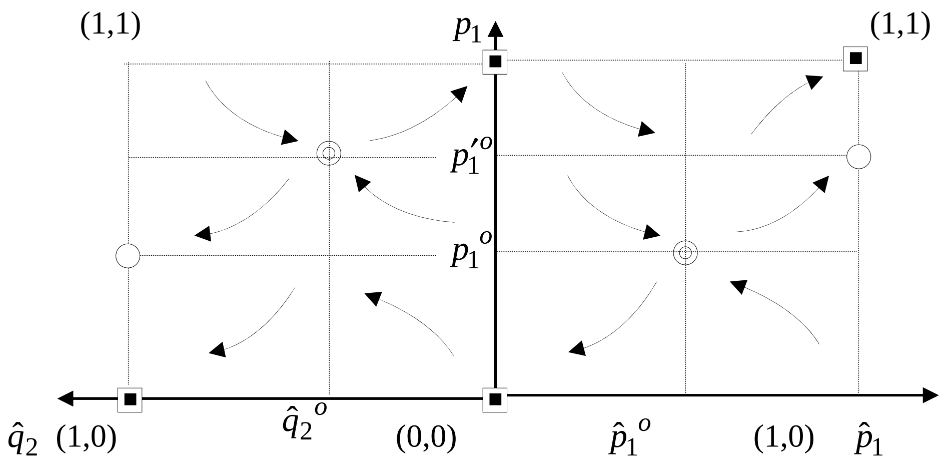
There exist three kinds of stationary points in the dynamic equation systems of (3) and (6) (see Fig-3). The first is a combination of diverse industrial structures and diverse banking systems; $\left(p_1, \hat{p}_1, \hat{q}_2\right) \in \left\{(p_1^o, 1,1), (p'^o_{1,}, 1,1)\right\}$ represented by ○ in Fig-3. The second is a combination of diverse industrial structures and complex banking systems; $\left(p_1, \hat{p}_1, \hat{q}_2\right) \in \left\{(p_1^o, \hat{p}_1^o, \hat{q}_2^o), (p'^o_{1,}, \hat{p}_1^o, \hat{q}_2^o)\right\}$ represented by ◎. The third is a combination of a simple industrial structures and simple banking systems; $\left(p_1, \hat{p}_1, \hat{q}_2\right) \in \left\{(1,1,0), (0,0,1)\right\}$ represented by ▣. Let these equilibria be (F^*, B^*), where

$$F^* \equiv p_1^* \in \left\{1, p'^o_{1,}, p_1^o, 0\right\} \subseteq F(t),$$

$$B^* \equiv (\hat{p}_1^*, \hat{q}_2^*) \in \left\{(1,1), (\hat{p}_1^o, \hat{q}_2^o), (1,0), (0,1)\right\} \subseteq B(t).$$

Considering $B(t)$ and $F(t)$ are nothing but the strategy profiles of the bank and firm respectively, we can define the *Nash equilibrium* and *ESS* (Evolutionary Stable Strategy) as follows.

<Figure 3> Evolution of Banking System and Industrial Structure



DEFINITION 2

(i) (F^*, B^*) is the *Nash equilibrium* if and only if for every bank and firm

$$Eu^b\left(F^*, B^*\right) \geq Eu^b\left(F^*, B\right), \quad Eu^f\left(F^*, B^*\right) \geq Eu^f\left(F, B^*\right) \quad \forall F, B.$$

(ii) (F^*, B^*) is the *ESS* if and only if for every bank and firm

① it is a Nash equilibrium,

② $(1-\varepsilon)Eu^b(F^*,B^*)+\varepsilon Eu^b(F,B^*)>(1-\varepsilon)Eu^b(F^*,B)+\varepsilon Eu^b(F,B)$,
$(1-\varepsilon)Eu^f(F^*,B^*)+\varepsilon Eu^f(F^*,B)>(1-\varepsilon)Eu^f(F,B^*)+\varepsilon Eu^f(F,B)$
are satisfied $\forall F,B$ and $\forall \varepsilon \in [0,1]$,

③ $Eu^b(F,B^*)\geq Eu^b(F,B), Eu^f(F^*,B)\geq Eu^f(F,B)$ are satisfied if $Eu^b(F^*,B^*)=Eu^b(F^*,B), Eu^f(F^*,B^*)\geq Eu^f(F,B^*)$ $\forall F=F^*$, $\forall B\neq B^*$ (Maynard Smith 1982; van Damme 1993)

Then we can derive the following proposition.

