Revisiting to Agent Based Modelling
for Unpayment Behaviour on Japanese Public Pension System

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Revisiting to Agent Based Modelling

for Unpayment Behaviour on Japanese Public Pension System [†]

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Abstract

In our previous paper [5] at WEHIA2005, we studied the influence of people's distrust in public pension system on the amount of the pension premium fund, whose propagation was simply implemented as fixed parameters. For the sake of dynamic change of people's distrust, in this paper, we devote some space to the discussion of it. Here, some questions now arise: When do people have distrust in public pension system? How is it propagated? For the purpose of answering these questions, we extended our previous model by introducing word-of-mouth communication model. Our "New" model can cause "micro-macro loop" in the propagation of people's distrust on public pension system. The result clearly shows that the propagation of people's distrust in public pension system by word-of-mouth communication have a considerable impact on public pension system.

Keywords: public pension system, multi agent based simulation, distrust in public pension system, word-of-mouth communication model

JEL Classification: C63, H55

1. Introduction

By using our previous model which was released at WEHIA2005, we examined the influence of people's distrust in public pension system on the amount of the pension premium fund, but its propagation is simply implemented in our previous model. What seems to be lacking in our previous model is a consideration of how people's distrust in public pension system is propagated. We will devote some space to the discussion of it.

Some questions now arise:

When do people have distrust in public pension system ?

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How is it propagated ?

For the purpose of answering these questions, we extended our previous model by introducing word-of-mouth communication model. Our "New" model can cause "micro-macro loop" in the propagation of people's distrust on public pension system. The result clearly shows how people's distrust in public pension system is propagated and changes dynamically.

It may be helpful to consider some important factors of how people's distrust in public pension system is propagated. The age which people start to have distrust in public pension system could offer the key to an understanding of the propagation of people's distrust.

According to [1], the proportion of young people having distrust in Japanese public pension system is larger than that of older age people. This situation is described in Table 1.

Table 1. The percentage of people who have signed up but are delinquent in their payments

	Person in Arrears (%)
Total	18.3
Age 20 - 24	23.1
25 - 29	27.7
30 - 34	25.1
35 - 39	21.0
40 - 44	15.0
45 - 49	13.6
50 - 54	12.0
55 - 59	8.7

(Source) [1].

Before we turn to the discussion of our model, it will be useful to be aware of current situation of Japanese public pension system. Japanese public pension system has adopted pay-as-you-go pension system. People aged 20 or above are forced to join in public pension system, and pay pension premium. Money collected as pension premium is distributed to people aged over 65 as pension benefit. However, Japan is well on the way to an aging country. There will not be enough young people to support the elderly through pensions. In addition to this, the pension reform bills were enacted in Japan on June 5, 2004. The bills involved an increase in the premium and benefit cutback. It is inferred from Table 1 that young people has dissatisfaction with the fairness of public pension system and concerns about future pensions. As a result, there may be some people who join in public pension system, though, not pay pension premium. And that the proportion of people who did not pay premium has gone up lately in Japan.

