Agent-based Simulation Model Embedded Accounting's Purchase Method; Analysis on the Systemic Risk of Mergers and Acquisitions between Financial Institutions

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Abstract: The aim of the present study is to evaluate systemic risks due to merger between financial institutions by manipulating the decline rate of marketable asset price. An agent-based simulation platform with purchase method of international financial reporting standards (IFRS) is developed and analyses the influence of the goodwill (*Noren*), produced by mergers between financial institutions. The research reveals the following two points: (1) the decline rate of marketable asset price determines the number of bankruptcies, (2) when market value asset price plumps sharply, the effect of merger is small.

1 INTRODUCTION

The most severe impacts of the financial crisis from 2007 to 2009 arose immediately after the failure of Lehman Brothers on September 15, 2008 (Acharya, 2012). As failures of financial institutions may affect market functions, the global financial crisis has precipitated an increasing appreciation of the need for a systemic perspective toward financial stability (Arinaminpathy, 2012). This is called "systemic risk", which is a possibility that an event at an individual company level could trigger severe instability or collapse an entire industry or economy. In the several past years, many studies have examined systemic risk, especially in EU countries and the U.S.A.

In Japan, major financial institutions had to merge to prevent systemic risk from increasing. Regional economies are shrinking with declining population. In January 2017, Japan's Mie Bank and Daisan Bank said they had agreed to consolidate their operations, in an attempt to boost their competitiveness and deal with demographic challenges (Nikkei, 2017). In addition, Sumitomo Mitsui Financial Group and Resona Holdings were finalizing an arrangement to consolidate group regional banks in March 2017. Earnings reveal the plight of Japan's regional banks. Net profit dropped on the year in the April-December period for 60 of 82 listed regional banks (Nikkei, 2017).

One of the previous researches has suggested that mergers between financial institutions have proved disadvantageous (Hashimoto, 2015). This model applied therein uses simplified balance sheet and some regulations. However, it is better to consider goodwill account separately after implementation of mergers. In this paper, we deal with mergers between financial institutions to investigate the possibilities of systemic risk due to financial crisis. The issue mentioned above is to analyse impacts of mergers between banks. Therefore, we introduce to our model the purchase method defined in international financial reporting standards and use the same modelling framework as Kikuchi's model (Kikuchi et al., 2016).

The goal of this article is to analyse systemic risk change due to mergers between financial institutions. By introducing purchase method, we can deal cases where the purchase amount is larger than the assets of a merged company. In addition, systemic risks are examined by changing the decline rate of marketable asset price.

2 RELATED RESEARCH

2.1 Interbank Network

Financial institutions such as banks and securities companies conduct various transactions in the

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interbank network. When one bank is insolvent, the stability of banking system is affected in various ways depending on the patterns of payment across locations (Freixas et al, 2000). Freixas et al. (2000) investigates the ability of the banking system to withstand the insolvency of one bank and whether the closure of one bank generates a chain reaction on the rest of the system.

Degryse and Nguyen (2007) investigates the evolution and determinants of contagion risk for the Belgian banking system over the period 1993-2002, using detailed information on aggregate interbank exposures of individual banks. They examine large bilateral interbank exposures, and cross-border interbank exposures. They find that a change from a complete structure toward a "multiple-money-center" structure, which is called core-periphery network, has decreased the risk and impact of contagion. In addition, an increase in the relative importance of cross-border interbank exposures has lowered local contagion risk.

May and Arinaminpathy (2010) explores that some simple mathematical figure for banking system with emphasis on the interplay between the characteristics of individual banks and the overall dynamical behaviour system.

2.2 Systemic Modelling

Another area of applied research that bears on the issue of systemic risk is related to agent-based simulation.

Maeno et al. (2012) presents a computer simulation model to analyse the risk of transmission of financial distress in a bank credit network and the knock-on defaults of banks. They find that the number of defaults is determined by the bank credit network, the balance sheet of banks including equity capital ratio, and the capital surcharge on big banks.

Some researchers have challenged to introduce interbank-network into agent-based modelling. These researches investigate stress tolerance of the banking system. The propagation of bankruptcy in financial institutions is as shown in the figure below (Fig.1):

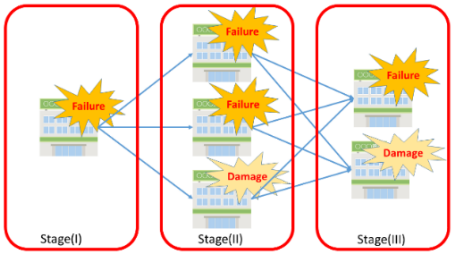

Figure 1: Propagation of failures of financial institutions.

