Overview of INAHSIM: A Microsimulation Model for Japan

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Abstract

Integrated Analytical Model for Household Simulation (INAHSIM) is a microsimulation model for Japan. This model was first developed in the 1980s as a tool for household simulation. Following several attempts to improve the model, the latest version of INAHSIM has been utilized as a comprehensive microsimulation model for policy simulation. The objective of this article is to provide an overview of INAHSIM, including its structure, transition probabilities, initial population, and some basic results.

1. Introduction

Integrated Analytical Model for Household Simulation (INAHSIM) is a microsimulation model developed specifically for Japan. This model was initially developed in the first half of the 1980s as a tool for household simulation. Following several attempts[1] to improve the model and to add socioeconomic characteristics of the population, the latest version of INAHSIM has been utilized as a microsimulation model for policy simulation.

The first version (Aoi et al., 1986 and Inagaki, 1986) was limited to the household simulation. It simulated only kinship and co-resident relationships. It incorporated the demographic events of birth, death, marriage, and divorce, and a few

[1] Fukawa (1994, 2007, 2009), Inagaki (2005, 2007a, 2007b, 2009), and Inagaki and Kaneko (2008) made attempts to improve INAHSIM.

household movements of "young people leaving home" and "living with elderly parents." The size of the initial population was 32,000 persons and 10,000 households. It took one hour for 50-year simulation by a mainframe computer since the performance of computers at that time was poor for the simulation.

The second version (Inagaki, 2005) was extended its capability for policy simulation. The socioeconomic characteristics of employment status, health status, and earnings are added, and the size of the initial population was increased to 126,000 persons and 46,000 household. Imputation of kinship relationships between the persons living in different households was newly introduced. It improved the quality of the results as household simulation. The impact of the increase in non-regular employment on income disparities (Inagaki, 2007b) was evaluated by using the second version model.

The third version (Inagaki and Kaneko, 2008 and Inagaki, 2009a) was a major revision of INAHSIM. The public pension scheme was incorporated, and it was applied to the evaluation of the effect of some proposals for pension reform on the income distribution of the elderly (Inagaki, 2009b). It was introduced a new technique to align the initial population with the Population Census, and obtained better consistency with the official population projections (Kaneko et al., 2008), and household projections (IPSS, 2008) prepared by the National Institute of Population and Social Security Research.

The latest version of INAHSIM introduced in this article is a minor revision over the third version. Two life events of international migration and payment of pension premium are added, and most transition probabilities are revised based on people's recent behavior. In particular, the transition probabilities of employment status are assumed to be consistent with the assumptions on the 2009 actuarial valuation on Employees' Pension Insurance and National Pension (Actuarial Affaires Division, Pension Bureau, Ministry of Health, Labor and Welfare, 2009). Consequently, the simulation results are very close to the official results.

The key feature of this model is that it can simulate kinship relationships in detail. This model is not limited to parents, children, husbands, and wives, and can simulate all kinds of kinship relationships including those involving uncles, nieces, cousins, sons of separated parents, grandnephews, and great-grandnieces. This information is very important to simulate household changes in Japan since household mergers among family members—for example, adult children resettling to care for their aged parents or returning to their parents' households following divorce—are common.

The kinship relationships are also important to determine the benefits of public assistance for the poor. Under the Public Assistant Law, certain relatives—for example, parents, children, grandchildren, and nephews/nieces—are required to support a person in need. The relatives are investigated as to whether or not they can support the person when the benefit of public assistance for the poor is claimed.

The objective of this article is to provide an overview of the latest version of INAHSIM. Section 2 describes the database structure of the model population, simulation cycle, transition probabilities, and statistics. Section 3 describes the initial population in its source, alignment method, and imputation of the kinship relationships. Section 4 shows some results for the future that indicate a super-aging society in Japan. Finally, the author will discuss the future of the microsimulation models that can be applied to Japan in Section 5.

2. Structure of INAHSIM

2.1. Model population

One of the most important aspects of this microsimulation model is the model population that expresses all individual characteristics. Since the model population defines all the characteristics that the model can simulate, there is a need to incorporate as many characteristics and as much family and household information as possible. On the other hand, keeping the structure of the model population as simple as possible is necessary to develop the model easily and to shorten the execution time of its simulation. This model is carefully designed to meet the abovementioned requirements.

In Japan, the “Family Register” and “Basic Resident Register” have been established as systems for recording such types of information; these registers contain all the particulars pertaining to family and household status. To record the basic changes in families and households, these two registers are updated through six types of notifications: births, deaths, marriages, divorces, move-ins, and move-outs. This system is well suited for the Japanese society and has been working well for more than 100 years. It is also applicable to this model and consequently, the model population is designed on the basis of such registers.

Therefore, the model population comprises three tables that correspond to the Family Register, Basic Resident Register, and individual socioeconomic characteristics. In INAHSIM, these three tables are referred to as “family segment,” “household segment,” and “individual segment,” respectively. As depicted in Figure 1, there are links between the family and individual segments and between the household and individual segments.

In this model, a family comprises a couple and their children. The family segment has individual segment ID numbers for the husband, wife, and the youngest child (if any). It also includes certain characteristics of the couple such as the year of marriage, number of children, (if separated) the year the marriage dissolved, and cause of separation (divorce or death of a spouse). A group of children is defined by a list structure. Figure 2 depicts a family comprising a couple—Jim and Mary—and their three children—Ken, Karen, and Tom.

Jim, as a child, is also a member of another family. Let us assume that Jim’s father is John, his mother is Liz, and he has a sister named Ann. This family is expressed by Figure 3. From these two family segments, we can know the relationships among these persons. For example, Ann is Ken’s aunt, Ken is Ann’s nephew, John is Tom’s grandfather, and so on. In the end, this model structure can define all the kinship relationships in the population.

The individual segment includes individual characteristics such as the year of birth, sex, marital status, health status, employment status, earnings, pension amount, lifetime income, category of the National Pension Scheme, status of premium payment, and history of these characteristics. The employment status is categorized into four different groups [2]—regular employees, non-regular employees, self-employed, and unemployed—on the basis of the category of the National Pension Schemes to which the individual belongs. The individual's health status is divided into two categories—good and poor—on the basis of his/her health awareness or related objective information such as whether or not they have been hospitalized.

