

# INAHSIM: A Japanese Microsimulation Model

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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 data source.

## 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 (Aoi et al., 1986 and Inagaki, 1986). Following several attempts<sup>i</sup> to improve the model and to add socioeconomic characteristics of the population, the latest version of INAHSIM<sup>ii</sup> has been utilized as a microsimulation model for policy simulation.

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 paper is to provide an overview of INAHSIM on the basis of Inagaki and Kaneko (2008). Chapter 2 describes the database structure of the model population, simulation

cycle, transition probabilities, and statistics. Chapter 3 describes the initial population in its source, alignment method, and imputation of the kinship relationships. Chapter 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 Chapter 5.

## 2. STRUCTURE OF INAHSIM

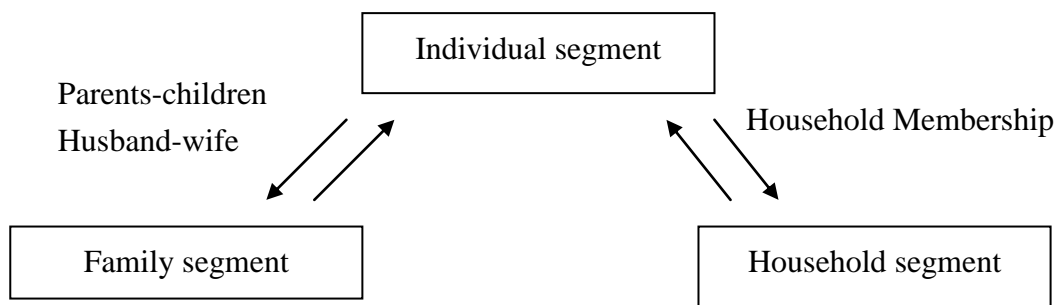
### 2.1. Model population

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.

**Figure 1: Basic structure of the model population**

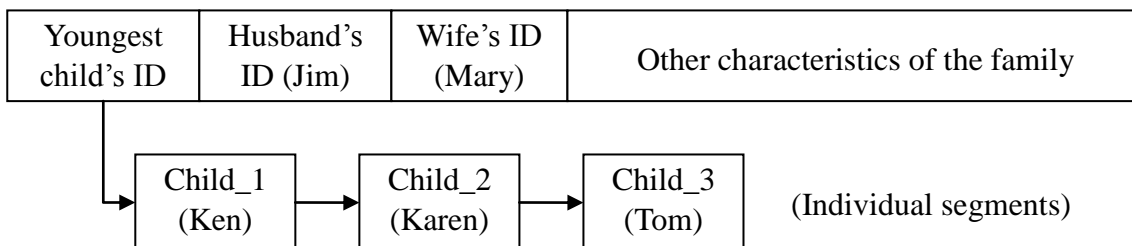


In this model, a family comprises a couple and their children. The family segment has individual

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 are defined by a list structure depicted in Figure 2. Figure 2 depicts a family comprising a couple—Jim and Mary—and their three children—Ken, Karen, and Tom.

**Figure 2: A family comprising a couple and three children**

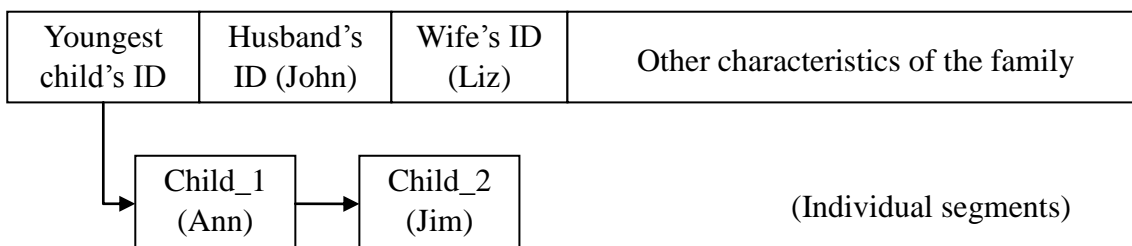
(Family segment)



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.