Hashimoto and Kurahashi (2015) proposes an indicator of systemic risk by gauging the risk of failure. It establishes the interbank market of Erodos-Renyi network. Each agent has a simplified balance sheet. They find that central bank financing may spread a chain of failures of financial institutions.

As a related work, Kikuchi et al. proposes new agent-based simulation model. Kikuchi's group develops an agent-based simulation platform and then examines how current systemic management regulations cause bankruptcies. They analyse how the borrowing and lending banks and the borrowers go bankrupt in the chain via interbank network. In the research, each financial institution has a simplified balance sheet as shown in Figure 2.

Non-marketable Asset	Debt (Deposit)
Marketable Asset	Equity
	Financing gap
Short-term investment	Short-term funding
deposit facilities	Lending facilities

Figure 2: Balance sheet in Kikuchi model.

In previous studies, researchers explored how the prevention of propagation of failures was possible. In these studies they focus on balance sheets of the financial institutions and investigate the effects on the propagation of failure (May and Arinaminpathy, 2010). Another area of applied research related to systemic risk has examined agent-based simulation (Kikuchi et al., 2016).

Extensive effort has been dedicated to documenting the negative effects on go-bankrupt-in-chain in the market. Little attention has been paid to positive value such as goodwill (*Noren* in Japanese) brought about by merger and acquisition; this is the focus of attention in this paper.

3 DEFINITION

This study is modelled from the method proposed by Kikuchi et al. (2016), which has been used to test the effects of Basel Capital Account in the market. We explain agent-based-model with goodwill (*Noren*) item included in the balance sheet to investigate the impacts on the inter-bank market.

3.1 Balance Sheet

Balance sheet is a financial statement that summarizes a company's assets, liabilities and shareholders' equity at a specific point in time (Saito, 2014). In this study, we use the same modelling framework as Kikuchi's model (Kikuchi et al., 2016). The difference from previous studies is the item of "goodwill". Goodwill is an intangible asset that arises as a result of the acquisition of one company by another for a premium value (Saito, 2014). Goodwill is considered an intangible asset because it is not a physical asset. Therefore, goodwill account can be found in the assets portion of a company's balance sheet (Saito, 2014). If goodwill is not introduced, corporate mergers cannot be evaluated properly, because we cannot add revenue of fixed asset.

In this research, we introduce goodwill upon merger of financial institutions. Each financial institution has a simplified balance sheet in Figure 3.

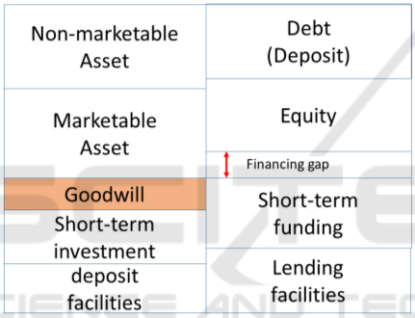

Figure 3: Balance sheet in our model.

3.2 Merger of Financial Institutions

A merger is a deal to unite two existing companies into one new company (Saito, 2014). There are two types of mergers.

First, we explain an absorption-type merger. When two or more entities are combined into an existing company, it is known as a merger through absorption. In this type of merger, only one entity survives after the merger, while the rest of all cease to exist.

Second, we explain a consolidation-type merger. When two or more companies fuse to give birth to a new company, it is known as a merger through consolidation. This implies that all the companies to the merger are dissolved, i.e. they lose their identities and a new company is established.

In our study, we only deal with an absorption-type merger.

3.3 Accounting Used in Mergers

In terms of accounting processing, there are two kinds of account items of transaction, "acquisition" and "affiliated company accounted for by the equity-method". It is necessary for each merger case to apply appropriate accounting treatment. "Acquisition" is account for the purchase method. On the other hand, "affiliated company accounted for by the equity-method" is account for pooling of interest method. In Japan, "pooling of interest method" has been abolished, so we use purchase method in this study.

3.4 Bankruptcy Mechanisms

In the proposed model herein, bankruptcy factors of financial institutions are as follows: 1) excessive debt 2) decrease of capital adequacy ratio to below a certain value and 3) lack of funds after funding to continue procurement. The first factor resembles the one handled by the model of May and Arinaminpathy (May and Arinaminpathy, 2010). The second factor means that minimum capital ratio is required. The third factor describes a situation where a company cannot cover its lack of funds in the short-term money market.

