RCSSディスカッションペーパーシリーズ
第28号　2005年2月

ISSN 1347-636X

Discussion Paper Series
No.28　February, 2005

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Abstract

The pension reform bills were enacted in Japan on June 5, 2004. The bills involved an increase in the premium and benefit cutback. Various issues, such as institutional complexity, negligence on the part of the competent authorities and distrust in the system, are caused of the problem of unpaid pension premiums. In fact, the phenomenon of nonpayment of pension premiums has arisen due to a combination of these factors. In this study, we explored the mechanism of the nonpayment of pension premium using a multi agent based simulation model. Especially, we examined the influence of people's distrust in public pension system on the amount of the pension premium fund. We show that people's distrust in public pension system and its propagation have a critical impact on public pension system.

Keywords: public pension system, multi agent based simulation, distrust in public pension system
JEL Classfication: C63, H55

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1. Introduction

The pension reform bills were enacted in Japan on June 5, 2004. The bills involved an increase in the premium and benefit cutback. These amendments in public pension system have greatly attracted both the media attention and the concern of the general public.[1)] Currently, various issues, such as institutional complexity, negligence on the part of the competent authorities and distrust in public pension system, are caused of the problem of unpaid pension premiums. In fact, the phenomenon of nonpayment of pension premiums has arisen due to a combination of these factors.

In this paper, we have implemented the artificial pension system presented in Tanida, N. and Murakami, M. (2004) using agent based modelling. On the implementation, we adopted the KK-MAS, a simulator developed by KOZO KEIKAKU ENGINEERING Inc.. The result obtained from the simulation is presented ahead.

In Tanida, N. and Murakami, M. (2004), the various factors caused of the present phenomenon of the nonpayment of pension premiums were divided into two categories—people's environment and people's consciousness. In addition to the factors related to the people's environment, such as employment, unemployment and income level, we have implemented into our model the factor of distrust toward public pension system and the propagation of the distrust. We analyse the influence that the factor of distrust would have on the amount of the pension premium fund and the benefits.

2. Agent Properties and Their Action Plans

In this chapter, we describe the factors that caused of the nonpayment of pension premiums based on Tanida, N. and Murakami, M. (2004), in which several factors have been presented using the Entity/Relationship (ER) diagram. Tanida, N. and Murakami, M. (2004) referred to Social Insurance Agency(1999), which is pension statistics from Social Insurance Agency, and to Cabinet Office Minister's Secretariat Public Relations Office (2003), which is an opinion poll on the Japanese public pension system. Based on these statistics, Tanida, N. and Murakami, M. (2004) have assigned properties to each agent as shown in Figure 1.

In Figure 1, we indicate the *entity* in the shape of square and indicate agent's properties in the shape of ellipse. We represent the *relationships* between two or more entities in the shape of lozenge.

The entity that connects the black dot at the end of a line is a *weak* entity. It does not exist by itself unless the other entity that has relationships exists. For example, as shown in Figure 1, if the agent that gets the external information for public pension system does not exist, neither will the external information.