The individual segment also includes the family segment ID number that indicates the individual's status as husband or wife, the family segment ID number that indicates the individual's parents, and the household segment ID number that indicates the household to which the individual belongs. These IDs facilitate the specification of the individual's families and households.

The household segment includes household information such as the year of formation of the household, number of household members, private/institutional household, total income of the household, and household structure. It also includes the individual segment ID number that represents one of the members in that household. A person in an institution is treated as a single household. A group of household members is defined by a list structure as depicted in Figure 4.

2.2. Simulation cycle and transition probabilities

2.2.1. Simulation cycle

The simulation cycle of this model is shown in Figure 5. The life events are assumed to occur in annual cycles. The life events incorporated in this model are marriage, birth, death, divorce, international migration, change in health status,

[2] Employees covered by the employees' pension insurance (Category No. 2 insured persons under the National Pension Scheme) are classified as regular employees, while other employees and family members working for family-owned businesses are classified as non-regular employees.

change in employment status, estimating earnings, determining pensions, young people leaving home, living with elderly parents, entering an institution, and payment of pension premiums.

Transition probabilities for each life event are given in advance, and it is possible to take into account their future trends. In the assumptions of the baseline scenario described later, declining trends in first marriage rates and mortality rates are assumed. The future trends in the transition probabilities of employment status are also taken in account. The other transition probabilities of the baseline scenario are assumed to continue in the future.

2.2.2. Marriage

First-marriage rates and re-marriage rates by sex and age are used for marriage. With regard to men, the first-marriage rate is differentiated with respect to the employment status, as the first marriage rate of unemployed or non-regular employees is much lower than that of regular employees.

It is necessary to adjust the numbers of brides and grooms since the numbers are not always the same. The adjustment process is as follows. First, select the candidate brides and grooms using the marriage rates twice, and then, calculate the average number of candidates. The number of couples would be the average figure divided by two. Next, take a sampling of the candidate brides and grooms. Finally, form couples between the sampled brides and grooms sorted by their age.

When a marriage takes place, the couple decides to live with the groom’s parents, live with the bride’s parents, or start a new household. This model simulates this decision using the probabilities of the living arrangements at marriage.

2.2.3. Birth

Marital fertility rates by parity and mother’s age and sex ratio (boys to girls) are used for birth. This model does not take into account illegitimate children since their proportion is very low[3] in Japan. Therefore, the total fertility rate is strongly affected by marriage rates. In fact, one of the major reasons why fertility rates in Japan are declining is the low marriage rate among young women. Newborn babies will belong to their mothers' households.

The nationality of newborn babies is Japanese if at least one of their parents is Japanese. Otherwise, the babies are non-Japanese. The z-score[4] to estimate their future earnings is given as the average of their parents' z-scores plus disturbance term. Therefore, the income level, a kind of social class, is inherited from their parents.

2.2.4. Death

Mortality rates by sex and age are used for death. It is also controlled by their health status, and the mortality rates for people with poor health status are higher than those for people with good health status.

In the case of a person's death, if there exists a nominee (the deceased's spouse) who is eligible to a survivors' pension, the pension amount is determined in this life event. The pension amount is principally three-fourths of the earnings-related part of the deceased's pension amount.

2.2.5. Divorce

Divorce rates by wife's age are used for divorce. It is also controlled by whether the couple has dependent children. The divorce rates for couples with dependent children are lower than for those without dependent children. The custody of children is determined by the given probabilities. The children will live with the parent who has their custody.

When a divorce takes place, the divorced husband/wife decides to return to his/her parents' household or form a new household. This event is important since around half of the divorcees return to their parents' households in Japan.

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[3] The percentage of illegitimate births in 2008 is 2.1%.
[4] Refer 2.2.9 Estimating earnings. Earnings are assumed to conform to a log-normal distribution.

2.2.6. International migration

The number of immigrants is higher than the number of emigrants in Japan. Here, the net migration is taken into account, and it is assumed that all immigrants are non-Japanese. The numbers of immigrants by sex and age are used for international migration.

It is assumed that the immigrants are all single, and the distributions of their employment status and earnings by sex and age are the same as those of Japanese single persons. Their z-scores are determined randomly.

2.2.7. Change in health status

The health status is classified as good or poor, and is assumed to deteriorate with age. The deterioration rates are specified by age and sex.

2.2.8. Change in employment status

With regard to the employment status, the individual is classified as regular employee, non-regular employee, self-employed, or unemployed. Transition probabilities between these four statuses by sex and age are used for the change in employment status. As for women, the transition probabilities are differentiated with respect to their marital status since the employment pattern among Japanese women differs with their marital status.

They are also controlled by whether the life event of marriage occurred for unmarried women since many women sometimes give up their regular employment at marriage in Japan. With regard to married women, they are controlled by whether the life event of the first birth occurred, and whether they live with their parents. Women in Japan still face difficulty in raising their children and working at the same time.

2.2.9. Estimating earnings

Earnings are assumed to conform to a log-normal distribution by sex, age group, and employment status. In this model, the z-score of the earnings-distribution for each person is given in advance, and the person's earnings are estimated on the basis of one's z-score assuming the earnings-distribution by sex, age group, and employment status each year. The z-score does not change over the lifetime of the individual.

2.2.10. Determining pensions

This event is a determination of the pension amount to a pension subscriber who has reached his/her pensionable age. Early and deferred payments are not considered. The amount of basic pension is estimated on the basis of subscription category assuming the distribution of newly awarded pension amounts. The amount of earning related pension is estimated on the basis of the pensioner's z-score.

2.2.11. Young people leaving home

Young people leave their parents' household for purposes of higher education, finding employment, or changing jobs. Here, the probabilities of never-married young people leaving home by sex, age, and employment status are used as the transition probabilities of young people leaving home.