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

(Family segment)



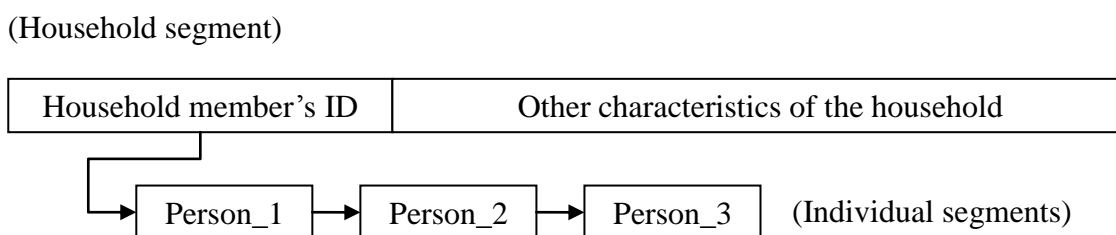
The individual segment includes individual characteristics such as the year of birth, sex, marital status, health status, employment status, earnings, and the pension amount. The employment status is categorized into four different groups<sup>iii</sup>—regular employees, non-regular employees, self-employed, and unemployed—on the basis of the pension schemes to which they belong. 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 (Figure 2), the family segment ID number that indicates the individual's

parents (Figure 3), 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 household earnings, 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 are defined by a list structure as depicted in Figure 4.

**Figure 4: Household comprising three persons**



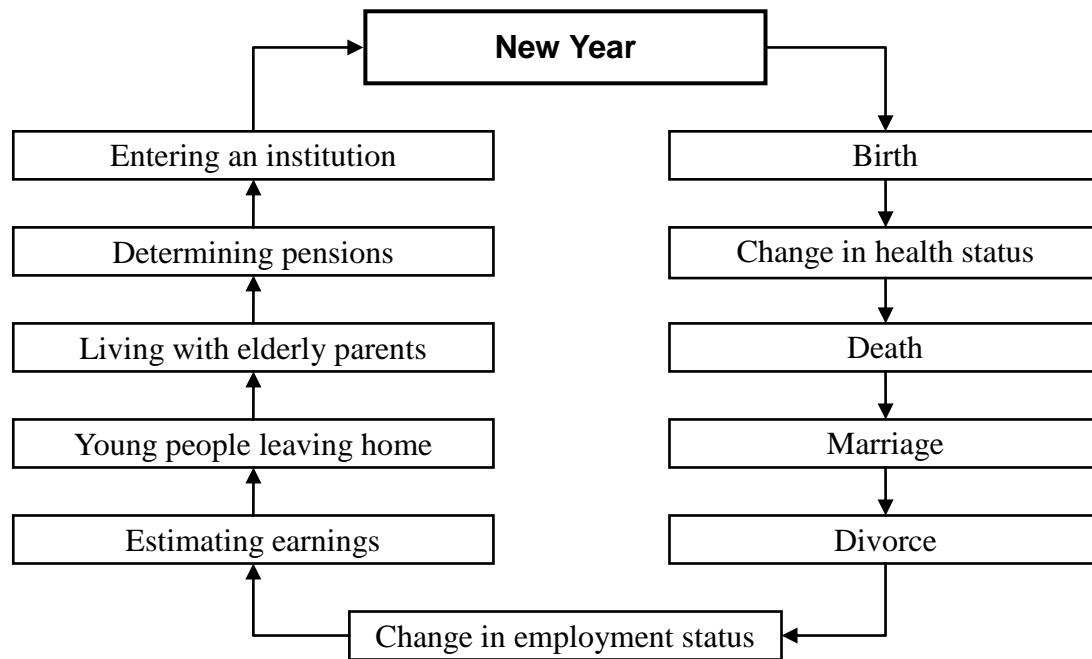
## 2.2. Simulation cycle and transition probabilities

### 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 birth, change in health status, death, marriage, divorce, change in employment status, estimating earning, young people leaving home, living with elderly parents, determining pensions, and entering an institution. Migration is not incorporated in this model since both immigration and emigration rates are still low in Japan.