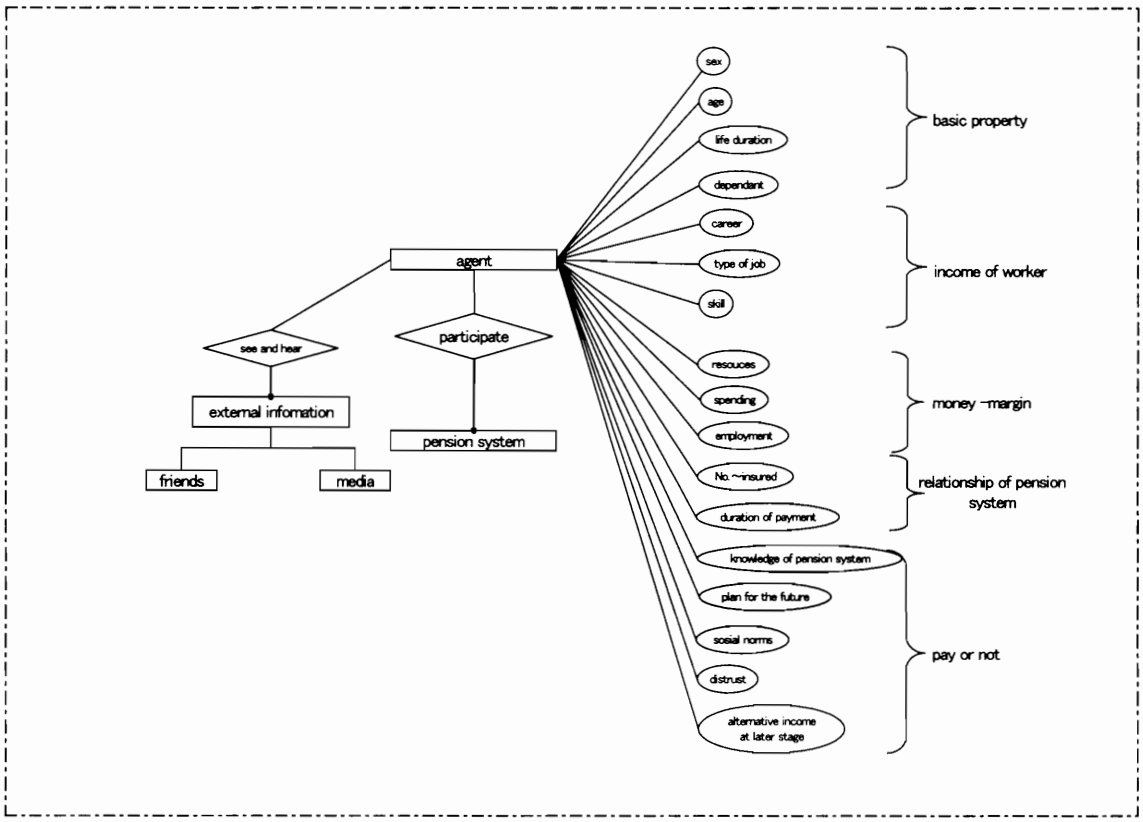

Figure 1. ER Diagram for Agent Properties

(Source) Tanida, N. and Murakami, M. (2004), p.26, Figure 1.

In addition, the entity shown as branching from another entity is called a *subtype*, and it shows the difference on the inside of the same entity. For example, the external information for public pension system is divided into media and friends.

Seventeen properties were assigned to each agent and they were divided into five categories—basic property, the income of a worker, the money-margin, the relationship of the agent to public pension system and whether or not a premium needs to be paid. The first four categories are related to the people's environment and the fifth category serves as the category related to the people's consciousness.

Agents having these characteristics experiences various life cycles from birth to death. Population dynamics is illustrated by agent movement between spaces, which is defined as *family line* in Figure 2.

As shown in Figure 2, a family consists of some kinds of agents, for example, adults, children, and house. A family line is illustrated as a space in our simulation. Practically, we make 10 spaces in our model. These spaces are stratified. Agents move between these spaces in the case of marriage and divorce. Moreover, the relationship with the parents after marriage and divorce are recorded.