2. The Specifications of our "New" Model
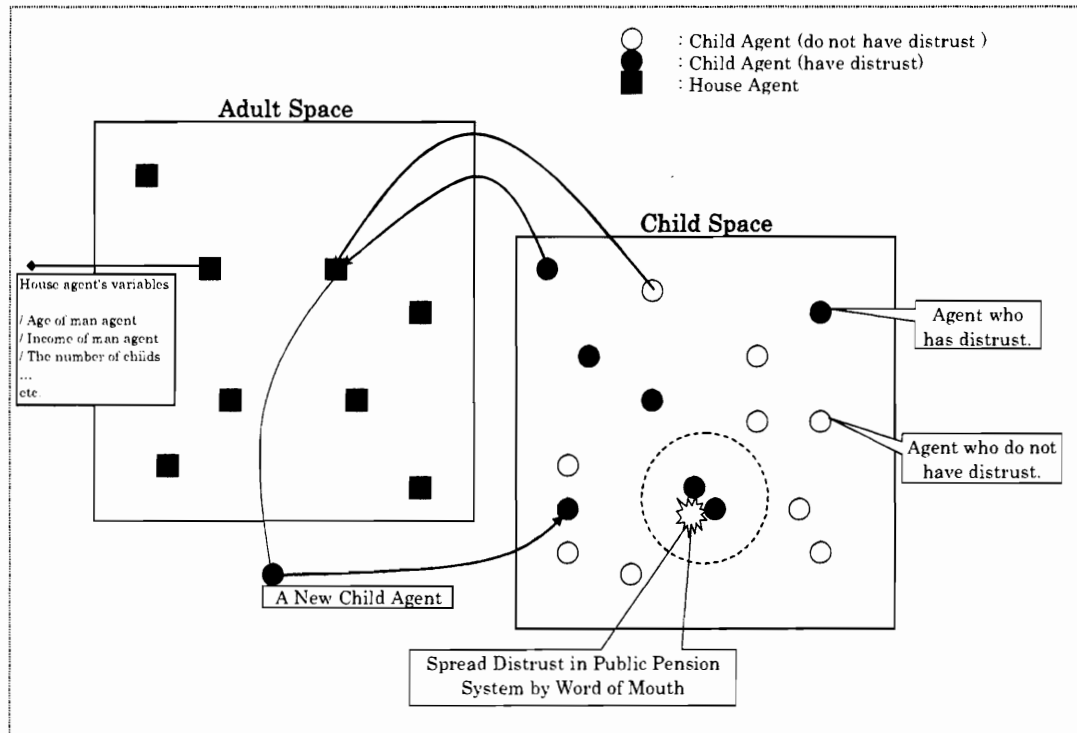
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2-1. The Entire Structure of our Model

Figure 1. The structure of our model

Here, we will give a graphic representation of our new model structure in Figure 1. In our model, there are two spaces ("Adult Space", "Child Space") which have two dimensions, respectively. We have allocated house agent in Adult Space and child agent in Child Space.

When a child agent has reached at the age of 15, he (she) may start to have distrust in public pension system. It is affected by which his (her) parent has distrust in public pension system. The child agent who has distrust in public pension system walks around in "Child Space". The child agent with distrust in public pension system, walks around in "Child Space", and spread his (her) distrust in public pension system by word of mouth.

In due course, the child agent (male) becomes independent at 20 years old, moves to "Adult Space" and makes up house agent. Meanwhile, the child agent (female) starts to look for a mate at 20 years old. If there is an agent (male), who remains single in "Adult Space", she gets married (moves to "Adult Space").

In "Adult Space", agents united by marital ties give birth to a new child agent. If parent (man or woman) agent have distrust in public pension system, a new child agent also has it, moves to "Child Space", and spreads it by word of mouth. In "Adult Space", house agent has information regarding man, woman and child agent, for example, age of man agent, income of woman agent,

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the number of child agent, as variables.

Micro-macro loop in propagation of distrust is emerged by using the method as stated above.

2-2. Agent's Properties

Agent's properties in our new model is essentially the same with which was introduced in our previous model. We have given a summary of agent's properties in our previous model, therefore, if a reader wants to know about agent's properties in our previous model for details, see [3], [4] or the website of WEHIA 2005.

3. Execution of Simulation and Data Analysis

3-1. The Initial Condition of Simulation

As stated in section 1, the proportion of young people having distrust in Japanese public pension system is larger than that of older age people. In addition, the proportion of people having distrust in public pension system is different between age groups.

For the sake of bringing our model close to real world, we have implemented the data described in Table 1 into our model. A certain percentage of agents have distrust in public pension system at the beginning of simulation.

3-2. Data Analysis

In the simulation, data were gathered from 1000 turns (steps), i.e., the time series of the amount of the pension premium fund and the monthly premium and benefit difference from the start of a simulation until about 80 years are completed. Thirty times simulations were performed in each models and the average of their result was calculated for analysis.

We have discussed earlier that people aged over 20 are forced to participate into public pension system, and pay pension premium in Japan. Therefore, our simulation setting has the assumption that agents aged over 20 participate into public pension system. In addition to this, we have adopted two types of simulation settings (No Distrust Model, Distrust Model). They vary in the point whether agents have distrust in public pension system.