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 other transition probabilities are assumed to be no change in the future.

**Figure 5: Simulation cycle**



#### 2.2.2. 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 in Japan. Therefore, 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 rates among young women. Newborn babies will belong in their mothers' households.

#### 2.2.3. 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.

#### 2.2.4. Death

Mortality rates by sex and age are used for death. 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. 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 the grooms.

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.

#### *2.2.6. Divorce*

Divorce rates by wife's age are used for divorce. The custody of the 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.

#### *2.2.7. Change in employment status*

With regard to the employment status, the individual is classified as regular employees, non-regular employees, 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, those transition probabilities are differentiated with respect to their marital status since the employment pattern among Japanese women differs with their marital status.

#### *2.2.8. Estimating earnings*

Earnings are assumed to conform to a log-normal distribution by sex, age group, and employment status. In this model, z-score of the earnings-distribution for each person is given in advance, and 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.

#### *2.2.9. 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.

#### *2.2.10. Living with elderly parents*

When elderly people, who do not live with their children, become very old age 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.

#### *2.2.11. Determining pensions*

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

#### *2.2.12. Entering an institution*

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

### **2.3. Compiling statistics**

This model produces a longitudinal micro data set 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 analysis, if necessary, can be made by using the longitudinal micro data output independently from the simulation process. Sampling errors derived from Monte Carlo method can also be estimated by repeating simulations with different random numbers sets.

### **2.4. Computer language and execution time**

This model is written in FORTRAN90. If the initial population is 127 thousand persons, that is, 1/1000 of Japanese population, it takes about 1 minute to make a 100-year simulation using a PC with 2GB RAM and Intel® Core(TM) 6600, 2.4GHz processor. Since the execution time is relatively short, it usually takes an average of 100 simulation runs to evaluate the simulation results.

## **3. PREPARATION OF 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. 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 49,089 private households and 126,487 household members is prepared by resampling with replacement from the micro data. The elderly population of 1,200 persons in institutional households is prepared separately and is added to the initial population. In the end, the initial population is 127,687 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, and so on—cannot be obtained from the CSLC. Such information is separately imputed.

Another problem with the 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. 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 between 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. The 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.

### **3.3. Imputation of other characteristics**

With regard to earnings, the micro data of the CSLC is modified because it surveyed the earnings in the previous year<sup>iv</sup>; consequently, the earnings are inconsistent with other characteristics such as employment status. Specifically, the earnings are imputed in the same way as estimating earnings.

Personal histories of employment status are imputed by applying the transition probabilities retroactively. Those of earnings are imputed in the same way as estimating earnings.

## **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 the impact of policy change or behavioral changes. The scenario is assumed that people's behavior—as it was in 2001—would not, in principle, change in the future. However, it is assumed the declining trends in mortality and first marriage rates.

## 4.2. Population

Table 1 shows the simulated future trend in Japanese 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 derived from their demographic assumptions. This model does not take into account international migration; further, the mortality rates and fertility rates used for this simulation are slightly different from those used for the official population projections.

**Table 1: Population by age group**

	Simulation results				Population projections 2006			
	Total	0-14	15-64	65+	Total	0-14	15-64	65+
2004	127,687	17,683	85,117	24,887	—	—	—	—
2025	118,453	13,145	70,397	34,911	119,270	11,956	70,960	36,354
2050	93,710	9,463	48,741	35,505	95,152	8,214	49,297	37,641
2075	66,616	6,677	34,419	25,520	68,216	5,732	33,686	28,798
2100	46,895	4,706	24,466	17,723	47,712	4,093	24,144	19,475

(Source) Population Projections for Japan (National Institute of Population and Social Security Research)

In any case, Japanese population will be very old, and the proportion of elderly people will be 29.5% in 2025 and 37.9% in 2050. On the other hand, children and working population will decline sharply.

