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Should Zombie Be in the Grave? :  
A Simulation-Based Policy Comparison  
between Two Types of Economies

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# Should Zombie Be in the Grave?: A Simulation-Based Policy Comparison between Two Types of Economies

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## Abstract

The aim of this paper is to examine the argument that low productive firms should be closed to make the macroeconomic performance better. It is said that the existence of zombie firms is one of the reason for the stagnation of Japanese economy. The process of creative destruction where the new entries which have higher productivity is not in the right way because of the existence of zombie, that is, “zombie firms prevent more productive companies from gaining market share, strangling a potentially important source of productivity gains for the overall economy (Ahearne and Shinada (2005), p364).”

But, if the bankruptcy of one firm affects on the other firms, this argument does not hold because there are firms which are embroiled into the bankruptcy chain. This firm’s productivity is not so low that they go into bankruptcy if the whole economic performance is good.

In this paper, the validity of zombie theory is examined by way of computer simulation with the network economy framework.

**Keywords:** Zombie Theory, Network Economy, Non-Network Economy, Bankrupt Chain

## 1 Introduction

The aim of this paper is to examine the argument that low productive firms should be closed to make the macroeconomic performance better. As well known, Japanese economy has faced prolonged recession after the burst of bubble in 1989. Although it has been said that there were several recoveries for these periods, almost all Japanese people have not been able to feel them. What is the problem? One of answers to this question is the existence of “zombie firms”, that is, unprofitable and less productive firms<sup>1</sup>.

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<sup>1</sup>See, for example, Caballero et al. (2008)

The firms with high debt and low productivity should not be alive because they distort the normal working of the market competition. If Japanese banks rationally decided not to lend any more to them, zombie must have been dead and as a result Japanese macroeconomy have shown better performance. This is the essence of the argument of zombie firms. This has an affinity for the neoclassical economic growth theories<sup>2</sup>. According to them, the main engine for economic growth is total factor productivity. If people desire the high performance of macroeconomy, it is necessary to make the productivity higher. However, the process of creative destruction where the new entries which have higher productivity is not in the right way because of the existence of zombie. “[Z]ombie firms prevent more productive companies from gaining market share, strangling a potentially important source of productivity gains for the overall economy (Ahearne and Shinada (2005), p364).” Because, by definition, the productivity of zombie firms is low, government or banks must leave them until they die. ‘Do nothing’ is the best way to get the macroeconomic performance better.

If the macroeconomic performance is determined only by supply side factors, this argument might be right from one aspect<sup>3</sup>. But, at the same time, there is the other point to be picked up. The above argument is based on the particular assumption that the operation of a firm is independent from that of other firms. The neoclassical method, representative agent model, is impossible to get hold of the interaction between heterogeneous agents in principle<sup>4</sup>. Especially, the effect of bankrupt on the whole system is out of focus. However, it is apparent that agents in the macroeconomic system are connected with each other through various networks. When some firms go into bankruptcy, it is possible that the effect of these events is propagated through these networks. Bankrupt chain, which is frequently seen in economic depressions, is one of the incarnation of the existence of network in the real world. In this case, it is difficult to discriminate the cause of bankruptcy because a firm can be involved in the bankruptcy of other firms. In the zombie theory, all zombie firms are composed of firms which have low productivity. But when the network economy is taken into consideration, the situation is a bit different. There may be firms which are not bankrupted if other firms are not bankrupted. It means that that the zombie theory does not always hold. If this is true, the policy evaluation can be also different. That is, some firms should be alive or salvaged even though they are considered as zombie from the perspective of the zombie theory based on the concept of non-network economy, because, in the network economy, firms which have relatively high productivity can be embroiled in the bankrupt chain. This is the main message in this paper.