4 THE MODEL IN THIS STUDY

4.1 Outline

Each agent has its own balance sheet. Marketable asset price follows the transition of probability difference equation. We analogize a network to a complete graph. Each financial institution updates its balance sheet when an agent completes a trade with another.

The goal of this study is to analyse systemic risk change due to mergers between financial institutions. By introducing purchase method, we can deal cases where the purchase amount is larger than the assets of a merged company. In addition, systemic risks are examined by changing the decline rate of marketable asset price.

4.2 Agents

We use the same modelling framework as the one in (Kikuchi et al., 2016), whereby each bank has a simplified balance sheet. Each balance sheet consists of the following factors. Compared with Kikuchi's model, our model has two more parameters, combination by purchase and goodwill, as shown in Table 1.

Table 1: Balance sheet items of banks.

Parameter	Label
1) Marketable Asset	$MA_i^{bookvalue}$
2) Non-Marketable Asset	$nonMA_i$
3) Debt	D_i
4) Equity	E_i
5) Deposit facilities	DF_i
6) Short-term investment	SI_i
7) Short-term funding	SF_i
8) Combination by purchase	BP_i
9) Goodwill	NR_i

Financing gap is then defined as below:

$$Gap_i = D_i + E_i - nonMA_i - MA_i^{bookvalue} - DF_i \quad (1)$$

Surplus/Shortage institutions are defined as below:

$$C^{surplus} = \{a_i | Gap_i \geq 0\} \quad (2)$$

$$C^{shortage} = \{a_i | Gap_i < 0\} \quad (3)$$

Note that the status of each bank remains unchanged from first step to final step.

We also define unrealized profit or loss (UP_i), capital adequacy ratio (CAR_i), income profit (IP_i) and ROE (ROE_i):

$$UP_i = MA_i^{t\ marketable} - MA_i^{bookvalue} \quad (4)$$

$$CAR_i = \frac{E_i + UP_i}{nonMA_i + MA_i^{bookvalue}} \quad (5)$$

Where β and γ denote the rate of return for marketable and non-marketable assets respectively.

Marketable assets are then defined as below:

$$MA_i^{t\ marketable} = \frac{MA_i^{bookvalue}}{P_0 \times P_t} \quad (6)$$

P_t is the market price of marketable assets in step t.

Next, we explain the process of a merger between randomly chosen two banks before trading on the interbank network. A bank with more assets acquires another bank with smaller assets. The purchase price of banks and the goodwill value are defined as follows.

First, we examine whether one bank can buy the other by the total capital amount.

$$MA_i^{bookvalue} + nonMA_i + SI_i > BP_i \quad (7)$$

If the bank cannot acquire the other, the model will choose another combination of banks.

When an acquisition is confirmed as executable, our model determines the amount of goodwill. We define as Marketable asset price of acquisition j: $MA_j^{bookvalue}$, Non-marketable asset of acquisition j: $nonMA_j$, debt of acquisition j:D_j

Then the amount of goodwill (NR_i) shall be determined as follows.

$$NR_i = BP_i - (MA_j^{bookvalue} + nonMA_j - D_j) \quad (8)$$

In addition, our model defines minimum capital adequacy ratio ($CAR\text{-}demand_i$). It is the lowest level of the bank's capital ratio to be an eligible borrower.

4.3 Network

We use the same modelling framework as the one proposed by Kikuchi et al. (2016). Bank a_i engages in short-term investment and funding with other financial institutions

$$W_i^{Intertbank} = \{a_j | m_{ij} = 1\} \quad (9)$$

and tries to eliminate its funding gap. Then, m_{ij} is the adjacency matrix of the I/B network.

4.4 Financial Behaviour

First, a shortage institution $a_i$issues financing orders to surplus institutions a_j

$$\text{Order(i, j, } amount_i^j\text{)}$$

Additionally, a_i places an order to all surplus institutions in the interbank network by evenly splitting the amount of its financial gap. a_j checks the financial condition of a_i and the amount available for lending to it to judge the feasibility of the loan to a_i.

4.5 The Effects of Bankruptcy

4.5.1 Individual Bankruptcy

If the capital ratio is equal to or less than the threshold value, or, if the funding gap is not filled, a_i shall be deemed "bankrupt" in our model.