## 4.3. Number and size 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 population projections of the National Institute of Population and Social Security Research (2008). Both estimates are very close, and they show that 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 2070.

**Table 2: Number and size of private households**

	Simulation results			Household projections 2008		
	Population	Number of households	Size of households	Population	Number of households	Size of households
2004	126,487	49,089	2.58	—	—	—
2010	125,341	50,385	2.49	124,460	50,287	2.47
2020	119,995	50,638	2.37	119,039	50,441	2.36
2030	111,499	48,631	2.29	110,637	48,802	2.27
2050	90,804	41,189	2.20	—	—	—
2075	64,262	29,723	2.16	—	—	—
2100	45,246	20,914	2.16	—	—	—

(Source) Household Projections for Japan (National Institute of Population and Social Security Research)

#### 4.4. Number of subscribers of National Pension Scheme

Table 3 shows the future trends with regard to the number of subscribers of National Pension Scheme by category and compares the same with the actuarial valuation conducted by the Actuarial Affairs Division, Pension Bureau, Ministry of Health, Labor and Welfare (2005). All residents in Japan between the ages of 20 to 60 are eligible and required to become a subscriber of the Japan's 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.

**Table 3: Number of subscribers of national pension Scheme by category**

	Simulation results				Actuarial valuation 2004			
	Total	Category No.1	Category No.2	Category No.3	Total	Category No.1	Category No.2	Category No.3
2004	71,223	24,572	36,581	10,070	—	—	—	—
2025	60,425	19,860	32,513	8,052	61,800	18,200	33,900	9,700
2050	41,248	12,909	22,689	5,649	46,200	13,600	25,500	7,100
2070	31,308	9,831	17,215	4,262	37,700	11,100	20,900	5,700
2100	20,689	6,502	11,373	2,813	29,700	8,900	16,300	4,500

(Source) Actuarial valuation 2004 on Employees' Pension Insurance and National Pension in Japan (Actuarial Affairs Division, Pension Bureau, Ministry of Health, Labor and Welfare)

The differences between the two estimates are mainly derived from the assumptions on the employment pattern. The baseline scenario of this model assumes that the proportion of regular employees will stay at the present level, but the Actuarial Valuation 2004 assumes that it will increase.

#### 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, 35.2% 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.

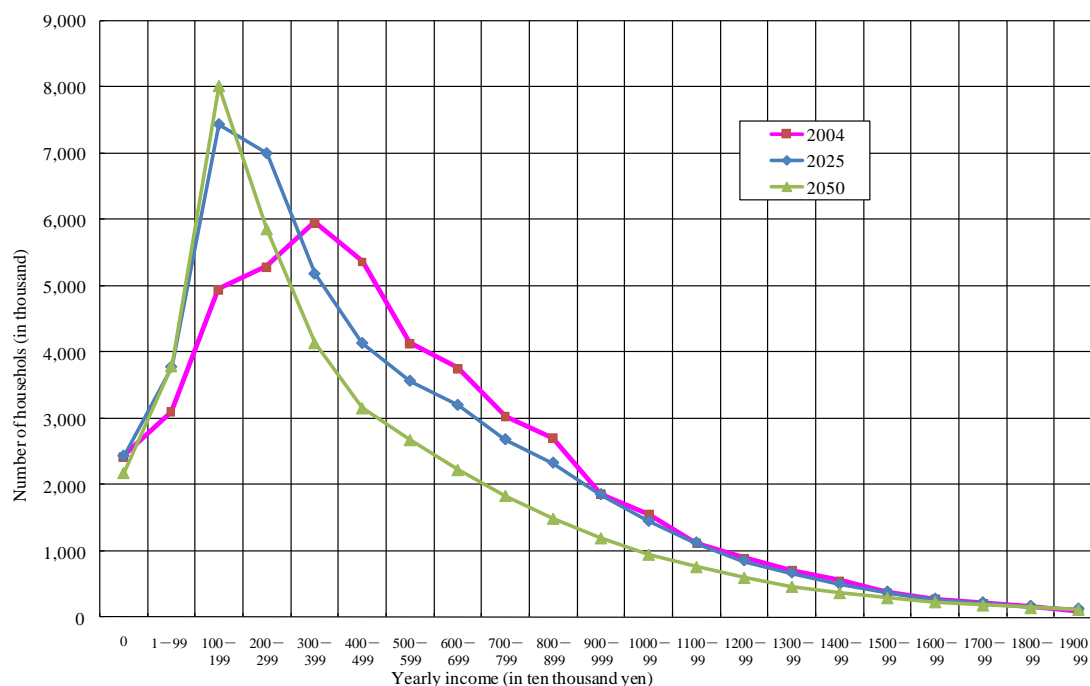
**Table 4: Elderly population by family type**