Here is a figure, which shows the time series of the amount of the pension premium fund in each of the two models (Figure 2).
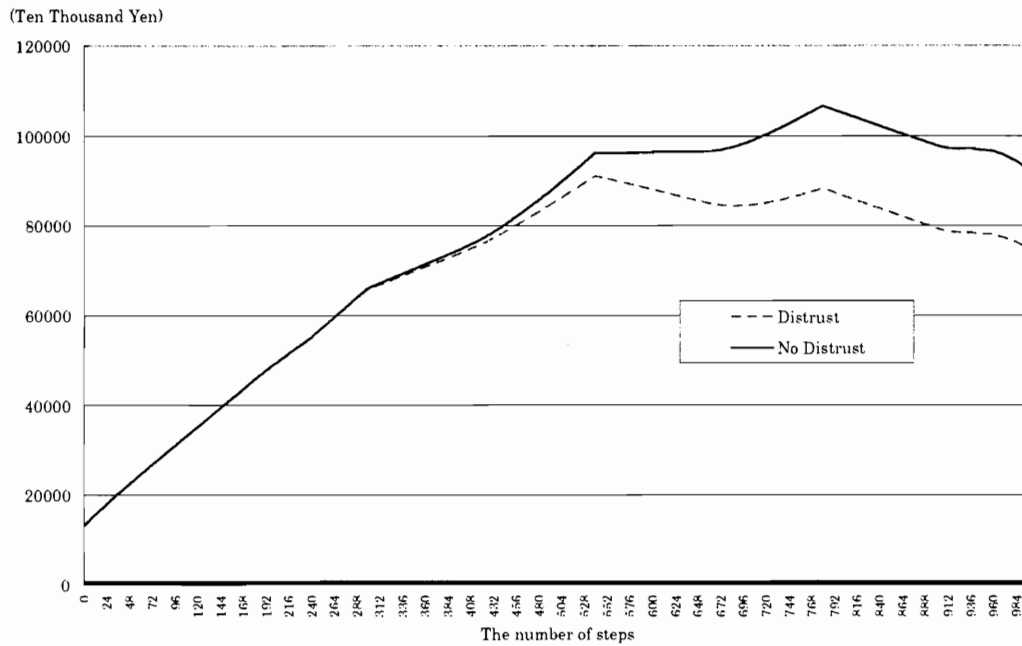
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(Ten Thousand Yen)

Figure 2. The progress of pension premium fund

As indicated in Figure 2, the following results were obtained:

1) The gap of the pension premium fund between "Distrust Model" and "No Distrust Model" start widening at the 310th step.

2) As simulation step goes on, the gap of the pension premium fund between two models gradually grow.

The reason why (1) and (2) occur is that the number of agents having distrust in public pension system gradually increase by word-of-mouth communication.

In addition to this, we will give a statistical test. Two models exist—'No Distrust Model', 'Distrust Model'. Moreover, the data gathered from simulation are the data of the pension premium fund that are obtained in every simulation step. Therefore, we should consider whether an agent's distrust affects the amount of the pension premium fund for every step. The numerical value for every step of the two models is influenced by the agents' distrust. As a result, two samples that change with distrust in each step are generated. A method for testing the numerical value of each corresponding step is required; therefore, we used Wilcoxson's sign rank sum test for this purpose. By this method, we can test whether the difference in the numerical value between the two models is statistically significant. Table 2 summarizes the results of the statistical test performed on the amount of the pension premium fund.

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Table 2. The result of the statistical test