2.2.12. Living with elderly parents

When elderly people, who do not live with their children, become very old and need care, many children move in with their elderly parents to take care of them. This is still an important life event to secure the life of the elderly in Japan. This life event is referred to as "living with elderly people" in this model, and the probabilities by parent's sex and age are used to simulate it.

2.2.13. Entering an institution

Probabilities by sex, age, and marital status of entering an institution are used for this life event.

2.2.14. Payment for pension premiums

The payment system of pension premiums differs with subscribers' categories under the National Pension Scheme. Category No. 2 subscribers are regular employees, and their premiums are paid to the government through their employers. Category No. 3 subscribers are dependent spouses of Category No. 2 subscribers, and they are not necessary to pay their premium. Category No.2 and Category No.3 subscribers will receive their pensions in accordance with their subscribing period.

Category No.1 subscribers are self-employed, non-regular employees, or unemployed. Low earners are exempt from the payment of the premiums[5], but others should pay their premiums by themselves. However, some of earners[6] do not pay their premiums. The percentages of people exempt from paying the premiums, paying the premiums, or not paying premiums by sex and age are given to simulate the payment of pension premiums for Category No.1 subscribers.

2.3. Compiling statistics

This model produces a longitudinal micro dataset of individuals, families, and households for the future. Many basic statistics such as population statistics or vital statistics are compiled during the simulation process. Other special statistics or statistical analyses, if necessary, can be made using the longitudinal micro data output independently from the simulation process.

Stochastic errors derived from the Monte Carlo method can also be estimated by repeating simulations with different sets of random numbers.

2.4. Computer language and execution time

This model is written in FORTRAN90. If the initial population is 127,782 persons, that is, 1/1000 of Japan's population, it takes about 30 seconds to make a 100-year simulation using a PC with 12GB RAM and an Intel® Core i7 975 Extreme Edition 3.33GHz processor. Since the execution time is relatively short, it usually

[5] They will receive a certain percentage of the full amount of the basic pension based on their type of exemption and subscribing period.
[6] About 40% of such subscribers did not pay their premiums in the fiscal year 2008.

takes an average of 100 simulation runs to evaluate the simulation results.

3. Preparation of the Initial Population

3.1. Source of the initial population

The Comprehensive Survey of the Living Conditions of People on Health and Welfare (CSLC) conducted by the Ministry of Health, Labor, and Welfare is the main source of the initial population[7]. The survey is conducted every three years using large sample sizes. In the 2004 survey, the sample size was 25,091 households and 72,487 household members. The survey covers kinship relationships within household members, marital status, employment status, health status, earnings, pension amounts, and other socioeconomic characteristics. The initial population of 49,307 private households and 126,570 household members is prepared by resampling with replacement from the micro data. The elderly population of 1,212 persons in institutional households is prepared separately and is added to the initial population. In the end, the initial population is 127,782 persons, and reflects Japan's society on a 1/1000 scale.

However, some information—for example, the kinship relationships between the persons living in different households, histories of employment status and earnings, nationality, and so on—cannot be obtained from CSLC. Such information is imputed.

Another problem with CSLC is its collection rate. It was 54.7% in the 2004 survey; note that this rate varies according to sex, age, and household structure. The collection rate of single-person households was very low, and that of young people was also very low. These differences are adjusted by weighing the resampling rates when the initial population was prepared.

3.2. Adjustment of collection rate and resampling with replacement

Since the collection rates of CSLC differs with the characteristics of persons or

[7] The data used in this study were made available to the author by the Ministry of Health, Labor, and Welfare of Japan, notice number No.0219001 dated 13 January 2009.

households, it is necessary to prepare the initial population by resampling the mother sample for consistency with the Population Census. However, the alignment of the initial population is not easy since we should align both the number of households and number of persons with census data. The iteration method is used in this model.

Repeat steps (a) to (c) until the adjustment rates are convergent. In our case, it took about 100 times to be convergent.

(a) Estimate (1) the numbers of persons by sex, age group and marital status, and (2) the numbers of household by sex and age group of the head of the household, and household structure using the adjustment rate for each household calculated in step (c).

(b) Compare the estimates with the Population Census, and recalculate the adjustment rates of the sampling fractions for (1) persons by sex, age group and marital status, and (2) households by sex and age group of the head of the household and household structure.

(c) Take an average of the adjustment rates in step (b) for each household and these averages are applied as the new adjustment rates in step (a).

3.3. Imputation of kinship relationships between the persons living in different households

As discussed in section 2.1, the two family segments (Figure 2 and Figure 3) are essential to specify the kinship relationships. This means that all of the kinship relationships will be specified if the parent-child relationships are specified among the initial population. Here, the question is how to impute the parent-child relationships among the persons living in different households. The imputation method is as follows:

(a) List the persons or couples who have children but live separately using the CSLC results. CSLC surveyed the number of children who live separately for each person.

(b) Randomly draw children whose parent(s) would be alive using the probabilities by child's age that his/her mother or father is alive. These probabilities can be estimated from the life tables using the average age difference between parents and children.

(c) Make a match between the couples on the list (a) and the children on the list (b) in order of age.

3.4. Imputation of other characteristics

With regard to earnings, the micro data of CSLC is modified because it surveyed the earnings in the previous year[8]; consequently, the earnings are inconsistent with other characteristics such as employment status. Specifically, the earnings are imputed in the same way as the life event of "estimating earnings."

The personal histories of employment status are imputed by applying the transition probabilities retroactively. Those of earnings are imputed in the same way as the life event of "estimating earnings."

The pension amounts of pensioners are also inconsistent with their age or employment status since it surveyed the amount in the previous year. These are imputed in the same way as the life event of "determining pensions."

Nationality is assigned randomly using the percentage of non-Japanese population[9] by sex and age.