Additionally, banks became bankrupt by either the above criteria through the same step is defined as N_b. Thus the following case is defined as "multiple simultaneous collapse":

$$\frac{N_b}{N} \geq \iota \quad (10)$$

4.5.2 Chain Reaction Collapse

If financial institution a_i experiences bankruptcy, financial institutions a_j that are involved in short-term operations with a_i end up with uncollectible

funds from these investments. In this model $a_j's$ uncollectible funds by the transactions with a_i are deducted from $a_j's$ capital.

$$E_{j+1} = E_j - SI_j^i \quad (11)$$

If the following conditions are satisfied, some of a_j banks suffer bankruptcy. In this way a chain reaction collapse occurs.

$$E_j < 0 \; or \; Gap_j < 0 \; or \; CAR_j < 0 \quad (12)$$

5 ANALYSIS OF MODEL BEHABIOR

5.1 Price Time Series of Marketable Assets

Market price provides the basis for the time series of marketable assets used in the simulation, and is calculated using the following discretized stochastic differential equation (Luenberger, 1997).

$$P_{t,j} = P_{t-1,j} + r_f P_{t-1,j} \Delta t + \sigma P_{t-1,j} \tilde{\varepsilon} \sqrt{\Delta t} \quad (13)$$

Where t is time step(t=-m+1, … ,0,1,…,T), j: is trail number, $P_{t,j}$ is price of marketable asset(j times, step t)(P_0=100), r_f is risk free rate[%], σ is volatility [%], and $\tilde{\varepsilon} \sim N(0,1)$. In this simulation, we set 1 step = 1 day = 1/250 year and $\Delta t = 1/250$, T = 125 (assuming 6 month is the budget-closing period for a bank account). Additionally, taking into account long-term government bond yield levels and stock markets in each country: $r_f = 2\%, \sigma = 25\%$, 1000 sample paths are generated and we adopt marketable asset price decline rate by 10%, 20%, 30% and 40% from the initial value.

5.2 Common Setting

The common setting of parameters is shown in the simulation Figure 5. There are 20 financial institutions in total, and I/B network is a complete graph. In terms of financing gap, since surplus institutions outnumber shortage institutions, surplus institutions are subjected to the following adjustment:

$$\text{(Financing gap adjustment)} = \frac{\sum(nonMA_i + MA_i^{bookvalue}) \times \kappa}{\#C^{surplus}} \quad (14)$$

Moreover, following assumption is made: α: 0%, β: 1.2%, γ: 1.0%, δ: 1, ε: 1%, ζ: 5%, η: 2.33, θ: 10%, ι: 10%, κ: 10%, n: 10, m: 16.