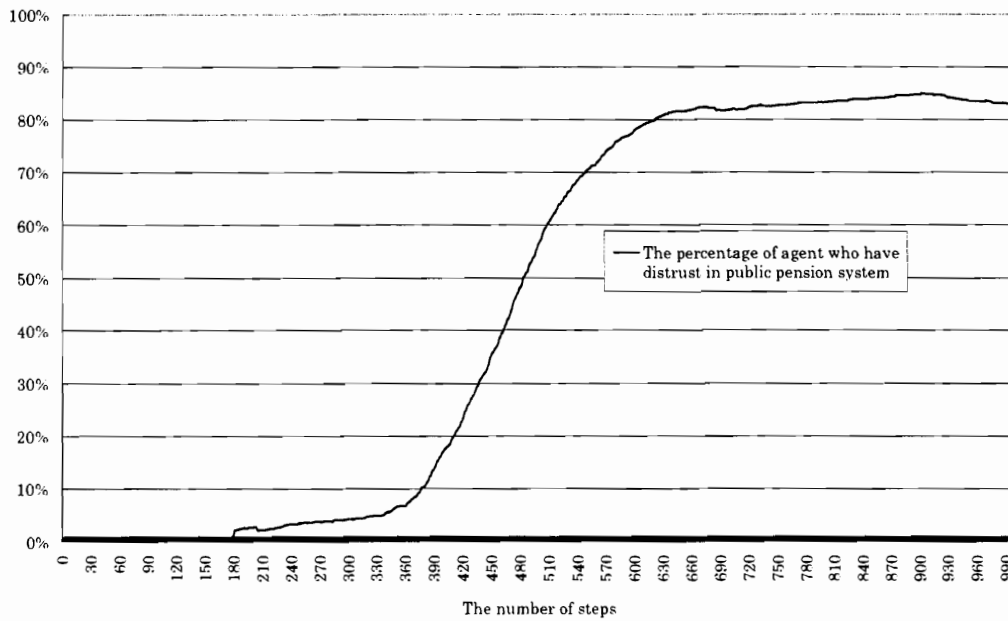| | [< Distrust Model > · < No Distrust Model >] | | | |
	Negative Rank	Positive Rank	Same Rank	Total
Number of Steps	984.00	16.00	1	1001
Rank Average	508.47	10.06		
Rank Sum	500339.00	161.00		
Z	-27.38			
Significance Probability	5.4×10^{-165}			

Figure 3. The progress of the number of agents having distrust in public pension system

As shown in Table 2, the significance probability is 5.4×10^{-165}. The result clearly shows a difference in the amounts of the pension premium fund between the two models. In addition, in Table 2, the number of steps, which has negative or positive rank, corresponds to the amount of pension premium fund in each step. The difference calculated by subtracting "No Distrust Model" from "Distrust Model" go negative in 984 steps out of all.

In addition to above, we will give a figure, which shows the transition of the number of agents having distrust in public pension system (Figure 3).

We see from Figure 3 that the number of agents having distrust in public pension system start to grow exponentially after the 310th step. The number of agents who have distrust in public pension system goes on to post double-digit growth for the next 300 steps. Shortly thereafter, the growth converges. We think that "micro-macro loop" is reflected in Figure 3 and Figure 2. In addition, the timing and process of exponential increase in the number of agents having distrust in public

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pension system corresponds to the timing and process of the gap expansion in pension premium fund between two models.

Let us examine Figure 3 in more detail. Clearly, the curve in Figure 3 looks like logistic curve. Although there are many types of logistic formulas, for the simplicity, we adopt the simplest form [1] of sigmoid functions. Estimating the sigmoidal function from our simulation results, we get the following:

$$D\ (\ A\ )\ =\ \frac{e^{-3.17\ +\ 0.008\ x}}{1\ +\ e^{-3.17\ +\ 0.008\ x}}$$
$$R^2\ =\ 0.83$$

As known in general, logistic functions are characteristic for emergence with "micro-macro loop". These results from our simulation may be sufficient to show "micro-macro loop" in propagation of distrust.

4. Conclusion

This paper examined the manner in which pension premium fund would change with distrust. From what has been discussed above, we can conclude that people's distrust in public pension system and the propagation of distrust has a decisive influence on the pension premium fund.

In addition to this, the degree of agent's distrust in public pension system is on an upward spiral in our new model. It appears in Figure 3. These situations expressed in our model may fit in well with real world.

Because of limitation of computational power, we could not contain results for the large-scale simulation. Of course, the slight differences of initial conditions ease to cause the big difference of simulation results (sensitivity). So we are needed to extend our model in next step without additional computational power. In our next paper, we will show that the large scale simulation is effective in "stable" results of simulations.

As another extension, individualization of agents is scheduled. For example, now, each agent is classified to 5 categories by agent age-interval. By subdividing age categories, we may capture the

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[1] We have assumed a very simple model described below.

D : Logistic function

x : Time

$A = \alpha + \beta x$

$D(A) = 1/\{1 + \exp(-A)\}$
$\quad\quad\ = \exp(A)/\{1 + \exp(A)\}$

With respect to the information diffusion in closed system, see [6].

more dynamic change of pension premium fund. By such an extension, our simulation model fit in well with real world.

Acknowledgment

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