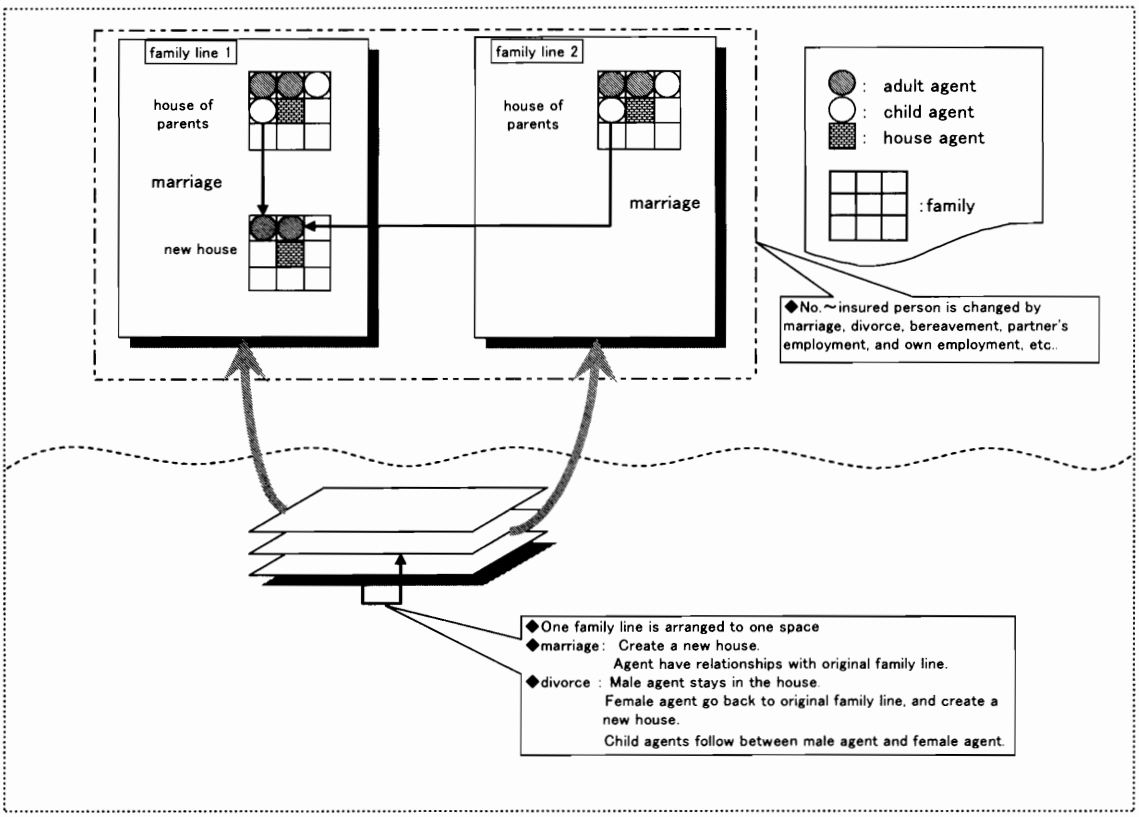

Figure 2. The Model Design for Population Dynamics (Agent moves between spaces)
(Source) Tanida, N. and Murakami, M. (2004), p.29, Figure 3.

3. Specifications of our model

3-1 The Entire Structure

This chapter explains the basic concepts of the model implemented on KK-MAS based on the design shown in Tanida, N. and Murakami, M. (2004). In addition to the design shown in Tanida, N. and Murakami, M. (2004), a house agent was implemented on our model.[2] By the help of this, we can get the information such as agent's income, consumption and each agent's position in the house. Next, let us suppose the state of the family line included in the model (Figure 3).

A *family* consists of nine cells. A house agent is placed at the centre of a family, a man agent at the upper left corner and a woman agent to the right of the man agent and a child agent in each of the remaining cells. A child agent (man) creates a new house in the same family line upon getting married at the age of 20 or more. A new house is created in the direction of the X-axis as shown in Figure 3. If a house is formed at the right-end corner of the first row, it comes to create a house at the left-end corner of the second row.

