Population-household Projection in Japan: INAHSIM 2017 Simulation

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Abstract

By using a dynamic micro-simulation model named INAHSIM-II, we conducted a population-household projection in Japan for the period of 2015-2065. In this paper, we described features of INAHSIM 2017 Simulation and showed basic results of it.

Key words: dynamic micro-simulation, population-household projection, initial population, transition probabilities, dependency level

1. Introduction

The household is one of the most important statistical bases for policy formulation on health and welfare. Statistical information on households and families is still inadequate, to understand the dynamic process of formation and dissolution of households and families in a systematic and coordinated way (Fukawa, 2012). Dynamic micro-simulation models are considered to be the most suitable method to observe the dynamic evolution of households and families and to forecast their future trends. However, the dynamic micro-simulation method does have some drawback, including difficulties in obtaining the initial population as well as estimating the transition probabilities.

INAHSIM (Integrated Analytical Model for Household Simulation), a dynamic micro-simulation model (**Note 1**), was first developed in 1984-85 in Japan by using an actual initial population derived from a national household survey (Fukawa, 2012). Since the 1994 Simulation, the initial population for the model was formed by using the INAHSIM model itself (called INAHSIM-II). This is especially important in Japan where it is particularly difficult to use micro data of household surveys to obtain the initial population. Therefore, INAHSIM-II is a solution to avoid the difficulty to obtain initial population for the model.

In the INAHSIM 2011 Simulation, setting 2010 as the start year, we conducted a population-household projection in Japan for the period of 2011-2060. Same as the 2009 Simulation, the dependency level of the elderly aged 65 or over was based on the data from the Long-term Care (LTC) Insurance, and institution was among the options of living arrangements for the elderly (Fukawa, 2012).

In this paper, important features of the INAHSIM 2017 Simulation were described in Section 2, and basic results from the simulation were shown in Section 3. Living arrangements of the elderly as well as institutional care needs of the elderly will be focused by separate papers, using the results of the INAHSIM 2017 Simulation.

2. Features of the INAHSIM 2017 Simulation

Observing the basic framework of the 2011 Simulation, the 2017 Simulation had the following characteristics: a) the Initial Population was formed by using the INAHSIM model itself; b) the dependency of the elderly was related to the data of the Long-term Care (LTC) Insurance; c) institutions were included as a possible option for the elderly to move (Fukawa, 2012). Compared to the 2011 Simulation, the 2017 Simulation had the following features:

- Base year was set at 2015, and all available data including population census 2015 and complete life table

2015 were used to create reasonable Initial Population of the Model for this new base year;
- Most transition probabilities were revised, especially annual dependency transition of the elderly was improved; and
- New results such as extended life tables and solitary rate were available.

(1) Initial Population

Preparation of the Initial Population was done by two steps. First, individual males and females, 3,000 of each, aged 20-29 according to age distribution in 2015, was created and put into the model. A simulation was executed for 205 years in order to obtain a stable population, using a set of transition probabilities. Next in Step 2, a specific set of transition probabilities was applied to create age-specific profile of the population in 2015. This step continued for 70 years. Higher birth rate and higher marriage rate were used in order to create the first (born during 1947-1949) and second (born in 1970s) baby-boomer generations. The final state of this Step 2 was compared with the result from the Population Census 2015 (Table 1).

Table 1 Creation of Initial Population for 2015

	Step 1	Step 2	Actual
Population by age group (%)			
0-14	33.9	12.8	12.6
15-34	27.6	20.5	20.4
35-54	18.0	27.4	27.6
55-74	13.5	26.5	26.5
75+	7.0	12.8	12.8
Household structure (%)			
One-person (1P)	22.4	34.8	34.5
Couple only (Cp)	15.7	21.0	20.1
Couple and child(ren) (CC)	44.6	25.6	26.8
Single parent and child(ren) (SC)	3.6	6.8	8.9
Three generation (3G)	8.6	5.5	5.7
The others (Oth)	5.1	6.4	4.0
Living situation of 65+ (%)			
One-person	14.7	18.1	17.7
Couple only	39.2	34.3	34.9
Co-resident with child (Couple)	22.6	13.7	13.4
Co-resident with child (Without spouse)	13.4	24.0	22.9
The others	4.7	5.2	5.1
Institution	5.5	4.7	6.0

Note: Actual figures are from the Population Census 2015.

Through these two steps, the Initial Population consisted of 128,534 individuals in 52,692 households. The Initial Population obtained was fairly good in general as shown in Table 1. Throughout the simulation, the Initial Population was fixed.

