Chapter 5

The Use of Microsimulation Models for Pension Analysis in Japan

5.1 Introduction

The public pension provision has been a central policy issue for the past ten years and is still a subject that provokes various controversies in Japan. Recently, unpaid contributions by some of the cabinet ministers and floating pension records sparked nation-wide anger. Japanese government and the Social Insurance Agency (SIA) are being flooded with claims. However, the vague uneasiness among the general public is not only due to these procedural defects but also with regard to the sustainability of the pension arrangement. The declining birthrate and the emerging grey society are well-known future scenarios, and people anticipate a systemic failure of the public pension scheme. Under the current pay-as-you-go system, the younger working generation supports the retired generation; however, the transformation into a grey society may not permit this arrangement to last.

There already exist many proposals pertaining to pension reform. The unification of public pensions is the dominant idea proposed by scholars and also by political leaders. The introduction of the Notional Defined Contribution (NDC), referred to as the Swedish system, is also popular. On the other hand, some individuals point out the need to change the funding source of the flat-rate basic pension from contributions to taxes. [125] The Japanese pension system is based on the public insurance scheme and people pay the contributions. In addition, the general budget currently disburses more than ¥5 trillion as the pension budget annually. The method of allocating the tax revenue among pensioners requires further consideration.

These abovementioned reform proposals have different directions. However, a common idea they share is a step towards “Personalization.” The NDC sets the individual account as

[125] VAT (value added tax) is regarded as the most likely prospect.

part of the pension scheme and keeps each person's pension contribution record. The unification and the tax funding proposals also embrace the idea of personalization. The unification proposal suggests that national pension (KN, *Kokumkin Nenkin*) and employees' pension insurance (KNH, *Kosei Nenkin Hoken*) should be integrated with the new means-test examination. This implies that an individual's personal economic condition becomes more significant than it was before. The amount of support from tax revenue that each pensioner receives is calculated based on the means-test examination. In these policy circumstances, the quantitative model that examines reform proposals should focus on individual conditions. The new model should be designed to take "individuals" into account.

This chapter explains that in the era of personalization, microsimulation is a promising alternative for quantitative pension analysis. Section 5.2 deals with the usage of microsimulation. The precedent studies are examined and the implications for the new model are discussed. Section 5.3 elaborates on the structures of the new model. PENMOD has recently been designed and this chapter introduces it. Section 5.4 provides the preliminary simulation results. Section 5.5 concludes this paper.

5.2 Microsimulation Models

5.2.1 The General Structure of Microsimulation

Microsimulation is the name of an economic modeling technique that employs microdata. Mitton, Sutherland, and Weeks (2000) summarized microsimulation as follows:

Microsimulation model uses micro-data on persons (or households, or firms or other micro-units) and simulates the effect of changes in policy (or other changes) on each of these units. Differences before and after the changes can be analyzed at the micro-level or aggregated to show the overall effect of the change.

The first feature of microsimulation is the usage of micro data. Other economic models use aggregate data for their analysis; however, microsimulation uses microdata. This feature is the same as that of panel data analysis. The use of microdata makes quantitative analysis more detailed.

The second feature of microsimulation is that this technique calculates "changes" in the sample. Unlike regression analysis, microsimulation does not estimate any type of parameters;[126] rather, it examines how the economic state (or behavior) of each person will change due to a policy change. For example, tax microsimulation employs personal income data. The datasets are composed of each person's age, income, marital status, number of children, etc. Suppose there is a policy change with regard to the tax rate, the model will calculate each person's tax base and the tax rates will be applied to these tax bases. Since the linearity between income and tax payment amounts is not maintained due to the complicated tax structure, the usage of aggregate (i.e., macro) data cannot estimate tax revenues precisely. Microsimulation is based on the micro sample, and the total tax revenue can be obtained from the summation of individuals. Hence, it can evade this addition problem.

The model that deals with time series data is referred to as "dynamic microsimulation." Each sample incorporates the life events (employment, retirement, marriage, death, etc.) that occur during one's lifetime. Dynamic microsimulation simulates these events within a model. Under the current pension system, a person is employed for more than 40 years and receives pension benefits for 20 years during the retirement period.[127] The pension benefit is calculated using contribution history (i.e., 40 years of employment). In dynamic microsimulation, individuals are treated as separate samples, and the model sums up this data to show the policy effects as a whole. In order to analyze the personal aspects in detail, it is preferable to use dynamic microsimulation.

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[126] Microsimulation does not deny regression analysis. The behavioral microsimulation estimates econometric parameters from the microdata.

[127] It is assumed that the typical Japanese person will work from the age of 20 to the age of 59 (i.e., the employment term is 40 years). The average benefit term is 17 years (65–82 years) for males and 22 years (65–87 years old) for females.