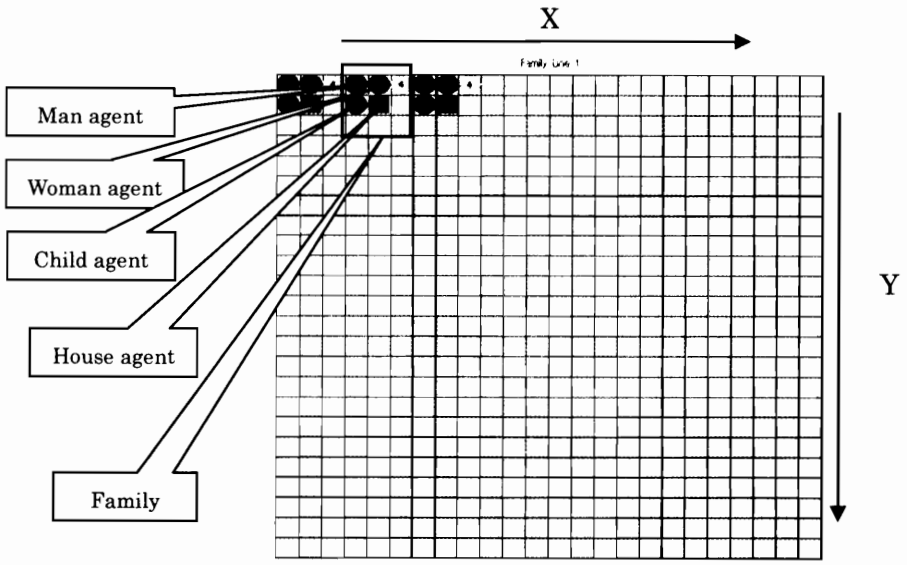

Figure 3. A State of Family Line

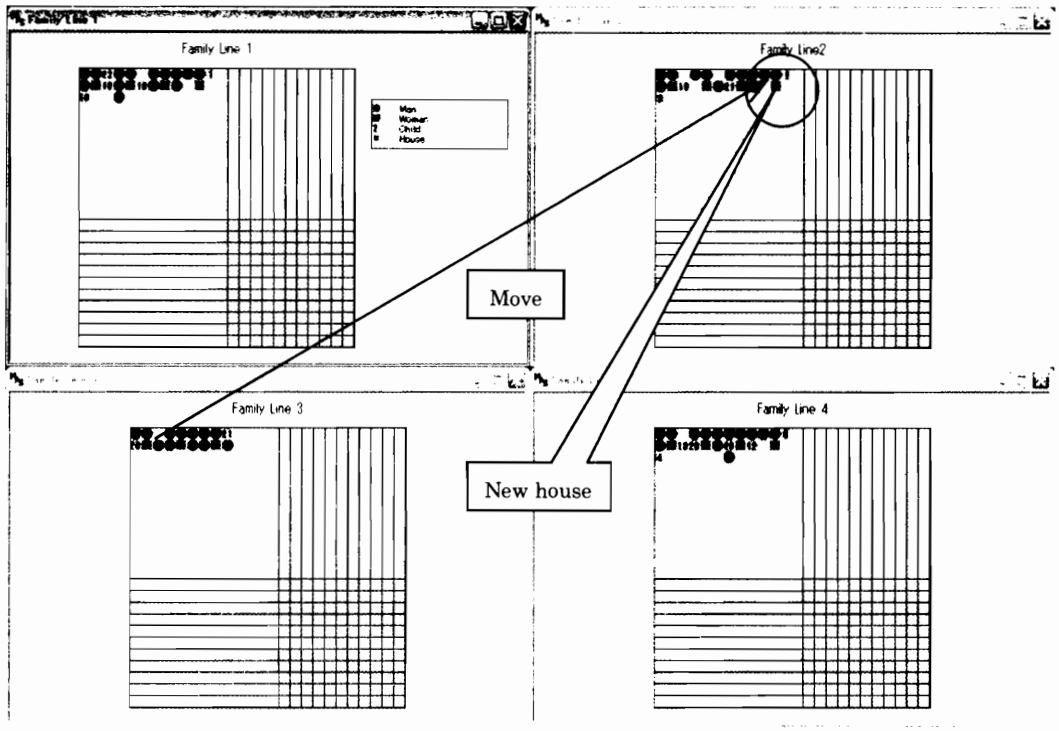

Figure 4. Agent moves between spaces

When the child agent (woman) attains the age of 20 years or more, the man agent of another family line is sought and, in the case an independent unmarried man agent is found, the child agent (woman) moves to the new family line and becomes a woman agent. It is randomly decided to which family line the woman agent should move. When there is no independent unmarried man agent in the family line, the family line for her

to go is randomly decided again. Figure 4 shows an example of two or more family lines.