4. Some results of the simulation

4.1. Baseline scenario

In this article, some simulation results on the basis of a baseline scenario are introduced. The baseline scenario is supposed to serve as a benchmark for assessing

[8] The earnings in the survey indicate the amount of earnings in the year 2003, and the employment status indicates the employment status as of June 1, 2004.
[9] According to the 2005 Population Census, the percentage of non-Japanese population was 1.2%.

the impact of policy change or behavioral changes. The scenario assumes that people's behavior—as it was in 2005—would not, in principle, change in the future. However, the declining trends in mortality and first marriage rates are assumed. The increasing trends of participation rates in the labor market of women, young persons, and aged persons are assumed in order to align with the assumption of the 2009 actual valuation on the public pension scheme.

4.2. Population

Table 1 shows the simulated future trend in population by age group and compares the same with the official population projections of the National Institute of Population and Social Security Research (Kaneko et al., 2008). The differences between the two estimates are within 1% or so except for the population under 15. This is because the fertility rates[10] used for this simulation are slightly higher than those used for the official population projections.

In any case, Japan's population will be very old, and the proportion of elderly people will be 30.5% in 2025 and 39.4% in 2050. On the other hand, children and working population will decline sharply.

4.3. Number of private households

Table 2 shows the simulated future trends with regard to the number of private households and their size and compares the same with the official household projections of the National Institute of Population and Social Security Research (2008). Both estimates are very close, and they show that the size of private households will decrease at least until year 2030. According to the simulation results, the household size will decrease after 2030, and will start stabilizing by 2075.

4.4. Number of subscribers of the National Pension Scheme

Table 3 shows the future trends with regard to the number of subscribers of the

[10] The recent trends in fertility rates are much higher than the assumptions used for the official population projections.

National Pension Scheme by category and compares the same with the 2009 actuarial valuation conducted by the Actuarial Affairs Division, Pension Bureau, Ministry of Health, Labor and Welfare (2009). All residents in Japan between the ages of 20 to 60 are eligible and required to become a subscriber of the National Pension Scheme. Regular employees covered by the Employees' Pension Insurance are classified as Category No. 2, and their dependent spouses are classified as Category No. 3. The others are classified as Category No. 1.

The estimates of the number of Category No. 2 are very close, but the numbers of Category No. 1 and Category No. 3 are slightly different. This simulation estimates more category No. 1 subscribers but less category No. 3 subscribers compared to the official actuarial valuation. In this model, the dependent spouses with their earnings below 1,300,000 yen are classified as Category No. 3. The earnings are assumed to conform to a log-normal distribution. It means that the distribution of these earnings is not exactly log-normal. However, it is noted that the official actuarial valuation does not always provide valid estimates since the proportion of dependent spouses is assumed to be exogenously fixed in the actuarial valuation.

4.5. Elderly population by family type

Table 4 shows the future trends with regard to the number of elderly people by family type. The elderly people in single-person households or institutions will increase rapidly. By 2050, 35.1% of the elderly people will live in such households. On the other hand, the number of elderly people living with married children will decline sharply. Living with married children was once common for elderly people in Japan. In fact, until 1980, over half of the elderly people were living with their married children. In the near future, Japanese people will experience not only a super-aging society but also dramatic changes in their family type.

4.6. Income distribution

Figure 6 shows the future trends in income distribution among private households. This income includes earnings and public pensions and excludes property income and social security benefits other than public pensions. This income is gross income, and social security contribution and tax burden are not considered. Since no economic phenomena such as wage increases and inflation rate are considered, the price of this income can be regarded as the price as of the year 2004.

The income distribution will shift to the left, and the number of low-income households will increase considerably. That is because the population is aging and household size shrinking. In the future, the peak of income distribution will be in the group of 1–2 million yen, and the majority of this group will comprise elderly persons living alone or in couple-only households. Their only source of income would be public pensions.

4.7. Gini coefficients

Figure 7 shows the trends in Gini coefficient. The Gini coefficient in 2004 was 0.426. It will increase yearly, and will reach 0.486 in 2050 and 0.499 in 2100. This implies that income disparities will widen, but this will be mainly caused by the aging of the population and shrinking of the household size.

4.8. Lifetime income distribution

Figure 8 shows the lifetime income distribution for people born in 1990 by sex. The peak for females will be between 50–74 million yen, and 60.8% of female will earn less than 100 million yen. This is because many females are/will be housewives in Japan, and will not draw salaries. Their main source of lifetime income is the basic pension. The median income for females born in 1990 is estimated to be 83 million yen.

On the other hand, the variation in the lifetime income for males is large, and its peak is around 150 million yen. The median income for males born in 1990 is estimated to be 211 million yen, and it implies that more than half of the males will receive 2 million yen as their lifetime income.

4.9. Distribution of the replacement rate of Employees' Pension Insurance

Figure 9 shows the distribution of the replacement rate[11] of Employees' Pension Insurance. The definition of "replacement rate" here is the ratio of a couple's pension amounts when the wife's age is 70 to their earnings when the wife's age is 50. If the wife is dependent, i.e., a Category No. 3 subscriber, their replacement rate is higher than that when the wife is not dependent, i.e., a Category No. 1 or No. 2 subscriber. In addition, the replacement rates distribute widely.

4.10. Stochastic errors

Table **5** shows the stochastic errors derived from the Monte Carlo method. This simulation takes an average of 100 simulation runs with the initial population of 128,000 persons. Therefore, the substantive size of the initial population is very large—12,800,000 persons, and stochastic errors are negligible.

However, the initial population itself has a sampling error, and the transition probabilities themselves have errors when they are estimated. Moreover, people's behavior may considerably change in the future. It is noted that these figures do not show the level of errors in these simulation results, but merely show the stochastic errors derived from the Monte Carlo method.

5. Future Directions

This model is a comprehensive microsimulation model for the Japanese population. As discussed, it provides us plenty of valuable simulation results, which are well aligned with the official projection results. However, it does not make projections for some characteristics such as wealth, education, housing, and health

[11] A replacement rate of a model couple is officially used when the level of pension is discussed. This model couple is defined as follows, and it is unrealistic. The wife and husband are of the same age, and they get married at the age of 20. The husband starts working as an employee (Category No. 2) at the age of 20. The wife is a dependent of her husband for her life (Category No. 3).

insurance premiums and tax burdens.