In this paper, I try to confirm whether the zombie theory can hold in the network economy setting by computer simulation. I use the model called as agent-based-model where there is a large number of heterogeneous interacting agents. The network in the system is made from financial contracts between each firm and one bank. In this sense, the explicit interconnection

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<sup>2</sup>See Acemoglu (2009) for reference to neoclassical growth theories

<sup>3</sup>In this paper, the demand side factors are totally ignored

<sup>4</sup>Representative agent model is characterized as reductionism in this meaning. See, for example, Delli Gatti et al. (2008).

between firms cannot be detected. Each firm, however, is connected implicitly through the variation of condition of financial contract (interest rates charged by the bank). To be concrete, when a firm goes into bankruptcy, this non-performing loan has to be wiped out by the same amount of the bank's net worth. By this process, the financial condition of this bank changes into worse. So, this bank rigidizes the financial condition between *other incumbent firms* by rising interest rates. The bankruptcy of one firm is propagated through this mechanism. In this model, the operation of all firms is not independent from others.

In the zombie theory, the irrational behaviors of banks are insisted. It means that zombie could be alive because banks saved them by giving them methods to roll over their debts. This is not a governmental policy. On the contrary, in this paper, I focus only the point that whether less productive firms should not be helped. Whether the institution is bank or not is not a problem. From this stand point, I introduce *government* as the player to salvage firms. That is, I treat this problem as the effectiveness of the governmental policy.

The rest of this paper is organized as follows. In the next section, an agent model is proposed. Because there are a large number of firms in this model, simulation is one of the important methods to analyze the model behavior. This is executed in section three. Section four is conclusion of this paper.

At last, two terms, 'Network economy' and 'Non-network economy', are used to depict two different economy hereafter. Of course, the first means the economy where networks between agents are built in. Any agents are connected with each other and their operations are not independent of the whole system. The second one represents the economy composed by independent agents<sup>5</sup>.

## 2 The Model

In this section, we build an agent based model with financial aid to low productivity firms. Basically, we follow Delli Gatti et al. (2005) because it is highly tractable.

### 2.1 Firm Sector

In the system, there is  $N$  firms. We assume the number of firms is constant for all periods. Each firm are indexed by  $i = 1, 2, \dots, N$ , and firm  $i$ 's production function is

$$Y_{it} = \phi_{it}K_{it}. \quad (1)$$

The productivity of firm  $i$  are composed of its "basic level of productivity",  $\bar{\phi}_i$  and random variable  $\varepsilon_{it}$ , that is,

$$\phi_{it} = \bar{\phi}_i + \varepsilon_{it}. \quad (2)$$

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<sup>5</sup>These two discrimination are hypothetical. The author considers that the real economy is closed to the network economy.

$\varepsilon_{it}$  is following uniform distribution with support  $(\varepsilon_{\min}, \varepsilon_{\max})$ , and  $E(\varepsilon_{it}) = 0$ . In this case,  $|\varepsilon_{\min}| = |\varepsilon_{\max}|$  and  $\varepsilon_{\max} - \varepsilon_{\min} = 2\varepsilon_{\max}$ . Furthermore,  $E(\phi_{it}) = \bar{\phi}_i$ . Balance sheet relation of a firm is

$$K_{it} = L_{it} + A_{it}. \quad (3)$$

For simplicity, we assume the rate of return for net worth  $A_{it}$  is equal to charged interest rate  $r_{it}$ . Firm  $i$ 's profit is the difference between its proceeds and its repayment costs with additional ones,

$$\pi_{it} = \phi_{it}K_{it} - gr_{it}K_{it}, \quad \text{where } g > 1 \quad (4)$$

Therefore, the law of motion of the net worth is

$$\begin{aligned} A_{it} &= A_{it-1} + \pi_{it} \\ &= A_{it-1} + \phi_{it}K_{it} - gr_{it}K_{it}. \end{aligned} \quad (5)$$

From this law of motion (5), a level of productivity shock  $\tilde{\varepsilon}_{it}$  at which firm  $i$ 's net worth is negative can be derived,

$$\tilde{\varepsilon}_{it} = gr_{it} - \frac{A_{it-1}}{K_{it}} - \bar{\phi}_i. \quad (6)$$

If  $\varepsilon_{it} < \tilde{\varepsilon}_{it}$ , the firm  $i$ 's net worth is negative. In the case there is no financial aid for firms with negative networth, these firms might go into bankrupt. This probability of becoming a would-be bankrupted firm (a bankruptcy candidate)  $Pr(\varepsilon_{it} < \tilde{\varepsilon}_{it})$  is determined by two financial variables. One of them is the interest rate charged on this firm. The other is its own net worth. The higher the interest rate is, and the smaller this firm's net worth is, this probability is high.