5.2.2 The Design of Pension Models

In advanced countries, progress in computer technology has enabled microsimulation analysis since the 1970s. The emergence of the personal computer (PC) promoted microsimulation further, and the leading models that we currently see began to be developed in the 1990s. O'Donoghue (2000) surveys the current dynamic microsimulation models. According to O'Donoghue (2000), there exist approximately 30 dynamic models in the U.S. and in European countries. Among these 30 models, 14 models support pension analysis (see Table 5.1). The years employed in model constructions vary widely between the 1970s and the 1990s, and some old models do not adequately simulate life events.

O'Donoghue's list suggests that the study on pension microsimulation is under development even among the Organisation for Economic Co-operation and Development (OECD) countries. The modeling methods of dynamic microsimulation have already been studied; however, most models deal with pension simulation as by-products.[128] Pension microsimulations that mainly treat pension benefits are limited. The reason that dynamic microsimulation does not deal with the subject of pension is the restrictions on the dataset. In order to calculate individual pension benefits, the model should support the pension contribution history of more than 40 years for each person; this requirement implies that the pension model should hold these past records for more than 40 years. Dynamic microsimulation cannot estimate pension benefits without past records. However, in practice, no panel data that can offer such an extended history exist. Therefore, to construct a pension microsimulation, the model builder should begin his study with panel data formation. Current panel data are prepared directly from questionnaires; moreover, techniques that will provide panel data from the beginning or that will connect different types of datasets should be sought. The lack of credible panel data delays the dynamic microsimulation of pension analysis.

DYNAMOD I and DYNAMOD II have been developed by the National Center for Social and Economic Modeling (NATSEM) at the University of Canberra. DYNAMOD is one of

[128] These models deal with other themes such as demography and household incomes. See Gupta and Kapur (2000).

the standard models in this academic field.[129] DYNAMOD begins with a study of income tax simulation and labor supply analysis. It develops techniques for the simulation of life events for dynamic microsimulation. The life events analysis estimates personal life history. A person commences his/her life at birth. He/she gets educated and enters the workforce. He/she may also get married and divorced. In old age, he/she will retire and live as a pensioner, and finally, he/she will die. The life events analysis specifies these personal histories, and the model determines a person's life history by using a probability technique. For example, to determine the mortality of a person, the model prepares the death probabilities according to age-sex categories. This generates a random number for that person. When this random number is smaller than the rate of death probability in reference, this sample will die. On the other hand, if the random number is greater than the rate of death probability, this sample continues to exist. By using this random number generation method, the model can offer different patterns of life events, and it can generate various types of personal histories. Since the probabilities for each life event are based on official statistics, the aggregate pattern of life events coincides with actual tendencies.[130]

SAGE is the abbreviation of the Simulating Social Policy in an Ageing Society project. The London School of Economics (LSE) and King's College, University of London, manage the ESRC (Economic and Social Research Council) and conduct the SAGE project jointly. They are both developing the SAGE microsimulation model. The technical paper on SAGE[131] explains the procedure involved in preparing a database of pension participants. With regard to contribution histories, three types of sample datasets exist in the U.K.[132] SAGE generates personal histories by connecting to these existing datasets. The methodologies for preparing datasets are common among SAGE (U.K.), MOSART

[129] DYNAMOD was developed with the support of the Australian government, and has a relatively long history. The home page and supply of discussion papers are worthwhile.

[130] When the future life events probability differs from the present one, the model provides the future probability. Some dynamic microsimulations examine the future demographic trends based on this setting.

[131] *Technical paper no.8*, see Evandrou, Falkingham and Scott (2004).

[132] (i) Retirement and Retirement Plans Survey (1989), (ii) British Household Panel Survey, and (iii) Family and Working Lives Survey (FWLS) (1994).

(Norway),[133] and DESTINE (France).[134] These dynamic microsimulations hold that a participant's history can be generated from actual datasets. They make all possible efforts to collect actual data in order to enable dynamic simulation. A dataset might contain the sample for a single year and its preparation involves correlating it with the samples of other years. On the other hand, a dataset may support personal employment histories but may not support information on pension contribution. Another dataset on pension premium is required in this case. The abovementioned projects are directed at accomplishing this.