Dynamic microsimulation models are not common in Japan. However, the output of microsimulation models, especially that pertaining the distributional aspect of any social change, is more important in Japan than in any other country as Japan will become the most rapidly aging society in the world. Some researchers and policy makers have acknowledged the importance of microsimulation models in social policy making.

Japan is sufficiently well-versed with the development of microsimulation models and has the necessary pre-requisites—availability of suitable micro data, the demands made by policy makers, and computer technologies. A supercomputer may be used for the simulation. The next task is to not only improve the simulation but also introduce the microsimulation models to researchers and policy makers.

References

Actuarial Affairs Division, Pension Bureau, Ministry of Health, Labor and Welfare (2009), *2009 actuarial valuation on Employees' Pension Insurance and National Pension in Japan* (in Japanese).

Aoi K., Okazaki Y., Fukawa T., and Hanada K. et al. (1986), *Household projection by INAHSIM: A comprehensive approach*, Life Span vol. 6 (in Japanese).

Fukawa T. (1994), "Future trends of Japanese households through micro simulation model: An application of INAHSIM," *The Journal of Population Studies* 18:13-27.

Fukawa T. (2007), *Household projection 2006/07 in Japan using a micro-simulation model*, IPSS Discussion Paper Series No.2007-E02.

Fukawa T. (2009), "Household projections and its application to health/long-term care expenditures in Japan using INAHSIM-II," paper presented to the second general conference of the International Microsimulation Association, Ottawa, June 8 - 10, 17 pages.

Inagaki S. (1986), "An Analytical Model on Household and Family via Micro Simulation (INAHSIM)," *Bulletin of the Institute of Actuaries of Japan* 39:89-188 (in Japanese).

Inagaki S. (2005), *Projections of the Japanese Socio-Economic Structure Using a Microsimulation Model (INAHSIM)*, IPSS Discussion Paper Series No.2005-03.

Inagaki S. (2007a), *Future Socio-Demographic Population Structure of Japan: Projections by a dynamic Microsimulation Model (INAHSIM)*, Tokyo: Japan Statistical Association (in Japanese).

Inagaki S. (2007b), "The Impact of the Increase in Non-regular Employment on Income Disparities," *Journal of Income Distribution* 16:71-87.

Inagaki S. (2009a), "INAHSIM: A Japanese Microsimulation Model," paper presented to the second general conference of the International Microsimulation Association, Ottawa, June 8 - 10, 15 pages.

Inagaki S. (2009b), "Effect of Proposals for Pension Reform on the Income Distribution of the Elderly in Japan," paper presented to the second general conference of the International Microsimulation Association, Ottawa, June 8-10, 20 pages.

Inagaki S. and Kaneko N. (2008), “Projections of Income Distribution using a Microsimulation Model (INAHSIM),” *Fiscal 2007 Report for Research on Social Security that Pays Attention to the Relationship between Income/Property/Consumption and Contribution/Taxes*, 383-410 (in Japanese).

Kaneko R., Ishikawa A., Ishii F., Sakai S., Iwasawa M., Mita F. and Moriizumi R. (2008), “Population Projections for Japan: 2006-2055 Outline of Results, Methods, and Assumptions,” *The Japanese Journal of Population* Vol.6, No.1, 76-114.

National Institute of Population and Social Security Research (2008), *Household Projections for Japan: 2005-2030*, Tokyo: Health and Welfare Statistics Association (in Japanese).

Tables & Figures

Table 1: Population by age group (in thousands)

	Simulation results				Population projections 2006			
	Total	0-14	15-64	65+	Total	0-14	15-64	65+
2004	127,782	17,766	84,983	25,033	—	—	—	—
2025	120,057	12,206	71,278	36,574	119,270	11,956	70,960	36,354
2050	96,061	8,524	49,694	37,843	95,152	8,214	49,297	37,641
2075	68,984	5,911	33,908	29,165	68,216	5,732	33,686	28,798
2100	48,133	4,126	24,272	19,735	47,712	4,093	24,144	19,475

Table 2: Number and size of private households (in thousands)

	Simulation results			Household projections 2008		
	Population	Number of households	Size of households	Population	Number of households	Size of households
2004	126,570	49,307	2.57	—	—	—
2010	126,037	50,800	2.48	124,460	50,287	2.47
2020	121,204	51,483	2.35	119,039	50,441	2.36
2030	113,193	50,085	2.26	110,637	48,802	2.27
2050	92,810	43,348	2.14	—	—	—
2075	66,153	32,318	2.05	—	—	—
2100	46,153	22,786	2.03	—	—	—

Table 3: Number of subscribers of the National Pension Scheme (in thousands)

	Simulation results				Actuarial valuation 2009			
	Total	Category No.1	Category No.2	Category No.3	Total	Category No.1	Category No.2	Category No.3
2004	70,993	24,345	36,536	10,112	—	—	—	—
2025	61,880	18,465	35,878	7,536	61,540	16,319	36,892	8,328
2050	43,169	12,050	25,940	5,179	42,793	10,944	26,244	5,605
2070	29,512	8,193	17,814	3,506	29,289	7,466	17,976	3,847
2100	21,125	5,858	12,771	2,496	20,990	5,364	12,869	2,757

Table 4: Elderly population by family type

	Total	Single-person household	Couple only	Living with married children	Living with unmarried children	Others	Institution
2004	25,033	3,746	8,087	5,869	5,177	942	1,212
2025	36,574	7,659	10,134	4,409	9,824	1,984	2,565
2050	37,843	10,050	9,024	3,274	8,913	3,331	3,251
2075	29,165	9,098	6,762	2,090	5,872	2,511	2,832
2100	19,735	6,335	4,498	1,415	3,930	1,575	1,981