Following Delli Gatti et al. (2005), each firm maximizes its profit with would-be-bankrupted probability. The firm  $i$ 's objective function is

$$\begin{aligned} \Pi_{it} &= E(\phi_{it})K_{it} - gr_{it}K_{it} - cY^2 Pr(\varepsilon_{it} < \tilde{\varepsilon}_{it}) \\ &= \bar{\phi}_i K_{it} - gr_{it}K_{it} - \frac{c\phi_{it}^2 K_{it}^2}{2\varepsilon_{\max}} \left[ gr_{it} - \frac{A_{it-1}}{K_{it}} - \bar{\phi}_i - \varepsilon_{\min} \right] \end{aligned} \quad (7)$$

and desired stock of capital,  $K_{it}^d$  is derived by the first order condition  $\frac{\partial \Pi_{it}}{\partial K_{it}} = 0$ , that is,

$$K_{it}^d = \frac{\varepsilon_{\max}(\bar{\phi}_i - gr_{it}) + \frac{c\phi_{it}^2 A_{it-1}}{2}}{c\phi_{it}^2 (\varepsilon_{\max} + gr_{it} - \bar{\phi}_i)}. \quad (8)$$

The amount of investment of firm  $i$  is determined by the difference of desired capital stock and capital stock in previous period. It is financed by profits earned in previous period and new credit flows.

$$\begin{aligned} I_t &= K_{it}^d - K_{it-1} \\ &= \Delta L_t + \pi_{it-1} \end{aligned} \quad (9)$$

in equation (9),  $\Delta$  means the difference of variables in period  $t$  and previous period  $t - 1$ ,  $\Delta X_t \equiv X_t - X_{t-1}$ . By the equation (8) and balance sheet relation, stock of credit demand function of firm  $i$  in period  $t$  is derived as follows:

$$L_{it}^d = K_{it}^d - A_{it-1} - \pi_{it-1}. \quad (10)$$

## 2.2 Government

In this paper, government has a role to help zombies (bankruptcy candidates). Government follows the undermentioned process to help zombies.

1. In the end of each period  $t$ , government gathers information of bankruptcy candidates.
2. Following particular salvage rules (they are formalized as ‘POLICY’ in next section)<sup>6</sup>, government chooses candidates to be helped.
3. Government gives resources to each of them. And the amount of resources are set as the same amount of networth held just before it becomes a bankruptcy candidate.
4. Government raises these resources as a lump sum tax from aggregate production at the corresponding period.

## 2.3 Bank Sector

The model of banking behavior is totally depend on the Delli Gatti et al.(2005) formalization. In this sense, no original view exists in banking sector. The role of bank is only to give explicit and implicit financial connections through which external technological shocks are propagated.

In each time, the bank’s balance sheet becomes

$$L_t = D_t + E_t. \quad (11)$$

I use  $L_t^S$  to indicate the total amount of credit supply at period  $t$ . Bank faces the quantity constraint in the total amount of credit supply. That is, the total credit supply is proportional to its net worth at period  $t$  with a constant  $\nu$ ,

$$L_t^S = \frac{E_t}{\nu}. \quad (12)$$

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<sup>6</sup>About these rules, there is four scenarios in this paper. First one is that bankrupt candidates included in high productivity group are helped. Second, candidates with low productivity are helped. Third, government does nothing. And finally, all candidates are helped. In the next section, simulation is executed following these scenarios

From the balance sheet constraint (11) and this credit supply rule (12), we can find the amount of deposit  $D_t$  is simply determined as a difference of credit supply and net worth. The bank supplies credit to the operating firms following simple rule shown below,

$$L_{it}^s = \frac{K_{it-1}}{K_{t-1}} L_t^s, \quad (13)$$

where,  $K_t \equiv \sum K_{it}$ <sup>7</sup>. Equation (13) shows bank rations its total amount of credit depending on the relative size of the firm  $i$  represented by the ratio of its own capital stock to the total capital stock. From the credit demand function (10) and this credit supply rule (13), we derive the interest rate charged on firm  $i$ ,

$$r_{it} = \frac{\phi_{it}\varepsilon_{\max} - c\phi_{it}^2(\varepsilon_{\max} - \bar{\phi}_i)(\pi_{it-1} + A_{it-1} + F_t) + \frac{c\phi_{it}^2 A_{it-1}}{2}}{g[\varepsilon_{\max} + c\phi_{it}^2(\pi_{it-1} + A_{it-1} + L_{it})]}, \quad (14)$$