The Department of Labor of the U.S. government developed the PENSIM[135] model, which simulates occupational pension (U.S. employer-sponsored pensions). This method of dataset generation is different from the other dynamic microsimulations. Although SAGE and PENSIM collect the existing datasets at most, the model requires the creation of a new dataset because a complete dataset with long-term history that enables pension analysis does not exist in practice. The PENSIM project has decided to create a dataset without actual data. PENSIM calculates past employment histories from 1935 onward by using the life events method. According to PENSIM, the life events are as follows: birth, schooling, employment, marriage, divorce, and death. These life events are simulated through probabilities and by switching the probabilities employed in PENSIM. The participant histories for people born after 1935 are accumulated up to the present time, and these are employed in future simulations. PENSIM verifies the estimation performance by comparing the actual data and estimation results from 1992 to 1999. PENSIM also prepares the following functions to enhance simulation performance: (1) survival function for employment duration—the model parameters are estimated based on the actual panel data; (2) wage function for employees; (3) retirement probability function for employees; and (4) selection function of pension types for employees, etc. Most existing microsimulation models are developed using several modules because the model either deals with several phases of life events or requires submodels. This is another feature of microsimulation analysis. Moreover, model

[133] See Andreassen, Fredrkksen and Ljones (1996).
[134] See Bonnet and Mahieu (2000).
[135] See Holmer, Janney and Cohen (2007).

construction tends to become large in general.

5.2.3 Pension Models in Japan

In Japan, there exist four types of pension estimations.[136] The first type is the cohort model. The cohort model divides the Japanese population into several groups based on age-sex categories; further, it simulates the pension histories for each cohort. The estimation results are then multiplied with the corresponding population size, and the aggregate pension finance is estimated. The pension bureau at the Ministry of Health, Labour and Welfare (MHLW) in Japan conducts pension projection every five years, and they employ their cohort pension model for their estimations. The higher the number of categories within a model, the more elaborate the model becomes. The cohort-type model has been used as the leading method for pension analysis in Japan because it utilizes actuarial mathematics and suitably estimates the long-term prospects of pension. In addition to the MHLW's cohort model, academic scholars are also examining this model type.[137] Although the cohort model suitably estimates future prospects, it also has a drawback. There exists only one individual who represents a cohort; therefore, the cohort model cannot simulate the internal realities related to a cohort. For example, the average income of a cohort is a unique value associated with this population group; however, in reality, individual earnings differ even if they belong to the same age-sex categories. The inaccuracy of the cohort model becomes evident when different rules are applied to persons in accordance with the income levels.

The second model type involves representative calculation. Representative calculation focuses on a typical individual. In Japan, the so-called "model household" refers to a family that consists of a couple (i.e., a husband and his spouse) and their two children. The analyst takes a random representative person, and examines his/her pension benefits. For example, when the future pension incomes of the model household are calculated, the generational

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[136] See Tajika, Kaneko and Hayashi (1996). The pension models referred to in this paper are restricted to those on public pension.

[137] In Japan, other research groups have promoted the application of the MHLW's model for pension projections.

imbalance among its members can be examined. Although representative calculation is convenient for studying policy effects, this model type cannot estimate the overall scenario related to pension schemes because it only deals with typical persons.

The third model type is the simultaneous macroeconomic model. Although this appears to be an outdated model technique in the international context, research in this field is also dominant in Japan. For example, the Economy and Public Finance Model, which was developed by the Cabinet Office (CAO), is a macroeconomic model.[138] Since this model deals with social security, it is able to construct simultaneous economic models for pension estimation. The basic idea underlying this model is the analysis of the relationship between the economy and public finance; therefore, it takes into account macroeconomic considerations. However, the variables and equations of the macroeconomic model are generally approximations. Furthermore, the advantage of this model is that it examines the links between the pension system and the overall economy; however, the macroeconomic model cannot suitably estimate future economic prospects in the long term, for instance, 50 years from now. The cohort model and dynamic microsimulation consider economic conditions to be exogenous.[139] Pension models cannot help treating the economic conditions as exogenous because it is not possible to estimate very long-term future economic prospects.

The fourth model type is the overlapping generation (OLG) model. In the OLG model, a typical person's life is divided into two periods: (1) working period and (2) retirement period. The OLG model is based on the general equilibrium model, and newer models have been developed in Japan. It suggests another direction in pension simulation.

5.2.4 Dynamic Microsimulations in Japan

In Japan, there were two preceding studies in the field of dynamic microsimulation. Kawashima (2005) constructed a regional dynamic microsimulation to estimate the

[138] CAO homepage, http://www5.cao.go.jp/keizai3/econome.html

[139] Wage increase, consumer price index (CPI), and interest rate are required for pension estimation.

long-term health care budget for the elderly.[140] His research concerns range from the examination of regional economic accounts to the study of social insurance. Kawashima's model (KEISIM) estimates the demographic changes in Kurume City. Since his dynamic microsimulation is based on individual samples, the relationship between health conditions and the need for long-term care for each person can be studied. KEISIM replaced the former cohort models with dynamic microsimulation. KEISIM also prepares a pension module that calculates each person's pension benefits on the basis of their final salary.