3-2 Employment, Unemployment and Income

A child agent's academic record is one of factors which determine his or her income level. When a child agent become an adult agent (a man or a woman agent), and the adult agent takes over the child agent's property. We used the statistics from Ministry of Internal Affairs and Communications Statistics Bureau (2004) for setting the income levels.

Data for academic records and income levels are originated from Ministry of Internal Affairs and Communications Statistics Bureau (2004). This data is categorized by academic record, and the number of people at every income level is captured. We take the weighted average, which is calculated by using the value associated with each income class and the number of people in that class.

It was assumed that employment and unemployment and occupation (self-employment, employee) are randomly decided on an appropriate distribution every six months (6 turn). We maintained the unemployment rate at 5% and assumed that 5% of agents aged 20 years or more lose their jobs. In the case of employed man agents, occupation was selected as either 'self-employment' or 'employee'. For woman agent, another condition was considered in addition to those of the man agent—when the man agent was an employee, the condition of being a housewife was added.

Agents who lose their jobs and agents who become housewife do not need to pay a premium. Man agents who are parents pay the premium for child agents who are in school, are not independent; however, these child agents, upon starting to work, start paying a premium themselves. If man agents who are parent are unable to pay a premium or choose to not pay a premium, the premium for a child agent who is 20 years or older is set as zero.

We have partially adopted the criteria for calculating the pension benefit using the Social Insurance Agency's method.[3)]

3-3 Agent's Consciousness

As stated above, in addition to their environment, it is quite likely that people's consciousness is related to whether or not they pay a premium. In Tanida, N. and Murakami, M. (2004), a design that assigns an agent various properties related to people's consciousness was shown. In this paper, distrust in public pension system is considered as a property of agents. Moreover, agents who had initially distrusted public pension system continue to do so. Each agent distrusts public pension system according

to the probability. Once an agent has distrusted public pension system, the distrust persists in that agent in the future and is propagated other agents. For example, unless that eliminates the distrust in public pension system people who have grown to distrust the system may continue to do so in the next month. This point will be re-examined later.

4. Execution of Simulation and Data Analysis

In the simulation, the probability of which employment or unemployment (people's environment) is fixed. Data were gathered from 480 turns, 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 40 years are completed. Fifty simulations were done for every model and the average was calculated for analysis.

We have adopted three models, which differed in the degree of distrust that agents have in public pension system—that is, 'no distrust', 'low level of distrust' and 'high level of distrust'. In order to classify these models, we calculated the criteria from the data in Social Insurance Agency(1999). The data are tabulated by age.

The numerical value in the investigation is used for the criteria when the level of distrust is low, as in 1996. Moreover, the criteria where the level of distrust is high are obtained from investigation, as in 1999.

In addition, when the man agent of each family distrusts public pension system, his distrust is propagated other members of the family. In the 'low level of distrust' model, his distrust is not propagated other members. In the 'high level of distrust' model, his distrust is propagated the woman agent, who is a partner.

Presented here are Figure 5, which shows the progress of the pension fund in each of the three models, and Figure 6, which shows the progress of the monthly premium-and-benefit difference.

The factors related to the people's environment, which are employment or unemployment, etc., are common in all models. However, Figure 5 and Figure 6 indicate that a large difference in the amount of the pension premium fund as well as in the monthly premium-and-benefit difference results on account of the degree of distrust. The distinction of graphs may be estimated as having resulted from the agents' distrust in the public pension system since conditions other than the agents' distrust are constant.