Bank profit becomes

$$\pi_t^B = \sum r_{it} L_{it}^s - \bar{r}_{t-1}[(1 - \omega)D_{t-1} + E_{t-1}], \quad (15)$$

where  $\bar{r}_{t-1}$  is the average interest rate in the previous period. In each period, there might be firms with negative networth (bankruptcy candidates). If they are not selected to be helped, they goes into bankruptcy. Total amount of negative networth becomes the stock of non-performing loans  $B_t = - \sum_{i \in \Theta_t} A_{it}$ , where,  $\Theta_t$  is a set of bankrupt firms. Bank wipes out this non-performing loans by subtracting them from its own networth. As a result, the law of motion of bank's net worth is

$$E_t = \pi_t^B + E_{t-1} - B_t. \quad (16)$$

### 3 Simulation Results

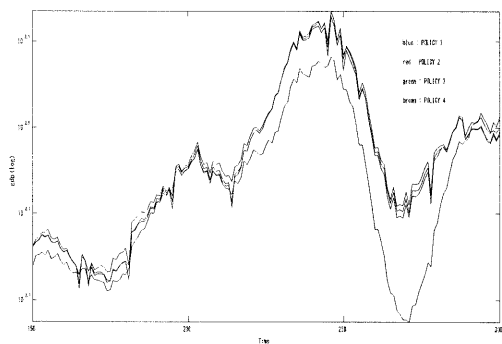
#### 3.1 Comparing with Non-Network Economy

In this section, some simulation results are shown. Parameters are given as follows: Number of firms  $N = 1000$ , Simulation span  $T = 150$ , Maximum value of productivity  $\phi_{\max} = 0.1$ , Minimum value of productivity  $\phi_{\min} = 0.05$ <sup>8</sup>, Bankruptcy cost coefficient  $c = 1$ , Total cost coefficient  $g = 1.1$ , Initial capital stock  $K_{i0} = 1$ , Initial net worth (firm  $i$ )  $A_{i0} = 0.4$ , Initial borrowing  $L_{i0} = K_{i0} - A_{i0}$ , Difference of lending rate and deposit rate parameter  $\omega = 0.0002$ , Quantity constraint on lending capacity  $\nu = 0.1$ , Initial lending  $L_0 = \sum L_{i0}$ , Initial net worth

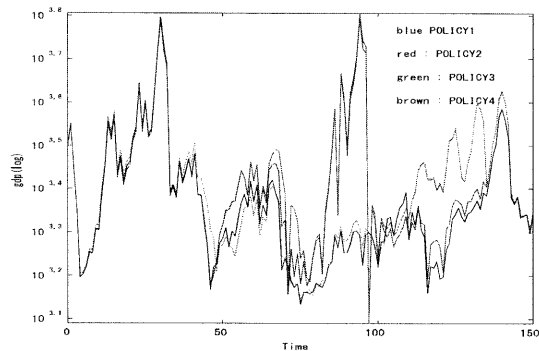
<sup>7</sup>Delli Gatti et al.(2005) has a bit more general credit supply rule, that is,  $L_{it}^s = \lambda \frac{K_{it-1}}{K_{t-1}} L_t^s + (1 - \lambda) \frac{A_{it-1}}{A_{t-1}} L_{it}^s$ .

<sup>8</sup>That is, two times productivity gap is assumed in this model simulation.