	Total	Single-person household	Couple only	Living with married	Living with unmarried	Others	Institution
2004	24,887	3,695	8,073	5,832	5,167	920	1,200
2025	34,911	7,731	9,880	4,374	8,628	1,881	2,417
2050	35,505	9,618	9,210	3,359	7,460	2,951	2,906
2075	25,520	7,627	6,459	2,252	4,988	1,840	2,354
2100	17,723	5,344	4,466	1,580	3,478	1,207	1,648

#### 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.

**Figure 6: Trends in income distribution**

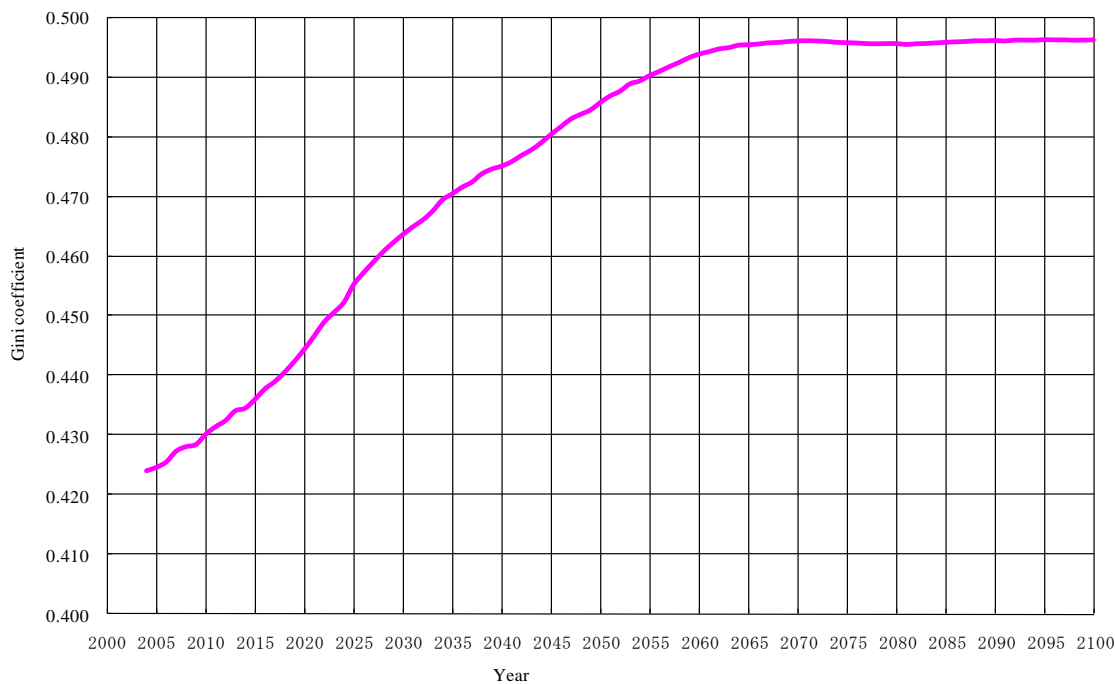


The income distribution will shift to the left, and the number of low income households will increase considerably. That is because population is aging and household size shrinking. In the future, the peak of income distribution will be in the group 1–2 million yen, and the majority of this group will 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 0.424. It will increase yearly, and will reach 0.486 in 2050 and 0.496 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.