PROPOSITION 2

(i) Every (F^*, B^*) except the combination of diverse industrial structures and diverse banking systems is a *Nash equilibrium.*

(ii) In the long run, the combination of simple industrial structures and simple banking systems is the unique *ESS.*

Proof:

(i) In order to ascertain that the combination of diverse industrial structures and diverse banking systems is not a Nash equilibrium, let $F^*=p_1^{\,o}$ (or $p_1'^{\,o}$) and B^*=(1,1). Then, we can easily check $Eu^b(F^*,B^*)=Eu^b(p_1^{\,o},B^*)=Eu^b(p_1^{\,o},B)$ (by the equation (2)) $=Eu^b(F^*,B)$ $\forall B$ [12]. However, $Eu^f(F^*,B^*)\geq Eu^f(F,B^*)$ cannot be satisfied $\forall F$. This is because $Eu^f(F^*,B^*)-Eu^f(F,B^*)=(\Phi-d+b)(F^*-F)$ is always negative by the equation (8) when B^*=(1,1) for $\Phi>d-b\Rightarrow F^*-F<0$ and $\Phi>d-b\Rightarrow F^*-F>0$ [13]. We can easily check that others are *Nash equilibria.*

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12 We can prove it in such a different way: Let F^* be $\alpha p_1^{\,o}+(1-\alpha)p_1'^{\,o}$ for any $\alpha\in[0,1]$. Then $Eu^b(F^*,B^*)=Eu^b(\alpha p_1^{\,o}+(1-\alpha)p_1'^{\,o},B^*)\geq \alpha Eu^b(p_1^{\,o},B^*)+(1-\alpha)Eu^b(p_1'^{\,o},B^*)$ (by the concavity of Eu^b with regard to p_1) $=\alpha\, Eu^b(p_1^{\,o},B)+(1-\alpha)Eu^b(p_1'^{\,o},B)$ (by the equation (2)) $=Eu^b(p_1^{\,o},B)$ or $Eu^b(p_1'^{\,o},B)$ for
$Eu^b(p_1^{\,o},B)=Eu^b(p_1'^{\,o},B)=(ad-bc)/(a-c+d-b)=Eu^b(F^*,B)$ $\forall B$.

13 $Eu^f(F^*,B^*)$ and $Eu^f(F,B^*)$ can be represented as $F^*u^f(1,B^*)+(1-F^*)u^f(0,B^*)$ and $Fu^f(1,B^*)+(1-F)u^f(0,B^*)$ respectively. In this case, F^* is identically same with $p_1^{\,o}$ or $p_1'^{\,o}$, and F is $p_1(t)$.

(ii) It is sufficient to check whether ◎ and ▣ are the *ESS*, for the *ESS* does not include a non-Nash equilibrium such as ○. At first, suppose ◎, i.e., $F^* = p_1^{\,o}$ (or $p_1''^{\,o}$) and $B^* = (\hat{p}_1^{\,o}, \hat{q}_2^{\,o})$, is *ESS*. Then it must satisfy $Eu^b(F, B^*) > Eu^b(F, B)$ and $Eu^f(F^*, B) > Eu^f(F, B)$ $\forall F, B$, for it can be shown that $Eu^b(F^*, B^*) = Eu^b(F^*, B)$, $Eu^f(F^*, B^*) = Eu^f(F, B^*)$ $\forall F = F^*$, $\forall B = B^*$. In order to check whether they are satisfied, suppose $F = 1(\neq F^*)$ and $B = (1,0)(\neq B^*)$ without loss of generality. Then we can find that $Eu^b(F, B^*) - Eu^b(F, B) = (\hat{p}_1^{\,o} - 1)(a - c) > 0$ and $Eu^f(F^*, B) - Eu^f(F, B) = (p_1^{\,o} - 1)(a - c) > 0$ should be satisfied; however, they contradict given assumption such as $a > c$[14]. Hence, ◎ is not an *ESS*. But we can easily check that ▣=(1,1,0) or (0,0,1) is an *ESS*. **Q.E.D.**