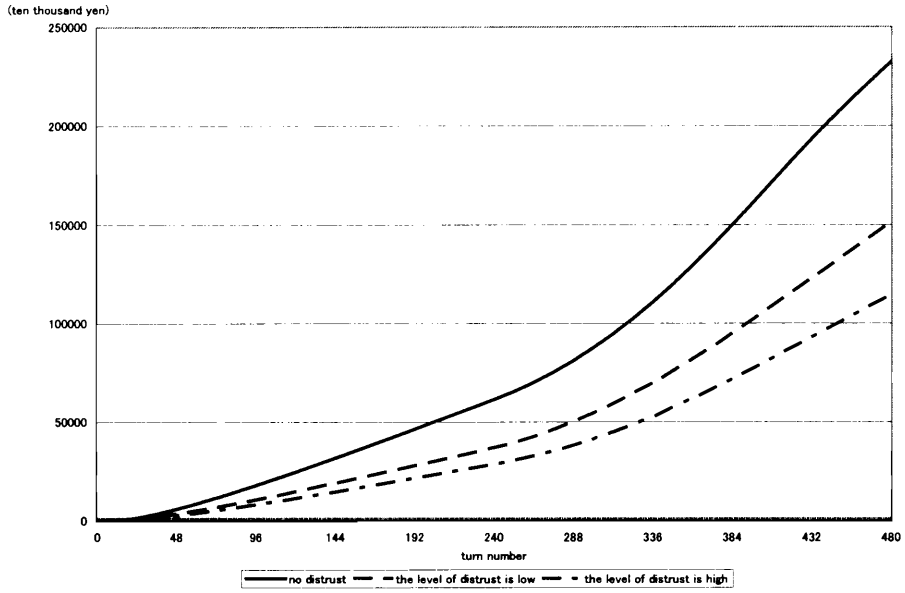

Figure 5. The Progress of Pension Premium Fund

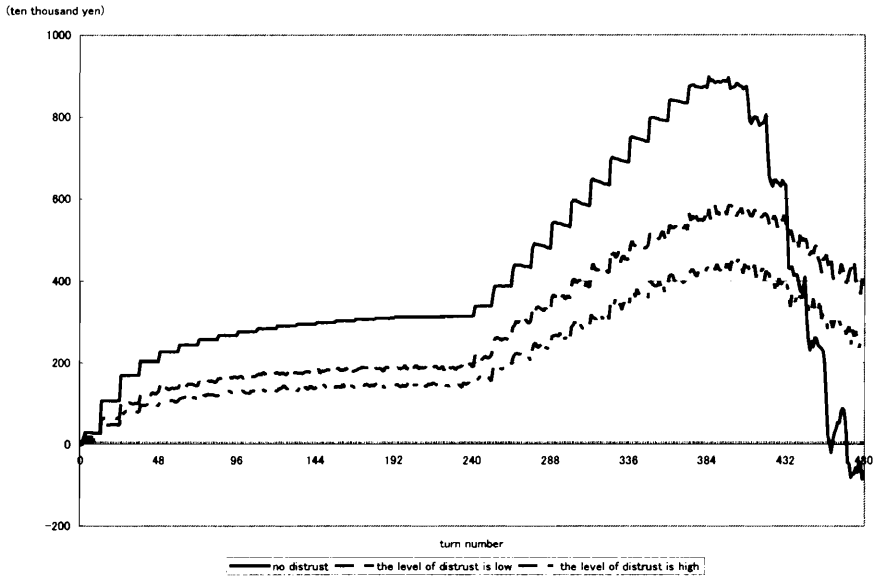

Figure 6. The Progress of Premium- Benefit Difference

However, what needs to be emphasised is the difference in the graphs representing past data, that is, the difference between 'low level of distrust' and 'high level of distrust'. As stated above, these distrusts were computed based on the 1996 and 1999 data from Social Insurance Agency(1999) and were assigned to agents as a property. Figure 6 shows that the change in the monthly premium-and-benefit difference for every turn is

large. Therefore, it is difficult to deduce an overall tendency from Figure 6.

