Analysis of the Influence of Inter-generational Asset Inheritance on the Sustainability of Retirement Funds using Social Simulation

Takamasa Kikuchi[*1] and Hiroshi Takahashi[*2]

[*1]Graduate School of Business Administration, Keio University 4-1-1 Hiyoshi, Kohoku-ku, Yokohama-city, 223-8526, Japan.
E-mail: takamasa_kikuchi@keio.jp
[*2] Graduate School of Business Administration, Keio University 4-1-1 Hiyoshi, Kohoku-ku, Yokohama-city, 223-8526, Japan.
E-mail: htaka@keio.jp

Abstract. In Japan, there has been great interest in life planning in pre- and post-retirement generations, and various policy simulations have been performed. However, few studies have analyzed the influence of intergenerational inheritance of assets on the sustainability of retirement funds. In this article, we performed clustering of the respondents' attributes based on data obtained from individual questionnaires for those who plan to inherit their assets in the future. Based on the clustering results, we simulated the impact on the sustainability of retirement funds using our proposed simulation model of asset formation and withdrawal policies. The main findings are as follows. 1) For clusters with a low and high balance of financial assets, steady asset succession is an essential factor in increasing the sustainability of retirement funds. 2) It is imperative to properly manage the assets to be succeeded before asset succession is implemented.

Keywords: Social Simulation, Feature Analysis, Life Planning, Finance, Individual Questionnaire Data

1. INTRODUCTION

In Japan, asset formation and reversal of generations before and after retirement are problems of interest [1]. Various measures, for example, increasing retirement age, asset formation from a young age, and curbing spending, are being discussed as national, individual, and social measures. However, there has been little discussion about the withdrawal of assets, and there is room to expand and modernize basic research and analysis to better consider current issues.

Regarding asset depletion, many studies have analyzed macro-statistical data, for example, the amount of financial assets and disposable income [2]. In addition, the effect of price fluctuations on owned assets and asset depletion based on market data has been analyzed [3]. However, these previous studies only expressed some of the attributes of individuals using actual data. In practice, simulations based on individual case studies are common, and these have high individual specificity. However, few studies have analyzed the influence of inter-generational inheritance of assets on the sustainability of retirement funds.

Therefore, in this paper, we propose an improvement to the analysis method in policy simulation related to asset formation and withdrawal for the generation before and after retirement. In this paper, we conduct clustering of the respondents' attributes based on the data of individual questionnaires for those who plan to inherit their assets in the future. Based on the clustering results, we simulate the impact on the sustainability of retirement funds using a simulation model of asset formation and withdrawal policies proposed by the authors.

The structure of this paper is as follows: Section 2 introduces related work. Section 3 describes the proposed methodology and explains the social simulation model we used. Section 4 provides a demonstration of the proposed method and in Section 5 we summarize the results.

2. RELATED WORK

2.1. Policy Simulation on Retirement Planning

Several studies have considered sustainable withdrawals from retirement personal portfolios [4]. In the United States, a fixed withdrawal rate of 4% for initial assets is a rule-of-thumb benchmark [5]. However, it has been stated that fixed withdrawal rates are inefficient [6] and that "rules" changing the withdrawal rate and amount should be set [7, 8]. However, the complexity of such rules when operated by an individual is an issue.

In Japan, there is a policy simulation related to asset formation on an actual amount basis using macro data, for example, stock data and flow data [2]. In addition, focusing on investment strategies in asset formation, some studies have estimated the depletion probability using the annual timeseries path of asset prices using computer simulations [3]. However, various attributes of individuals are not considered explicitly. In addition, many case study-based life plan simulations are performed by determining the specific attributes of individuals; however, while individual specificity is high, there is room to improve the generality and representativeness of individual attributes set as samples. In order to improve such situation, the authors have proposed a method for simulating asset formation and withdrawal measures based on cluster analysis of individual questionnaire data [9, 10, 11]. In this paper, we analyze the influence of inter-generational asset inheritance on the sustainability of retirement funds using the proposed method.

2.2. Clustering Individual Questionnaire Data

Numerous reports have attempted to categorize decision-making from theoretical models and sample data using various methods, for example, statistics and machine learning [12, 13]. For example, in the social sciences (specifically marketing) and in response to the diversification of customer lifestyles and values, the provision of services suitable for each category was considered broadly after categorizing according to individual characteristics. In this paper, we categorize the respondents to a questionnaire using feature analysis of individual data.