Intuitively, proposition 2 suggests that the recent phenomena such as one-stop banking would not last long; in the long run, a big industry or firm would gobble up smaller ones fully supported by great dummy banks. This is not only because the combination of diverse industrial structures and diverse banking systems is neither a *Nash equilibrium* nor an *ESS*, but because the combination of diverse industrial structures and complex banking systems is not an *ESS*. The dummy banks would be emerging as a result of full-scaled bank mergers, and there would be numerous redundant branches that do not realize economies of scope and economies of scale.

Then, how can we explain the fact de novo banks are proliferating especially during the period of great bank mergers? Interpreting the simple banking system as a cluster of small and specialized banking units, these kinds of de novo banks might be more efficient in that they can grab the region-, class-, and industry-specific nitch market demand without incurring the costs of diversity and complexity, although they might seem to play redundant roles in the dimension of the whole banking system.

V. Concluding Remarks

This paper suggests two points; one is about a banking system, the other an industrial structure. With regard to the banking system, the paper indicates that one-stop banking would disappear in the long run. This would mean that diseconomies of complexity and diversity (i.e., costs of expanding scope) are greater than those of simplicity and redundancy, and that realizing scale economies remains an important problem to be solved in the long run. In one sense, the wave of bank mergers might reflect the effort to address the diseconomy of the simplicity and redundancy, and realize scale economies on the cost side. On the other, the proliferation of de novo banks might reflect the fact that numerous redundant branches are being resuscitated as efficient region- or industry-specific entities and realize scale economies on the revenue

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14 $Eu^b(F, B^*)$ and $Eu^b(F, B)$ can be represented as $\hat{p}_1^{\,o} u^b(F,1) + (1 - \hat{p}_1^{\,o}) u^b(F,0)$ and $\hat{p}_1 u^b(F,1) + (1 - \hat{p}_1) u^b(F,0)$ respectively, where 1 means $\hat{p}_1$=1 and 0 means $\hat{p}_1$=0. Similarly, $Eu^f(F^*, B)$ and $Eu^f(F, B)$ can be represented as $p_1^{\,o} u^f(1, B) + (1 - p_1^{\,o}) u^f(0, B)$ and $p_1 u^f(1, B) + (1 - p_1) u^f(0, B)$ respectively, where 1 means p_1=1 and 0 means p_1=0.

side. More important might be that the two phenomena should be synchronized. Otherwise, the banking system might fail to not only solve the problem of information asymmetry but also provide the necessary funds to the industrial sector.

With regard to the industrial structure, this paper indicates that only a fascinating or star industry would remain in the long run. The future might be gloomy in the sense that the banking system would be caught hostage by the star industry and the "too-big-to-fail" sentiment would become extreme. This might suggest, for example, lending and underwriting exposures to big industries and firms should be limited within a reasonable level, and that investment banks should be excluded from the deposit insurance system. In other words, this might suggest that freedom of dominance from industry interest is important in order to achieve systemic stability in the financial market as suggested by Dionne (2003). This also suggests that a ceaseless revolutionary effort in the industrial structure should be pursued through such means as providing equal opportunity for vocational education and reinforcing antitrust and balanced growth strategy, which would be not only a means of realizing economies of scope in the banking system but also a prerequisite for more rational and stable evolution of an economy[15].

15 We can easily check that there do not appear any complex/diverse evolutionary phenomena if there does not exist informational asymmetry in our model. Ironically, it might mean that the very incompleteness (in respect of information) does give us a clue to make more rational and stable evolutionary process.

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