(2) Transition Probabilities

Various transition probabilities shown in **Appendix** were used in the model. The death rate is given by age (single year of age) and sex for those who are less than 65 years old, but it is determined by dependency transition which is given by age group and sex for those who are 65 years old or over. The dependency of the elderly aged 65 or over is classified into 4 levels as follows:

Level 0: No disability and completely independent;
Level 1: Some disability but basically independent;
Level 2: Slightly or moderately dependent; and
Level 3: Heavily dependent.

Levels 2 and 3 correspond to persons eligible for the LTC Insurance, and Level 3 corresponds to care need assessments 4 and 5 in particular. Annual dependency transition of the elderly as well as the distribution of the elderly according to age group, sex and dependency level will be discussed separately by another paper.

As shown in **Appendix,** We employed four kinds of household mergers: (a) Co-residency rate of adult child with parents upon marriage, (b) Reuniting rate of adult child to the parent's household upon becoming widowed, (c) Reuniting rate of adult child to the parent's household upon divorce, and (d) merger rate of aged parent(s) with child. The merger rate of aged parent(s) changes according to marital status, average age and dependency of aged parent(s).

Concerning the possibility of the elderly to move into institutions, we assumed two cases (standard case and independent case). This process occurred separately from merger of aged parent(s) with child. Whether an elderly person moves to an institution or not depends on living arrangements, marital status, and dependency level. This theme will be discussed separately by another paper.

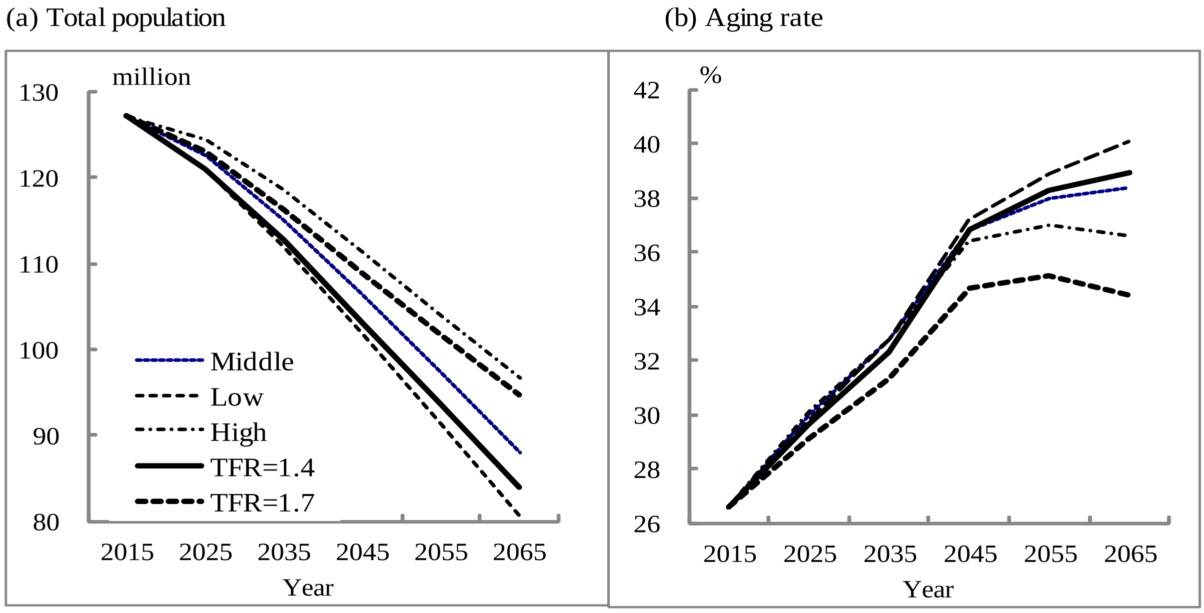
(3) Simulation Cases

The total fertility rate was assumed to remain the same throughout the simulation period, and we assumed two levels (TFR=1.4 and 1.7). On the other hand, the death rate was assumed to decline gradually, resulting life expectancy at birth as 85 years for males and 91 years for females in 2065. The other transition probabilities, including the possibility of the elderly to move to institution, remain the same throughout the simulation period.