2.3. Behavior Clustering and Social Simulation

Yamada et al. [14] proposed a method that utilizes actual data and agent simulation to solve problems in business and industry. They categorized multiple types of behavior at an airport based on real-world data, and they reproduced congestion conditions when new equipment was introduced to Fukuoka Airport in Japan via agent simulation [15]. Such detailed analyses that can withstand onsite decision-making will greatly contribute to efficient decision-making in both social and economic activities.

In addition, many analyses, for example, corporate behavior and analysis by modeling based on finance theory, have been reported [16, 17]. In this paper, based on the clustering results of individual questionnaire data, we perform policy simulation on retirement planning in consideration of asset succession and risk asset price fluctuations.

3. SOCIAL SIMULATION MODEL

3.1. Outline

As an example of the proposed method, we present a simulation of the customer's asset situation at a future point in time, taking into account asset succession and price fluctuations of risky assets, based on individual questionnaire data concerning asset formation and withdrawal in old age. In this section, we explain the social simulation model.

We constructed a computer simulation model that expresses asset formation and withdrawal before and after retirement (Fig. 1). This model is based on a model previously proposed by the authors [9, 10, 11].

Each actor in the model has a specific asset balance at a certain age. Each actor also has regular income and expenditure (cash inflow and outflow) and sudden income and expenditure (depending on life events) according to the actor's own status (before and after retirement). The attributes of each actor are expressed as statistical data. In addition, by manipulating the attributes of the actors, what-if analysis can be performed to examine responses to the implementation of a particular policy.

The assets held by each actor include cash, deposits, and risk assets. Risk assets are fully invested in a portfolio of traditional assets and provide returns according to the risk of the portfolio. In addition, the regular income and expenditure are adjusted according to the inflation rate. Together, the risk-return of the portfolio, the inflation rate, and the variance of each constitute the external environment, as described later.

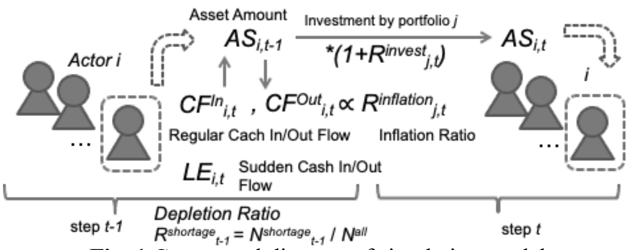

Fig. 1 Conceptual diagram of simulation model.

3.2. Actor

Let A be the set of actors and let $\#A=N^{all}$. Actor i has the following attributes in step t of the simulation: age $age_{i,t}$, retirement age $age_i^{retired}$, cash and deposit balance $CA_{i,t}$, risk asset balance $RA_{i,t}$, cash inflow $CF^{In}_{i,t}$, cash outflow $CF^{Out}_{i,t}$, cash flow from life event $LE_{i,t}$, and total asset balance $AS_{i,t} = CA_{i,t} + RA_{i,t}$.

$$A = \{a_i = (i, age_{i,t}, age_i^{retired}, CA_{i,t}, RA_{i,t}, CF^{In}_{i,t}, CF^{Out}_{i,t}, AS_{i,t}, LE_{i,t})\}$$

Here, age is expressed as follows.

$$age_i \in \{age_{i,0}, age_{i,0}+1, \ldots, age_i^{retired}, \ldots\}$$

3.3. Simulation Step

For the simulation time step, a single step represents one year in real time.

3.4. External Environment

The return and inflation rate of portfolio j are generated in time series by Monte Carlo simulation as follows, where the number of trials is K.

The portfolio return (annual) is expressed as

$$R^{invest}_{j,t} = X_{1,t}\,\sigma_j + \mu_j.$$

The inflation rate (annual) is given as

$$R^{inflation}_{j,t} = (\rho_j X_{1,t} + \sqrt{(1-\rho^2_j)}\, X_{2,t})\, \sigma_{inflation} + \mu_{inflation}.$$

Here, σ_j is the risk of portfolio j, μ_j is the expected return rate of portfolio j, $\sigma_{inflation}$ is the standard deviation of the inflation rate, $\mu_{inflation}$ is the expected inflation rate, ρ_j is a correlation coefficient between portfolio j and the inflation rate. $X_1, X_2 \sim N(0,1)$, and $\mathrm{cov}\,[X_1, X_2] = 0$.