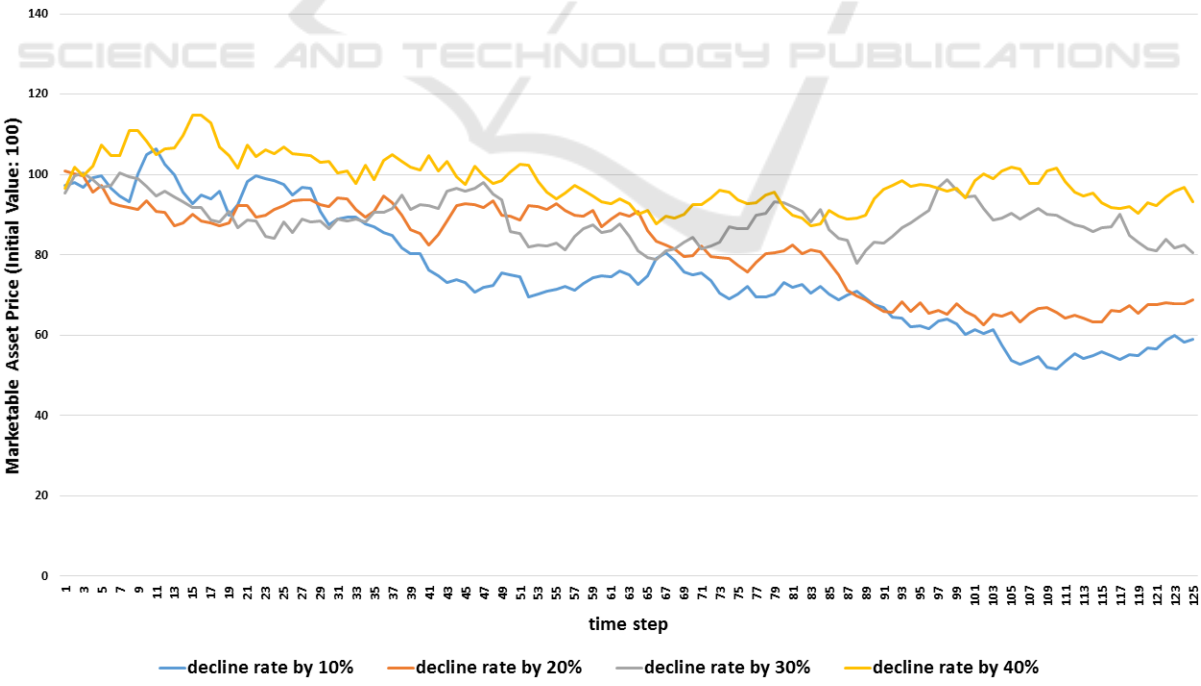

Figure 4: Price time series of marketable assets employed in this simulation totalled 1,000 trials and we adopted the decline rate by 10%, 20%, 30% and 40% prices from the initial value.

5.3 Check the Model

When marketable asset price fall by 40%, we carry out one set simulation shown in the Figure 5. Figure 7 shows the number of remaining banks. In this experiment, 6 out of 20 banks remain in the final step. In this experiment, continuous failure has occurred at the 50^{th} step and involving 10 banks' continuous bankruptcy has occurred at the 92^{th} step. This chain collapse is similar to the previous study. One bankruptcy causes another, which leads to still others. Some banks cannot keep capital and this brings further bankruptcy. As a result, a chain of bank failures occurs.

Parameters	Label	Value
Number of institutions N	N	20
Interbank network	$W^{interbank}$	Complete graph
Non-marketable asset	$nonMA$	100, constant
Marketable asset	MA	20-50, uniform distribution
Deposit facilities	DF	10-25, uniform distribution
Debt	D_i	90-110, uniform distribution
Equity	E_i	20-40, uniform distribution
CAR-demand	$CAR - demand$	0%-4%, uniform distribution
Risk aversion	λ	0.0-1.0, uniform distribution
Budget target	γ	1.5-2.0, uniform distribution

Figure 5: Parameter set used for this simulation.

Label	Parameters	Value
α	Capital adequacy level	0%
β	Marketable asset return	1.2%
γ	Non-marketable asset return	1.0%
δ	Minimum order quantity	1
ζ	Allocation ratio	50%
η	99% confidence level	2.33
θ	Distributed investment ratio	10%
ι	Definition of simultaneous multiple failures	10%
κ	Funding gap adustment	10%

Figure 6: Parameter rationale.

5.4 Impact Analysis by Bank Merger

We use the same modelling framework as in the Kikuchi's model (Kikuchi et al., 2016), and expand it to introduce bank mergers by purchase method. We investigate the impact of mergers between banks amid declining marketable asset prices. We assume 4 patterns of decline rate of marketable asset price. It is a pattern that falls by 10%, 20%, 30%, 40% respectively from initial price. Simulation is carried out 100 times and the average number of bankruptcy banks is compared with the decline rate of asset price.