3. Basic Results of the INAHSIM 2017 Simulation

(1) Total population and aging rate

According to the 2017 simulation, the total population continues to decline throughout the projection periods, while aging of the population will continue (Fig. 1). Total population and aging rate (the proportion of those who are 65 years old or over to the total population) in future years are more or less in line with the result of the latest official population projection published by the IPSS (National Institute of Population and Social Security Research) in April 2017 (IPSS, 2017).



Note: Middle, Low, High mean middle, low, and high scenarios of the Population Projection by the IPSS as of April 2017 respectively.

Figure 1 Total population and aging rate: 2015-2065

The total number of population will decrease from 127 million in 2015 to 84 million, and aging rate will increase from 27% in 2015 to 39% in 2065, if future TFR remains at 1.4 level (Table 2). Ageing rate will be saturated around 35% if we assume future TFR as 1.7.

Table 2 Trends of population and household: 2000-2065

TFR	Year	Population							Households (million)	
		Number (million)			Age Structure (%)				Total	With 65+
		Total	65+	(Re)75+	0-14	15-64	65+	(Re)75+		
Actual	2000	126.9	22.0	9.0	14.6	68.1	17.4	7.1	46.8	15.0
	2005	127.8	25.7	11.6	13.7	65.8	20.1	9.1	49.1	17.2
	2010	128.1	29.2	14.1	13.1	63.8	23.0	11.0	51.8	19.3
	2015	127.1	33.5	16.1	12.6	60.7	26.6	12.8	53.3	21.7
1.4	2025	120.9	35.8	20.7	11.6	58.8	29.6	17.2	52.8	24.6
	2035	112.7	36.4	21.4	10.9	56.8	32.3	19.0	50.5	25.4
	2045	103.0	37.9	21.3	10.5	52.7	36.8	20.7	47.2	26.2
	2055	93.6	35.9	23.4	10.4	51.3	38.3	25.0	42.9	24.7
	2065	83.9	32.7	21.6	10.3	50.8	38.9	25.7	38.2	21.9
1.7	2025	123.0	35.8	20.8	13.1	57.8	29.1	16.9	52.5	24.6
	2035	116.2	36.4	21.3	12.8	55.9	31.3	18.4	50.4	25.2
	2045	108.7	37.7	21.2	12.7	52.6	34.7	19.5	47.6	26.0
	2055	101.8	35.8	23.3	13.2	51.7	35.1	22.9	44.4	24.6
	2065	94.8	32.6	21.5	13.3	52.3	34.4	22.7	40.6	22.1

Note: Figures for 2000-2015 are based on the Population Census.

The total number of household starts decreasing since 2015, but the number of households with elderly members (65+) will continue increasing until around 2045 and starts decreasing thereafter (Table 2).

(2) Dependency level

Table 3 shows the distribution of the elderly (65+) by dependency level. The proportion of dependency level 2 was 8.2% (6.1% for males and 9.8% for females), and dependency level 3 was 3.6% (2.2% for males and 4.7% for females) in 2015 (Fukawa, 2017a). As shown in Table 3, the proportions of those elderly with dependency levels 2 and 3 will steadily increase, and about 9% of female elderly (65+) will become dependency level 3 in 2065.

Table 3 Distribution of the elderly (65+) by dependency level: 2015-2065

(in %)

Year	Total				Males				Females			
	Dependency level				Dependency level				Dependency level			
	0	1	2	3	0	1	2	3	0	1	2	3
2015	53.9	34.3	8.2	3.6	52.0	39.7	6.1	2.2	55.4	30.2	9.8	4.7
2015	53.1	34.8	9.0	3.2	51.7	36.7	8.9	2.7	54.3	33.2	9.0	3.6
2025	50.7	35.0	10.5	3.8	49.5	36.2	10.8	3.5	51.6	34.1	10.3	4.0
2035	48.8	35.2	11.5	4.5	47.5	36.7	11.7	4.1	49.9	33.9	11.4	4.8
2045	48.1	35.3	11.5	5.1	47.1	36.8	11.5	4.5	49.0	34.0	11.4	5.6
2055	45.4	35.6	12.9	6.2	43.9	37.2	13.4	5.6	46.6	34.2	12.5	6.7
2065	42.9	34.5	14.6	8.0	41.9	36.3	14.7	7.2	43.8	33.1	14.5	8.6

Note: Values in 2015 above the dotted line are based on Fukawa (2017a).
Source: Fukawa (2017b)

(3) Living arrangements of the elderly

In 2015, among the elderly population aged 65 or over, 17.7% live in one-person households, 34.9% in couple-only households, 36.3% live with the child generation, and 6.0% live in institutions (Fukawa, 2017c). According to the simulation, the proportion of one-person households will increase until 2055, decrease afterwards. The living arrangements of the elderly are rather different between males and females. Reflecting the difference in death rates, the number and proportion of one-person households was much higher for females than males in 2015. However, both the number and proportion of one-person households for males will be catching up to that for females in 2065.