Table 5: Stochastic errors

	Year 2025			Year 2050		
	Estimate	Standard error	Stasndard error rate	Estimate	Standard error	Stasndard error rate
Population (in thousand)						
Total	120,057	18	0.01%	96,061	66	0.07%
under 15	12,206	5	0.04%	8,524	9	0.11%
15 - 64	71,278	2	0.00%	49,694	22	0.04%
65 and over	36,574	5	0.01%	37,843	9	0.02%
Houshold (in thousand)						
Number	51,057	4	0.01%	43,348	8	0.02%
Average Size	2.30	0.00	0.00%	2.14	0.00	0.00%
Household income (in ten thousand yen)						
Average	522.1	0.8	0.15%	481.5	1.9	0.40%
Median	393.4	0.9	0.23%	328.6	1.7	0.50%
Gini coefficient	0.455	0.000	0.00%	0.486	0.000	0.00%

Figure 1: Basic structure of the model population

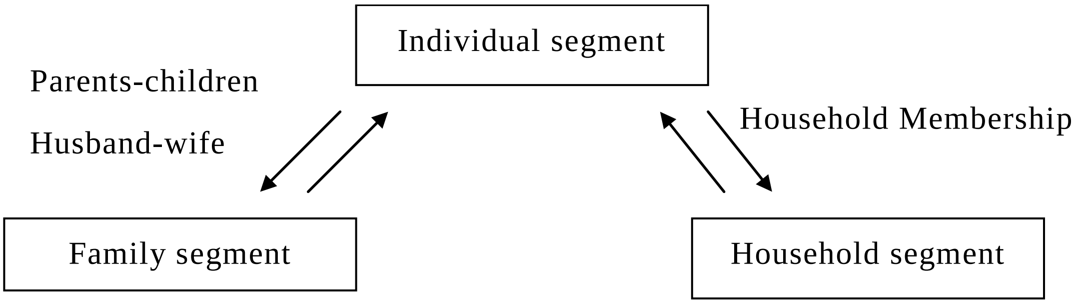

Figure 2: A family comprising a couple and three children

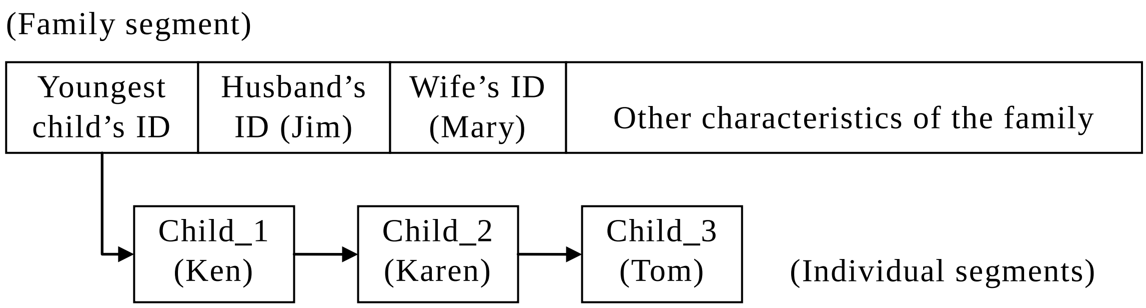

Figure 3: Jim's family when he was a child

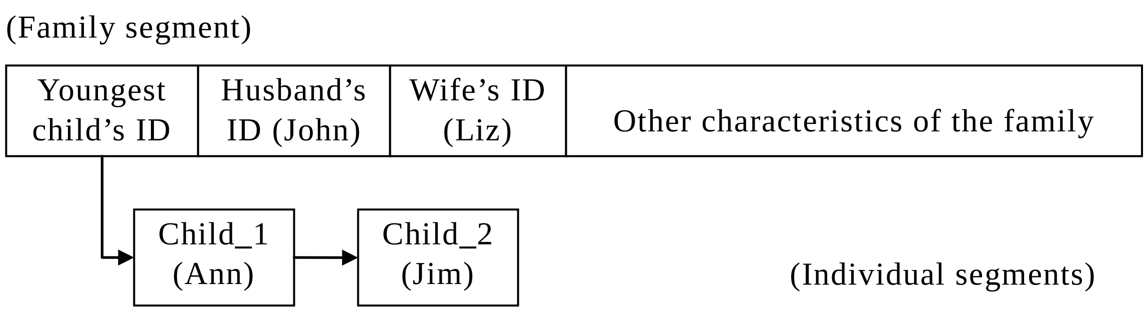

Figure 4: Household comprising three persons