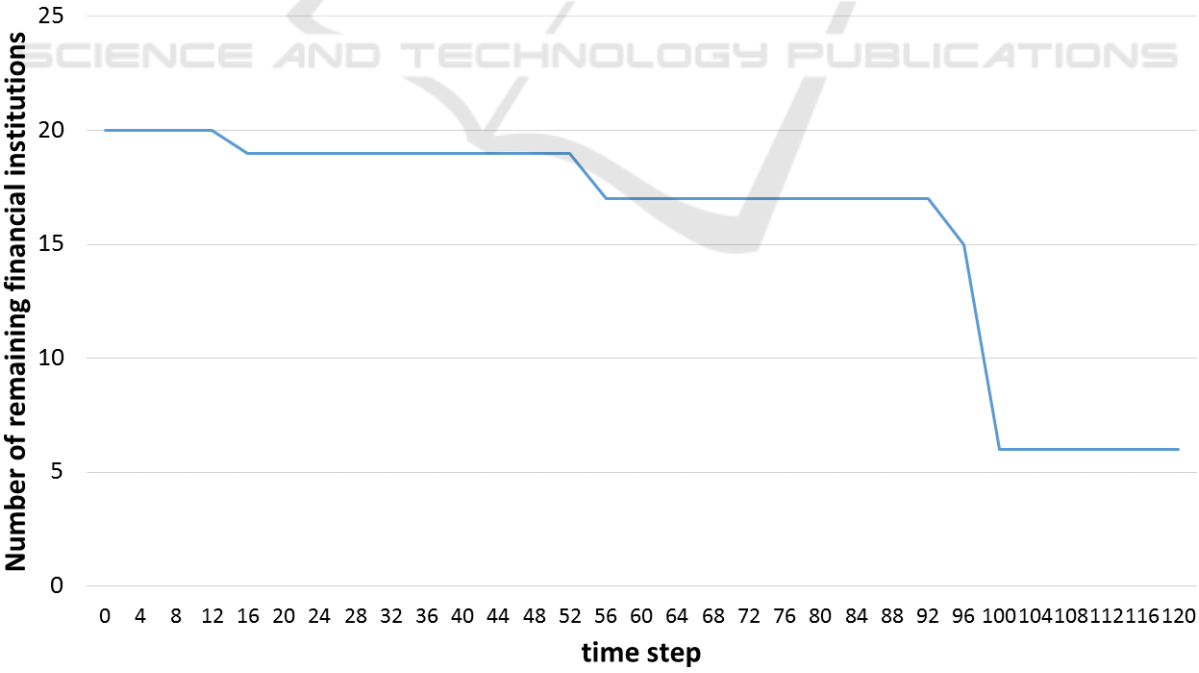

Figure 7: Changes in the number of remaining banks in individual trials.

Parameter (Marketable asset price decline rate in the final step)	Before financial institution merger	After Financial institution merger
Average number of failures(10%)	0.09	0.07
Average number of failures(20%)	2.38	1.75
Average number of failures(30%)	3.71	4.49
Average number of failures(40%)	4.15	4.44

Figure 8: Changes in the average number of bank failures.

The data in Figure 8 shows that when the decline rate of asset price is low, it is very effective for financial system to implement a merger and that when the decline rate of asset price is high, it is not effective.

Parameter (Marketable asset price decline rate in the final step)	After financial institution merger
Average number of failures(10%)	0.05
Average number of failures(20%)	0.08
Average number of failures(30%)	0.51
Average number of failures(40%)	0.48

Figure 9: Number of bank failures by 4 falling asset price patterns.

Figure 9 shows the average number of failures of integrated banks. When the decline rate of marketable asset price is 20%, such bank failure is 0.08. At this time, it turns out that integrated banks hardly go bankrupt. However, when it declines more than 30%, there is a higher possibility that integrated banks will collapse.

6 DISCUSSION

We discuss the results of the experiment. First, the number of bankruptcies of financial institutions increase due to decline in marketable asset price. From Figure 8, it is found that the higher the decline rate of asset price becomes, the larger the number of failures is examined when banks merged. The factor of the increase in the number of failures is a deterioration in the capital ratio. It is because some banks cannot raise funds due to worsening capital ratio rate, even if banks conduct merger.

Next, we discuss Figure 9. When the decline rate of asset price is high, half of banks go bankrupt. There is almost no improvement in the capital adequacy ratio due to merger.

On the other hand, when the decline rate of asset price is low, it is better for bank to implement a merger. Figure 6 shows that the number of failures is greatly reduced due to merger. By strengthening capital, the number of financial institutions of going bankrupt declines. In other words, as shown in Figure 7, the decline rate of asset price is less than 20%, the banks hardly go bankrupt. A possible contributor to this finding may have been amount of capital. Banks after merger have more capital than other banks.

7 CONCLUSION

The main purpose of this study is to examine whether goodwill brought about by the merger and acquisition prevents the go-bankrupt-in-chain in the interbank market.

The most important finding of this study is that if the marketable value asset prices plummet sharply, the effect of merger is small.

Another key finding is that the decline rate of marketable asset price determines bankruptcies.

The data in Figure 8 shows that the number of failures has been greatly reduced due to merger. When the decline rate of asset price is low, it is better for bank to implement merger.

The results of this study imply that by strengthening capital, a possibility of financial institutions of going bankrupt declines.

In addition, as shown in Figure 9, if the decline rate of asset price is less than 20%, banks have hardly go bankrupt. A possible contributor to this finding may have been amount of capital. Banks after merger have more capital than other banks.

We examine the effects of goodwill (*Noren*) that have received very little attention in the literature.

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