The co-resident rate of the elderly aged 65 or over declined from 70% in 1980 to 50% in 2000, and it was 36% in 2015. Co-residence of the elderly with adult child includes various patterns, and the historical trend of declining co-resident rates will be maintained in future years. The proportion of those elderly who live in institutions will steadily increase throughout the projection periods, especially among women.

4. Some remarks

Due to rapid aging of the population in Japan, the distribution of the elderly by living arrangements and dependency level is important information for future social system. The proportions of those elderly with higher dependency levels will steadily increase, and the increase in the number of highest dependency level is especially remarkable for females. The choice of the elderly among a) living in one-person households, b) co-resident with child households, and c) moving to institutions has a profound impact on future LTC expenditures in Japan.

The dependency of the elderly aged 65 or over was classified into 4 levels, and we observed a sharp increase in the proportion of heavily dependent elderly between 2015 and 2065. This finding suggests that aging of the population will have a strong pressure to increase LTC expenditure, unless future improvement in the dependency of the elderly is not assumed.

From the INAHSIM model, we can obtain a population-household projection in a coherent manner as well as dynamic statistics which are difficult to obtain from static surveys or macro simulation (Fukawa, 2012). However, in order to extract useful information from the INAHSIM, a pertinent initial population and accurate transition probabilities are necessary. By adding place of dwelling, housing and employment situation into the model, we can improve the usefulness of the model remarkably. Inagaki (2005) added employment situation into the model, and analyzed the effects of recent increases in non-regular workers on the future fertility and household situation. Fukawa (2010) applied the simulation results to make a projection of health and long-term care expenditures in Japan. While dynamic models typically do capture some types of behavioral change, they face problems (like static models) when attempting to incorporate either behavioral change in response to government policy changes or second round effects because they do not necessarily allow changes in behavior initiated by government policy changes (Harding, 1996).

(Note 1) INAHSIM is a dynamic micro simulation model, and the occurrence of each event is based on the Monte-Carlo method: that is if and only if a random number generated by the computer for each event is equal to or smaller than the probability given, the event is allowed to occur. When an event is determined to occur, all the necessary procedures will be carried out step by step to simulate the changing of the actual society. The operation of each event is carried out once a year, and the order of operation is as follows: marriage, birth, death, divorce, separation, return, and merger of aged parents.

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Appendix Derivation of Model Parameters (Transition Probabilities)

Event	Transition Probabilities		Value
Birth	Birth rate	age of mother and birth order	actual data in 2015
	Sex ratio at Birth		105.5 males for 100 females
Death	Death rate	age and sex for 0-64 years old	actual data in 2015
	Dependency transition	age and sex for 65+ years old	
Marriage	First marriage rate	age and sex	actual data in 2015
	Re-marriage rate	age and sex	actual data in 2015
Divorce	Divorce rate	duration of marriage	actual data in 2015
	Probability of husband leaving household upon divorce		0.6939
Separation & Return	Separation rate	age, sex and marital status	
	Return rate	age, sex and marital status	
Household Merger	Co-residency rate of adult child with parents upon marriage		bridegroom's 0.29215 bride's 0.12605(no brothers) 0.01695(otherwise)
	Reuniting rate of adult child to the parent's household upon becoming widowed		0.3
	Reuniting rate of adult child to the parent's household upon divorce		Male 0.43 Female 0.35
	Merger rate of aged parent(s) with child	marital status, average age of aged parent(s), and dependency. Standard rate U is modified according to dependency as follows: Dependency 0 1 2 3 Single ×2 ×4 ×10 1.0 Couple ×1 ×2 ×3 ×5	Standard merger rate of aged parent(s)=U

Note: U changes according to marital status and age/average age as follows (age in parenthesis):

Single male: 0.015(65), 0.026(70), 0.045(75), 0.077(80), 0.134(85), 0.207(90+)

Single female: 0.015(65), 0.023(70), 0.036(75), 0.056(80), 0.086(85), 0.123(90+)

Couple: 0.0(65), 0.002(70), 0.003(75), 0.004(80), 0.007(85), 0.01(90), 0.03(95), 0.05(1000+)