The cumulative value IRC of the inflation rate, referred to as cumulative inflation rate, is expressed as

$$IRC_{j,t} = IRC_{j,t-1}(1+R^{inflation}_{j,t}),\ IRC_{j,0} = 1.$$

3.5. Cash In/Out Flow

Retirement cash inflows and outflows CF in step t are determined by considering the asset class to which actor i belongs and the cumulative inflation rate as follows:

$$CF^{In}_{i,t} = CF^{In}_i\,(1+IRC_{j,t}),$$
$$CF^{Out}_{i,t} = CF^{Out}_i\,(1+IRC_{j,t})$$

In order to keep the estimated possibility of withdrawal conservative, the net cash flow before retirement is set to zero.

3.6. Asset Formation and Withdrawal Rules

The cash and deposit balance and risk asset balance in each simulation step are varied according to the following rules.

This expresses the preferential withdrawal of highly liquid cash and deposits at the asset withdrawal stage.

if $CA_{i,t} + CF^{In}_{i,t} - CF^{Out}_{i,t} >= 0$

then

$$CA_{i,t+1} = CA_{i,t} + CF^{In}_{i,t} - CF^{Out}_{i,t} + LE_{i,t}$$
$$RA_{i,t+1} = RA_{i,t}\,(1 + R^{invest}_{j,t})$$

else

$$CA_{i,t+1} = CA_{i,t} + LE_{i,t}$$
$$RA_{i,t+1} = RA_{i,t}\,(1 + R^{invest}_{j,t}) + CF^{In}_{i,t} - CF^{Out}_{i,t}$$

3.7. Asset Depletion Rate

For the K trials, the number of times the asset balance becomes negative at age τ is denoted $K^{shortage}$, and the asset depletion rate, hereafter referred to as the depletion rate, is expressed as

$$R_{i,\tau}^{shortage} = K_{i,\tau}^{shortage}/K.$$

3.8. Advantages and Feasibility of Our Model

The advantage of our proposed model is that it could explicitly treat the problem of asset succession as an interaction, which has not been taken into account much in previous studies [2;3]. We also confirm that the feasibility of our proposed model is grounded with the results of previous literature [2] by imposing various constraints on our model.

4. DEMONSTRATION

4.1. Datasets: Various Attributes of Individuals

We used the individual questionnaire data from the "Awareness Survey on Life in Old Age for Before and After Retirement Generations" conducted by the MUFG Financial Education Institute [18]. The survey period was January 22 to 25, 2019, and the survey target was men and women aged 50 and over. The survey was conducted in Japan, and the number of valid responses was 6,192. This questionnaire comprehensively investigated the asset status of each individual (current asset balance and expected income/expenditure in old age), the planned asset succession amount, the individual's stance on investment, and the individual's outlook for old age, etc.

4.2. Feature Analysis of Individual Questionnaire Data

The targeted items from the individual questionnaire data are listed in Table. 1; clustering was performed using the k-means method [19]. Here, the number of clusters was set to five based on the results of elbow chart and silhouette analysis that are often used to determine the number of clusters. The individuals whose questionnaires included all data items numbered 757.

Table. 1 Questionnaire items used for feature analysis

Item	Question Matters
Attributes	Age, Sex, Household Composition, etc.
Financial Status	Stock data: Asset Balance Current, To be Inherited, etc. Flow data: Regular Cash In/ Out Flow, etc.
Risk Preference	Investment Experience, Risk Asset Holding Ratio, etc.

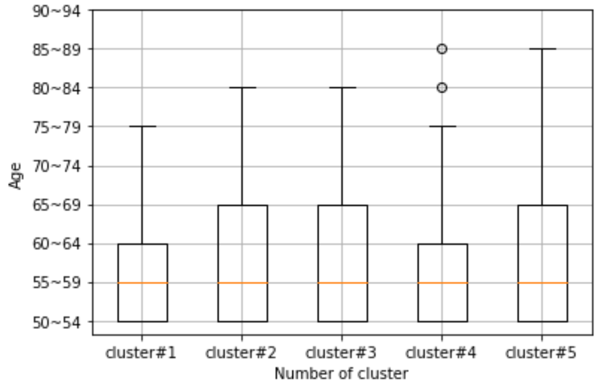

Fig. 2(a) Distribution of age groups for each cluster.