In the case of the 'no distrust' model, it is reasonable to suppose that partial exemption from the payment of premium due to unemployment and income level has affected the change in the monthly premium fund and benefit difference. An agent receives the pension benefit, which includes the number of exemption periods. The sharp fluctuation in the graph is due to these reasons. In the case of other models, since the agents do not pay a premium due to reasons of distrust in public pension system, the total amount of the pension premium fund decreases. Moreover, under the present Japanese public pension system, since the nonpayment of an agent's premium due to distrust is not considered as an exemption period, the pension benefit that the agents receive also decreases. Therefore, unlike in the 'no distrust' model, the sharp fluctuation in the graph is not affirmed in the 'low level of distrust' and 'high level of distrust' models.[4)]

As long as it sees in graph, as for the fund, the direction which assigned 'high level of distrust', that is, the amount of the pension premium fund obtained from1999 survey, is low. On the other hand, it is difficult to deduce an overall tendency in the monthly premium-and-benefit difference from the graph as the monthly changes are large. We will discuss the statistical tests performed for these differences in the following chapter.

5. The Statistical Test of the Differences in the Fund and the Premium-and-Benefit Difference

The results of the analysis described above have been tested as described below. Here, the averages of 50 simulation results from each model are used.

Three models exist—'no distrust', 'low level of distrust' and 'high level of distrust'. Moreover, it is the amount of the pension premium fund data and the monthly premium-and-benefit difference data that are obtained in every simulation turn. Therefore, we should consider whether an agent's distrust affects the amount of the pension premium fund and the monthly premium-and-benefit difference for every turn. The numerical value for every turn of the three models is influenced by the degree of the agents' distrust. As a result, three samples that correspond on the time axis are produced. That is, three samples that change with distrust in each turn are generated. A method for testing the numerical value of each corresponding turn is required; therefore, we used Friedman's test for this purpose. By this method, we can test whether the difference in the numerical value between the three models is statistically significant. Table 1 summarizes the results of the statistical test performed on the amount of the pension premium fund, and Table 2 summarizes the results of the

statistical test performed on the monthly premium-and-benefit difference. We will now discuss the statistical significance of the difference in the amount of the pension premium fund.

Table 1. The Result of the Statistical Test Performed on Premium Fund

	No Distrust	Low level of Distrust	High Level of Distrust
Number of Turns	481	481	481
Rank Average	2.99	2.00	1.00
X^2	956.004		
Degrees of Freedom	2		
Significance Probability	2.54×10^{-208}		

Table 2. The Result of the Statistical Test Performed on the Monthly Premium-and-Benefit Difference

	No Distrust	Low level of Distrust	High Level of Distrust
Number of Turns	481	481	481
Rank Average	2.82	2.10	1.08
X^2	740.246		
Degrees of Freedom	2		
Significance Probability	1.8×10^{-161}		

As Table 1 indicates, the significance probability is 2.54×10^{-208}. The result clearly shows a difference in the amounts of the pension premium fund between the three models. In addition, as shown in Table 1, the value of the rank average is smallest in the case where the agents' distrust is high. Since this value is a rank average, the difference in the values shows the difference of the amount of the pension premium fund.

We now proceed to discuss the statistical test of the difference in the monthly premium-and-benefit difference in Table 2. As Table 2 indicates, the significance probability is 1.8×10^{-161}. The result clearly shows a difference in the amounts of the monthly premium-and-benefit difference between the three models. In addition, as shown in Table 2, the value of the rank average is the smallest in the case where the agents' distrust in public pension system is large. These results are similar to those presented in Table 1, where the value of the rank average is smallest in the case where the agents' distrust is high, followed by the case where the level of distrust is low; in this case, the value of the rank average is the highest in the case where there is no distrust.