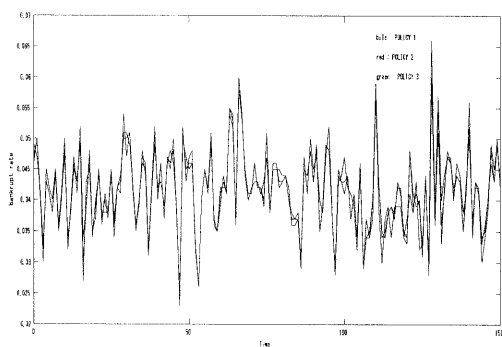


(a) Network Economy

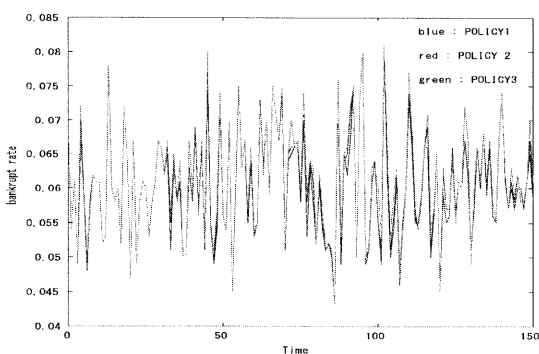


(b) Non-Network Economy

Figure 1: Time Evolution of GDP

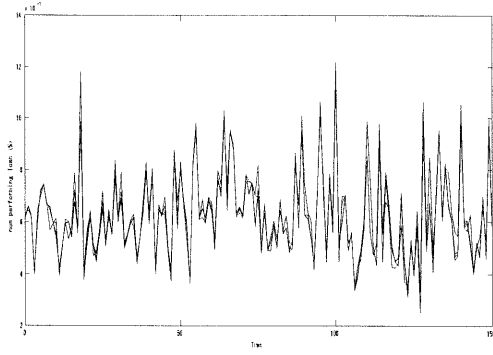


(a) Network Economy

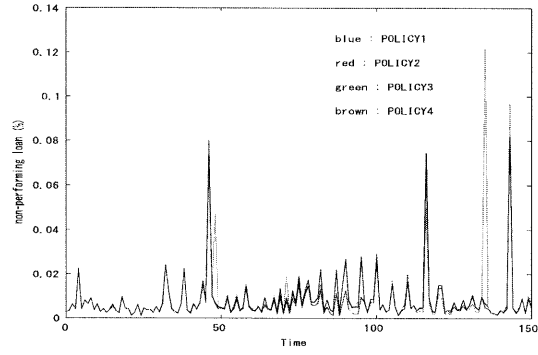


(b) Non-Network Economy

Figure 2: Bankrupt Rate

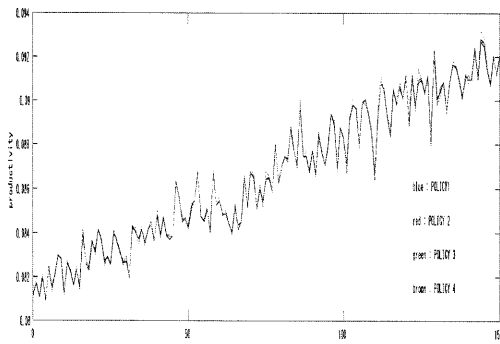


(a) Network Economy

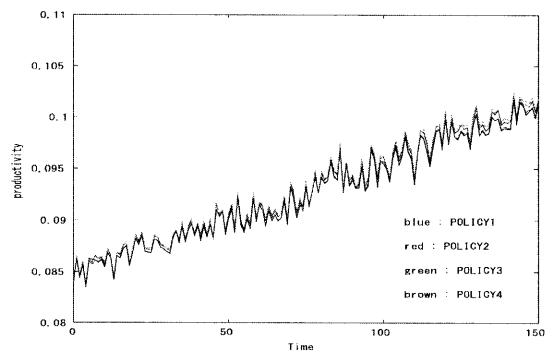


(b) Non-Network Economy

Figure 3: Non-Performing Loan Rate



(a) Network Economy



(b) Non-Network Economy

Figure 4: Time Evolution of Productivity

Table 1: Statistic Comparison between Two Types of Economies

Non-Network Economy	POLICY1	POLICY2	POLICY3	POLICY4
std(GDP)	738.5625	719.7634	503.2065	505.0839
mean( $\phi$ )	0.08241	0.08238	0.08246	0.08237
mean (growth)	0.0055	0.0205	0.0055	0.0122
std (growth)	0.1875	0.2514	0.1450	0.1446
coef.var.	34.2620	12.2919	26.5588	11.8747
Network Economy	POLICY1	POLICY2	POLICY3	POLICY4
std(GDP)	10.8336	11.0145	11.3007	10.8479
mean( $\phi$ )	0.08173	0.08172	0.08176	0.08172
mean (growth)	0.0049	0.0065	0.0048	0.0067
std (growth)	0.0320	0.0327	0.0296	0.0332
coef.var	6.5424	5.0244	6.1703	4.9988