**Figure 7: Trends in Gini coefficient**

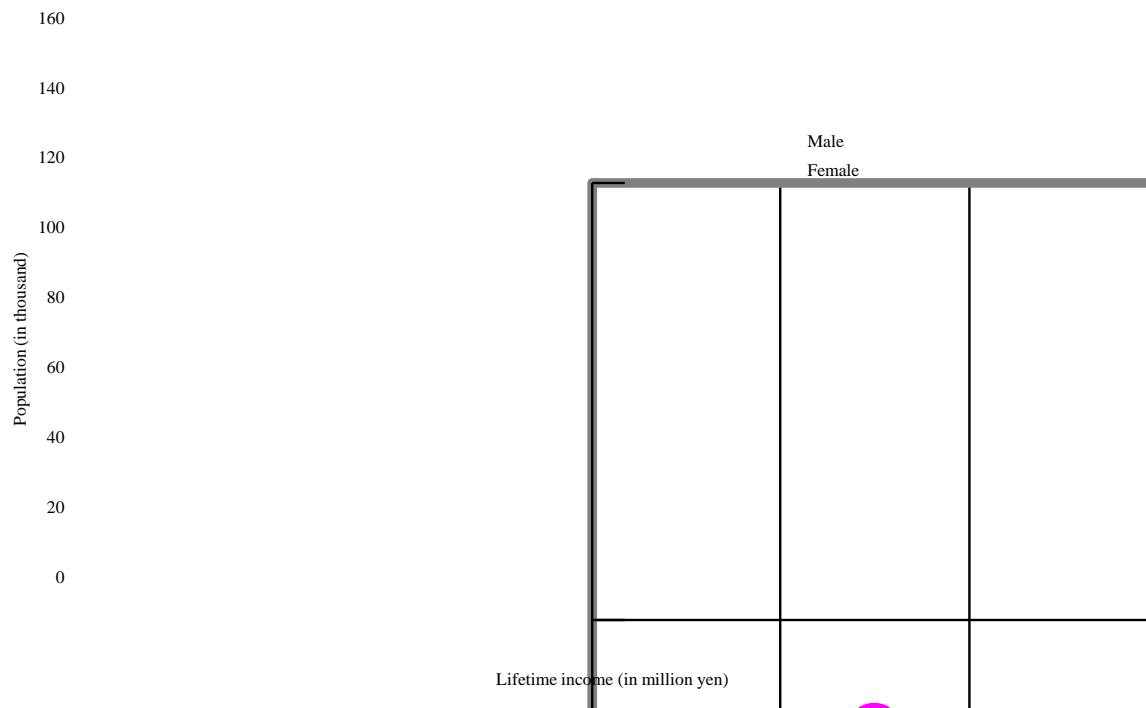


#### 4.8. Lifetime income distribution

Figure 8 shows the lifetime income distribution for people born in 1990 by sex. The peak for females will be between 25–50 million yen, and 67.3% 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 71 million yen.

On the other hand, the variation in the lifetime income for males is large, and its peak is between 150–175 million yen. The median income for males born in 1990 is estimated to be 197 million yen, and it implies that more than half of the males will receive 2 million yen as their lifetime income.

**Figure 8: Lifetime income distribution by sex**



## 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 social security contribution and tax burdens. International migration should be considered since it will become an important political issue in the super-aging Japanese society.

Microsimulation models are not common in Japan. However, the output of microsimulation models, especially that which pertains to 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.

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## ENDNOTES

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<sup>i</sup> Fukawa (1994, 2007, 2009), Inagaki (2005, 2007a, 2007b, 2009), and Inagaki and Kaneko (2008) made attempts to improve INAHSIM.

<sup>ii</sup> Fukawa (2009) uses a modified version of INAHSIM.

<sup>iii</sup> 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.

<sup>iv</sup> 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.