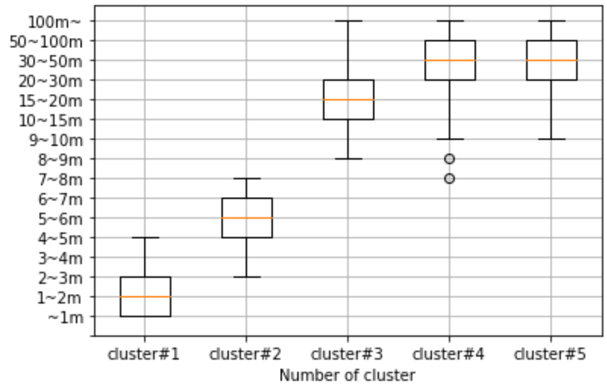

Fig. 2 (b) Distribution of current financial asset balances for each cluster (y-axis label: Current Financial Asset Balances, units: m Yen).

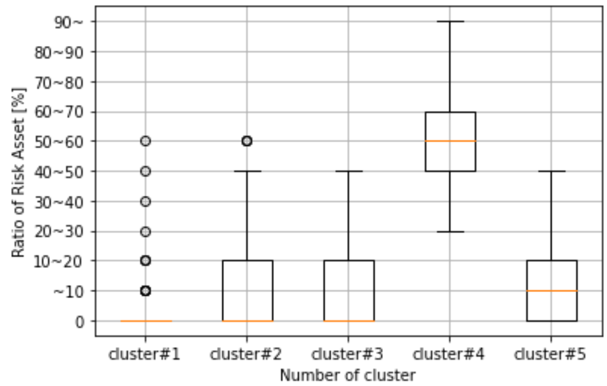

Fig. 2 (c) Distribution of risk assets holding ratio for each cluster.

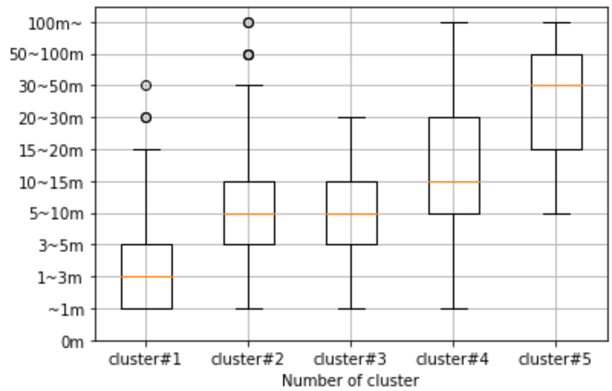

Fig. 2 (d) Distribution of financial assets to be inherited for each cluster (y-axis label: Financial Asset Balance to be Inherited, units: m Yen).

For the obtained clustering results (clusters #1 to #5), Figs. 2(a) to 6(d) show box plots indicating the distributions of answers to typical questionnaire items for each cluster.

The median of age group of *age* was 55–59 years for clusters #1 to #5, as shown in Fig. 2(a).

The median current balances of financial assets FA^{now} was 1–2 million yen for cluster #1, 5–6 million yen for cluster #2, 15–20 million yen for clusters #3 and 30–50 million yen for clusters #4 and #5, as shown in Fig. 2(b).

The median holding ratio of risk assets R^{risk} was 0% for clusters #1 to #3, 0 to 10% for cluster #5, 50 to 60% for cluster #4 as shown in Fig. 2(c).

The median balance of financial assets to be inherited FA^{future} was 1–3 million yen for cluster #1, 5–10 million yen for cluster #2 and #3, 10–15 million yen for clusters #4 and 30–50 million yen for clusters #5, as shown in Fig. 2(b).

These results are summarized in Table. 2. Each attribute value is taken as the median of the box-and-whisker diagram for each cluster.

Table. 2 Summary of Clustering Results.

Cluster #	#1	#2	#3	#4	#5
Age	57	57	57	57	57
Current balances of financial assets	1.5 m yen	5.5 m yen	17.5 m yen	40.0 m yen	40.0 m yen
Holding ratio of risk assets	0 %	0 %	0 %	55 %	5 %
Financial assets to be inherited	2.0 m yen	7.5 m yen	7.5 m yen	12.5 m yen	40.0 m yen

4.3. Asset Formation and Withdrawal Simulation

Based on the data in Table. 2, we simulated asset depletion using the model described in Section 3.

We performed computer simulations of asset formation and withdrawal based on the individual questionnaire data. Here, the annual income and expenditure CF^{net} for each asset class was set based on the macro statistical data for Japan [20]. The correspondence with the model described in Section 3 is expressed follows:

$N^{all} = 5$ (cluster#1〜#5), $CA_{i,0} = FA^{now}_i * (1 - R^{risk}_i)$, $RA_{i,0} = FA^{now}_i * R^{risk}_i$, $CF^{Out}_{i,0} - CF^{In}_{i,0} = CF^{net}_i$.