(bank)  $E_0 = \nu L_0$ , Initial deposit  $D_0 = L_0 - E_0$ , and finally, the stochastic technical shock is generated from uniform distribution with support  $[-0.035, 0.035]$ .

First of all, results under two different economic situations are compared. The one is called ‘non-network economy’. It means that each firm is not connected by each other. Because all of them are independent from others, one firm’s bankruptcy does not affect on other incumbents. On the contrary, in the ‘network economy’, all firms are implicitly connected with each other.

There are four figures, from Figure 1 to Figure 4, and each figure has two subfigures. The results of Network economy are shown in the left ones. Naturally, Non-Network cases are put on the right. Each figure has four lines which correspond to following four policy scenarios.

- POLICY1: Bankrupt candidates are salvaged in the top  $\beta$  percent productivity (Line Blue)
- POLICY2: Bankrupt candidates are salvaged in the bottom  $\beta$  percent productivity (Line Red)
- POLICY3: No bankrupt candidates are salvaged (Line Green)
- POLICY4: All bankrupt candidates are salvaged (Line Brown)

In this simulation,  $\beta$  is set as a parameter and its value is 0.3.

GDP dynamics can be seen in Figure 1. GDP performance is quite different in these two types of economy. Because in non network economy, there is no change in the interest rate charged at all firms (they are set as a constant), all the sources of fluctuation are from exogenous

technological shock  $\varepsilon_{it}$ . Moreover, all firms' bankrupt are independent from others, no bankrupt chain occurs. In the right figure (b) in Figure 1, this is the reason why all the degree of decline of GDP is very steep. When relatively big firm goes into bankruptcy, total GDP moves down as well. On the contrary, as seen in figure (a) in Figure 1, GDP fluctuates gradually in the case of network economy. Because of this network, firms can be involved in the others' bankrupts. This interrelationship makes endogenous fluctuations. By seeing Figure 2 and Figure 3, the difference of performance is much more understandable. These figures show financial conditions of each economy. Figure 2 depicts the dynamics of bankrupt rate. The mean value of this variable is around 0.06 in both cases. But, this variable is less stable in non-network economy. Figure 3 contains the dynamics of non performing loan rates. This variable means the size of the bankrupted firms. As easily seen, the left panel (network economy case) shows the low values and high correlations and the right panel inversely shows the high values and low correlations. These different financial conditions make quite different performance.

On the zombie argument, an interesting result is derived. The notable point is that the economic performance of each policies are quite different in these two types of economies. When POLICY 3 is taken, this brings prosperity in some periods in non-network economy, and realizes the lowest standard deviation of GDP (503.2065, see Table 1). Under POLICY 3, furthermore, the average productivity becomes the highest (Figure 4). The creative destruction process works. But, see in the case of network economy. In network economy, GDP performance is better to take some actions (POLICY1,2,or 4) than to do nothing (POLICY3). Because the exogenous shocks are generated the same random process<sup>9</sup>, the qualitative behavior is similar. But the degree of fluctuation is much larger in the case of POLICY 3 than in the other cases. In fact, on the contrary to standard deviation in POLICY 3 being 11.3007, those of other POLICY cases are 10.8336, 11.0145, and 10.8479 respectively (see Table 1). Moreover, the highest growth rate is seen in POLICY4 and the lowest standard deviation of growth rate seen in POLICY2, as a result, the lowest coefficient of variance of growth rate, 4.9988, is realized in the case of POLICY4 and the second one, 5.0244, is in POLICY2 (6.1703 in POLICY3). As seen in Figure 3 (a), the size of bankrupt firm is generally higher in POLICY 3 than in the other policies. It is natural that salvage policies prevent the bankrupt chain propagation. This mechanism helps to smooth the GDP fluctuation. And the fact that the peak level of GDP is higher suggests that the zombie theory not always holds. Because of the correlation of bankrupts, some firms are involved in the bankrupt chain. It means that if they are helped, they can survive in succeeding periods. Their productivity are not so low. They are only embroiled.