These results lead us to the conclusion that the people's distrust in public pension system and the propagation of this distrust has a decisive influence on the amount of the pension premium fund and on the amount of the monthly premium-and-benefit difference.[5)]

However, in our model, the process by which people develop distrust in public pension

system is not studied. In addition, Tanida, N. and Murakami, M. (2004) had shown the plan of a simulation in which agents are provided with 'knowledge of pension system', 'alternative income', 'lack of planning for the future', 'social norms', etc. Implementing these properties into the model and studying it in further detail are directions for future studies.

When agents distrust public pension system, they do not pay the premium. Therefore, the amount of benefit that the agents receive at a later stage also decreases in proportion. The rank average of the amount of the pension premium fund and the monthly premium-and-benefit difference is affected by a change in the agents' degree of distrust. The greater the number of people who distrust public pension system, the fewer are the benefits received by each agent. Although the cost of maintaining a reasonably normal standard of living at a later stage needs to be discussed further, it is too complicated to be examined in detail here.

6. Conclusion

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

Since the amount of the pension premium fund decreases with an increase in distrust and an increase in the number of unpaid agents, the benefit also decreases accordingly. This paper examines the statistical difference in the amount of the pension premium fund by the degree of distrust and the monthly premium-and-benefit difference. However, as also described in this paper, the nonpayment of a premium has not necessarily occurred only due to distrust. A future direction for this study will be implementing other variables, for example, 'alternative income', 'lack of planning for the future', etc. into the model. Moreover, it is also necessary to examine anew the manner in which various types of variables are related.

In this paper, we discussed, in terms of the numerical value, the total amount of the pension premium fund and the monthly premium-and-benefit difference. However, numerical values, such as the continuous change in each agent's environment and consciousness, are not analysed in this paper. In addition, the agreement of the behaviour of the model with the real-world situations cannot be completely analysed. The adjustment of our model will probably be required when variables other than

distrust are implemented. 'Verification', 'validation and test' and 'sensitivity analysis' remain to be discussed further.[6]

Note

1) In this paper, we used the term "public pension system" as "Japanese public pension system."

2) A house agent collects all of the information of the other agent belonging to a house.

3) As for this point, see Social Insurance Agency (1999). According to Social Insurance Agency(1999), if people were born after April 2, 1941, the calculation method of pension benefit at 2004 will be as mentioned below.

$$794{,}500\ yen \times \frac{(premium\ \ paid\ \ period) + \left(\begin{matrix} period\ \ of\ \ half\ \ exemption \\ from\ \ premium \end{matrix}\right) \times \frac{2}{3} + \left(\begin{matrix} period\ \ of\ \ total\ \ exemption \\ from\ \ premium \end{matrix}\right) \times \frac{1}{3}}{40\ (the\ \ maximum\ \ participat\ \ ion\ \ year) \times 12}$$

In our model, we define 1 turn as 1 month, and agents have premium paid period as property. If agent loss of job or agent' income is below a specified level, agent have period of total (half) exemption from premium as property. In addition, in our model, when agent's age is 65, the provision of pension benefit is start, automatically. In Japanese public pension system, the insured can receive benefit when he/she becomes 60 years old, but, in this case, the amount of pension benefit is reduced. The insured can delay the receipt of benefit until he/she becomes 70 years old, and, in this case, the amount of pension benefit is increased.

4) The reason why we used 1996 data and 1999 data is that these data are the latest data (final result) in Social Insurance Agency.

5) In addition to this, we tested these data using Wilcoxon signed-ranks test. The result indicated that pension premium fund and monthly premium and benefit difference in each model differ significantly.

6) As for this point, see Tanida, N. (2004).

Acknowledgment

KOZO KEIKAKU ENGINEERING Inc. Innovative Information Technology Dept. is greatly acknowledged for giving Multi Agent Simulator (KK-MAS).

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