Table. 3 Simulation parameter settings.

Item	Value
$age^{retired}$	60
R^{future}	{0%, 100%, 156%}
μ_j, σ_j	(6.37%, 18.0%)
$\mu_{inflation}$	{0.53%, 2.0%}
$\sigma_{inflation}$	1.26%
K	10,000

We also define the parameters as follows: $age_i^{retired} = 60$, age $age_{i,t'}$ at which an actor's life event occurs = 70, $LE_{i,t'} = FA^{future}_i * R^{future}$. Here, R^{future} is the ratio of asset succession, representing the ratio of actual balance of financial assets to be succeeded.

Other parameter settings, e.g., the portfolio risk-return and inflation rate etc., are shown in Table. 3. Note that the risk-return of the portfolio was set assuming a portfolio comprising foreign stocks and bonds. The expected inflation rates were according to two patterns, i.e., (1) moderate inflation (actual results for the past 30 years in Japan [21]: 0.53%), and (2) 2% inflation (monetary easing target). Here, the standard deviation of the inflation rate was the same as pattern (2), which is the actual result for the past 30 years in Japan. The ratios of asset succession were according to two patterns, i.e., (1) case with no asset inheritance (0%), (2) case where the financial assets to be inherited are succeeded without asset management (100%), and (3) case where the financial assets to be inherited are succeeded without asset management (156%). Then, in (3), it is assumed that the financial assets to be succeeded will be invested at an annual rate of 3.5% over the period from the current age to the expected age of 70. This is based on the assumption that safe assets such as U.S. bonds will be invested.

As a result of the simulations, the depletion rates at age 90 and 100 are shown for each person, asset inheritance scenario, and inflation scenario (Table. 4 (a) - (c)).

Table. 4 (a) Depletion Rates by Cluster and Inflation Scenario: Case with no asset inheritance.

# of Cluster	Depletion Rates by Inflation Scenario			
	(1) Modarate Inflation		(2) 2% Inflation	
	age: 90	age: 100	age: 90	age: 100
#1	99%	100%	100%	100%
#2	100%	100%	100%	100%
#3	100%	100%	100%	100%
#4	0%	25%	20%	100%
#5	0%	2%	4%	37%

Table. 4 (b) Depletion Rates by Cluster and Inflation Scenario: Case where the financial assets to be inherited are succeeded without asset management.

# of Cluster	Depletion Rates by Inflation Scenario			
	(1) Modarate Inflation		(2) 2% Inflation	
	age: 90	age: 100	age: 90	age: 100
#1	0%	0%	0%	0%
#2	0%	0%	0%	49%
#3	0%	100%	68%	100%
#4	0%	0%	0%	46%
#5	0%	0%	0%	0%

Compared to Table. 4(a), Table. 4(b) shows that the depletion rate has improved, especially in the clusters with low (#1, 2) and high (#4, 5) financial assets. This indicates that steady inheritance of assets is important in this asset class. On the other hand, in the cluster with middle financial assets (#3), the degree of improvement in the depletion rate is limited. There are also cases in which the depletion rate remains high at age 100 with 2% inflation

(#2, #4). In these cases, the depletion rate can be further improved by investing the financial assets to be inherited (Table. 4(c)).

Table. 4 (c) Depletion Rates by Cluster and Inflation Scenario: Case where the financial assets to be inherited are succeeded with asset management.

# of Cluster	Depletion Rates by Inflation Scenario			
	(1) Modarate Inflation		(2) 2% Inflation	
	age: 90	age: 100	age: 90	age: 100
#1	0%	0%	0%	0%
#2	0%	0%	0%	0%
#3	0%	7%	0%	100%
#4	0%	0%	0%	0%
#5	0%	0%	0%	0%

5. CONCLUDING REMARKS

In this paper, we conducted clustering of the respondents' attributes based on the data of individual questionnaires for those who plan to inherit their assets in the future. Based on the clustering results, we simulated the impact on the sustainability of retirement funds using a simulation model of asset formation and withdrawal policies proposed by the authors. The main findings are as follows: 1) For clusters with low and high balance of financial assets, steady asset succession is an important factor in increasing the sustainability of retirement funds; 2) It is important to properly manage the assets to be succeeded to before the asset succession is implemented.

Future work is as follows: 1) survey of other attributes that affect the financial assets to be inherited by questionnaire analysis, 2) diversify the decision-making of actors regarding asset inheritance.

Acknowledgements

The authors would like to thank Enago (www.enago.jp) for the English language proof.

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