### 3.2 A Result of Monte-Carlo Simulation

Next, the result of Monte-Carlo simulation is shown. In this type of simulation, each result depends on the corresponding value of stochastic variable. Even if one stochastic shock brings

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<sup>9</sup>This simulation was executed under the same 'seed' of random variables.

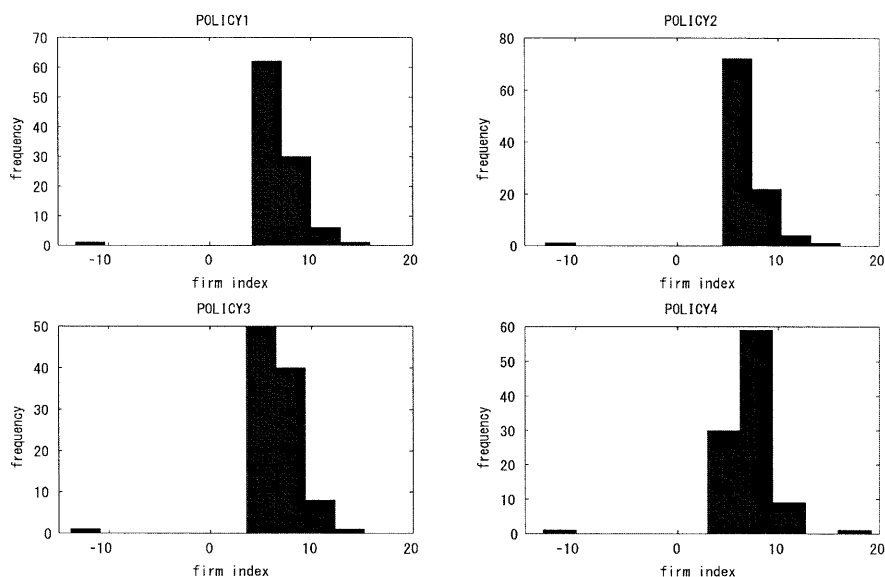


Figure 5: Coefficients of Variance of Growth Rates

a different result, the property of the model behavior can be detected by executing simulations in many times. I executed 100 times simulations in this paper. Of course, the set of the values of exogenous shock hitting firms in all periods  $t$  is the same in every Monte-Carlo simulations turn. This Figure 5 is a histogram of coefficients of variance of growth rate in all four scenarios. Each panel of upper left, upper right, lower left, and lower right corresponds to POLICY1, POLICY2, POLICY3, and POLICY4 respectively. This figure helps the policy evaluation.

The coefficient of variance is calculated by dividing the standard deviation of a particular variable by its mean value. Here, growth rate is taken as a variable concerned. By definition of coefficient of variance, the smaller it is, the better performance is. From this perspective, POLICY 2 exhibits the best performance. POLICY 2 panel contains the highest frequency of the lowest grid (between 5 and 10)<sup>10</sup>. Under POLICY 2, bottom 30 percent firms are helped. It means that the rest of firms are replaced by the new firms which have higher productivity. That is, taking this POLICY effectively accomplishes to stop the bankrupt chain and not to interfere the creative destruction process at the same time.

<sup>10</sup>The case of negative number should be ignored because it means negative growth rate

## 4 Conclusion

In this paper, the validity of zombie theory is examined. The proponents of this theory insist that the existence of zombies, low productive firms, hinders the creative destruction process in which the normal entry and exit mechanism makes the whole economy productive. The prescription to such a economy is simple: putting all zombies away from the system. However, in these argument, the assumptions that all firms' bankrupt occur independently and that these bankrupts does not affect on other firms' operations. When all firms are connected by economic network, this above argument does not hold. By way of computer simulation, it confirmed that policies to salvage the bankrupt candidates improved the macroeconomic performance in the network economy. That is, governmental intervention can be effective in this kind of economy. It prevents propagation of bankrupt chain and helps firms which are embroiled into that.

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