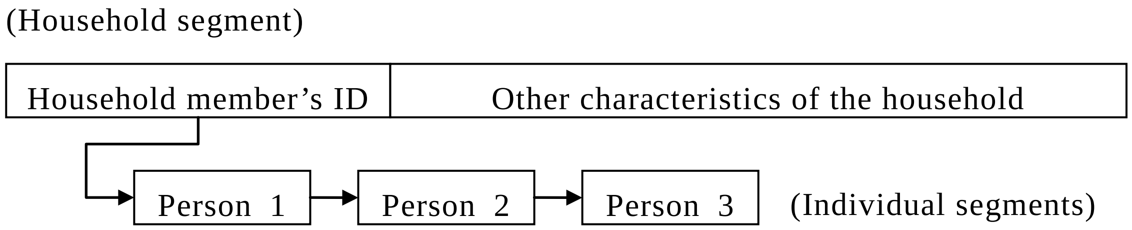

Figure 5: Simulation cycle

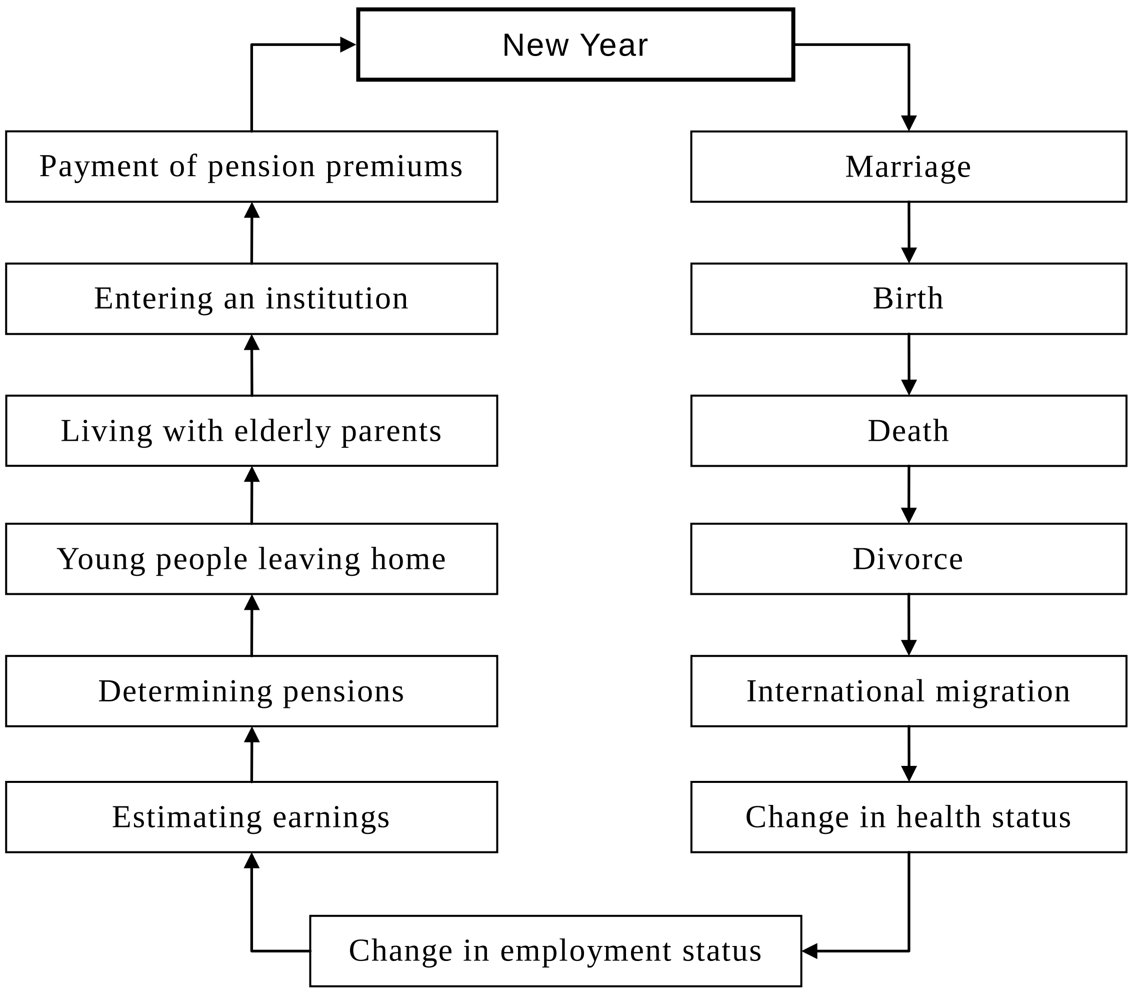

Figure 6: Trends in income distribution

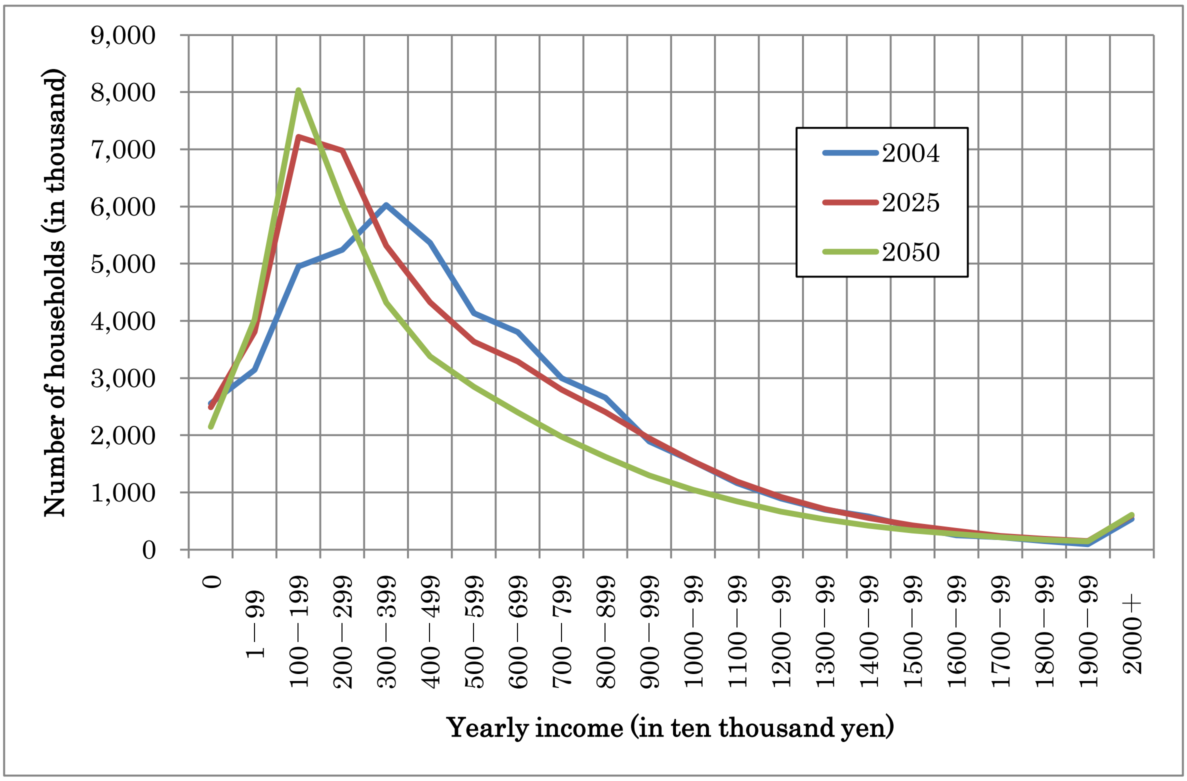

Figure 7: Trends in Gini coefficient

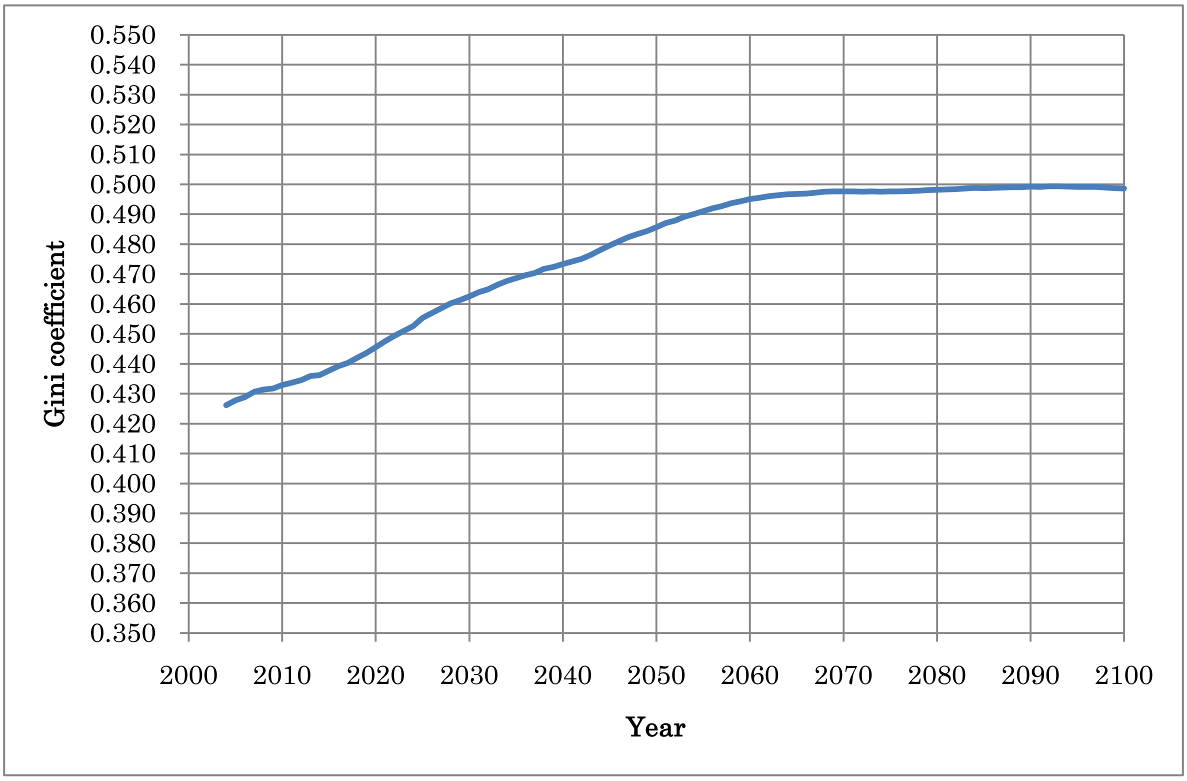

Figure 8: Lifetime income distribution by sex

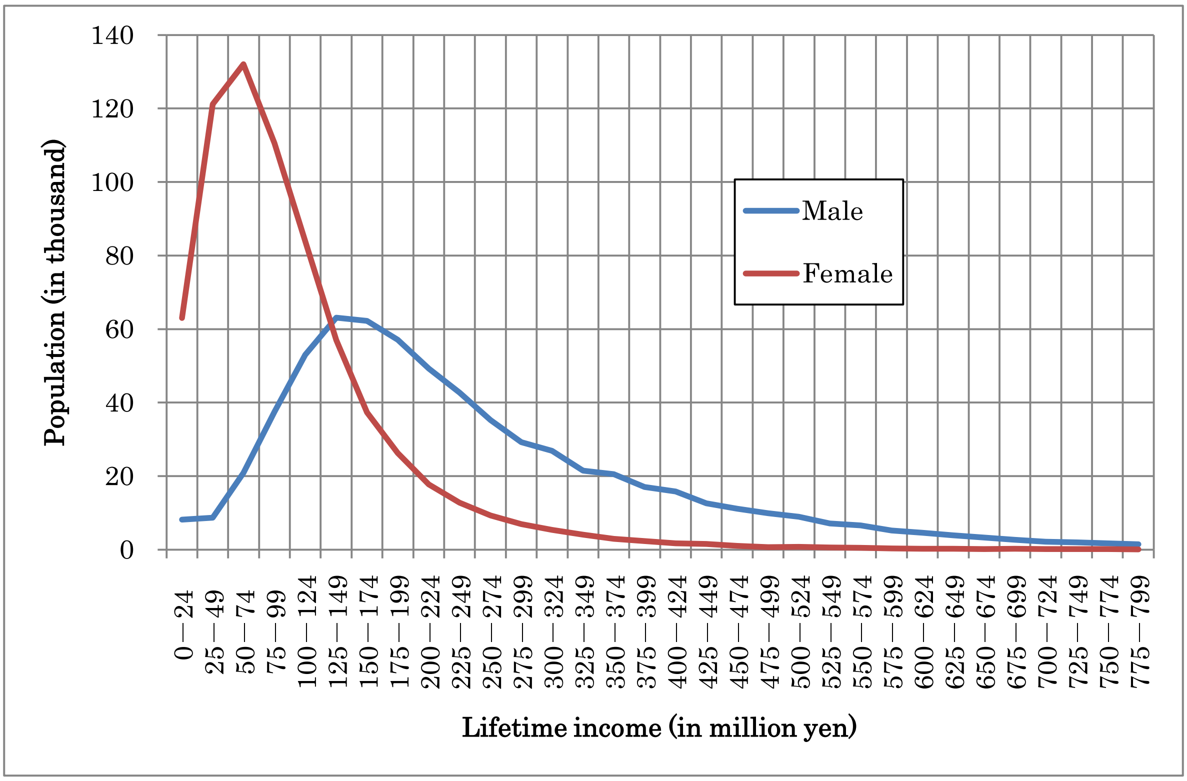

Figure 9: Distribution of the replacement rate of Employees' Pension Insurance