Inagaki (2007) compiles his studies based on microsimulations for his INASIM model. His academic theme is an examination of the future of family structures in Japan. In particular, he focuses on the impact of the so-called "parasite single" on Japanese households. The superiority of INASIM lies in Inagaki's rigorous scientific definitions in the simulation of life-events. For example, INASIM can simulate marriages, and the simulation procedures are as follows: (1) the selection of marriage candidates from both sexes, which is determined by the probability method, (2) matching of individuals for marriage, and (3) registration in the "couple record" (i.e., database formation). As part of INASIM, a newly married couple can have a child. Kawashima (2005) and Inagaki (2007) developed database programming independently;[141] their studies suggest that database construction is a critical component of dynamic microsimulation. Since dynamic microsimulation conducts a life events analysis, a database that is easy to handle and reliable is required.

5.2.5 The MHLW's Pension Model

Before proceeding with the new model, it is necessary to examine the MHLW's pension model in this section. This model is called the *Zaisei-Saikeisan-Program* (ZSP, public pension recalculation). The ZSP was developed by the pension bureau at MHLW, and it estimates both the national pension (KN) and employees' pension insurance (KNH). The

[140] Kawashima simulated the long-term health care budget of Kurume City in Japan. Long-term health care and nursing are the responsibilities of the municipal government in Japan. The system is based on insurance arrangements.

[141] Kawashima employs visual basic (VB) and Inagaki employs FORTRAN.

estimation processes of the ZSP are as follows:[142] (1) Estimation of participants (i.e., the working generation): The ZSP applies share parameters to population projection, and it determines the numbers of participants under each pension type. (2) Estimation of the contribution revenue: Annual revenue is the product of the participants, average earning, and contribution (premium) rates. With the help of revenue calculation, the pension basis for each cohort is estimated. The pension basis is revalued annually using the conversion factor.[143] (3) Retirement decision and the calculation of pension benefits: Retirement is judged based on cohort age, and pension benefits are calculated from pension formulas. (4) Public finance: overall estimations (i.e., revenues and disbursements) are collected together. Fiscal measures such as tax funding are added to it.

The ZSP is a highly complicated model; however, in practice, there are fewer types of variables. Pension contribution is calculated on the revenue side. The number of participants and their average incomes are the major variables. Pension provision is calculated on the expenditure side. The number of retirees and their pension benefits are used as the variables. The retirement age is estimated in the ZSP. In practice, the reason that the ZSP deals with many variables is that there are a large number of categories for each variable. Since the pension benefit is calculated based on the pension basis in the ZSP, it can perform revaluations of the pension basis annually. The projections related to the retirement decision and revaluation process also make the ZSP a complicated model. The variables of the ZSP are as follows: (1) numbers of participants (categories: sex, age, and participation years), (2) average terms of participants (categories: sex, age, and pension type), (3) average monthly income (categories: sex and age), (4) Number of retirees (categories: sex, age, and types of pension benefits), (5) average amount of pension benefit (categories: sex, age, and types of pension benefits), and (6) pension funds (aggregate variable).

The ZSP implements the simulation of life events for each cohort; thus, it supports several

[142] MHLW (2005) explained the simulation process of ZSP. The ZSP is written in FORTRAN and C languages.

[143] The earning-related pension is calculated from the pension basis. The pension basis is the sum of annual salaries, and it is converted to the present value. Under the current Japanese system, the wage increase rate is the conversion factor.

probabilities within the model.[144] These are as follows: (1) the rates of employment, withdrawal, and reemployment, (2) death rate, (3) probabilities of occurrence for the disabled, (4) probabilities of occurrence for the survivor's pension, and (5) increase in the wage rate. The ZSP simulates the changes in the employment pattern and the occurrence of life events. By replacing these parameters with the probabilities, a new dynamic microsimulation can be developed.

5.3 The New Model: PENMOD

5.3.1 Overview of PENMOD

PENMOD is a dynamic microsimulation model that deals with public pension arrangements.[145] The first objective of PENMOD is to apply dynamic microsimulation techniques to pension analysis in Japan. As discussed above, individual sample usage is appropriate for the personalization tendency associated with the future of pension reform. The second objective concerns the usage of actuarial mathematics. The standard pension model developed by the MHLW is cohort estimation, and it is based on strict actuarial mathematics. A clear-cut analysis of the burden and benefit is required because the pension system is similar to insurance in nature. The participants contribute premiums for the long term, and the pension benefits are calculated based on the evaluation of these premiums. The dynamic microsimulation describes the actuarial calculation that enables precise pension estimates. The third objective is to forecast future pension prospects, for instance, pension deficits resulting from design failures. The new dynamic microsimulation explains the causes and outcomes of pension reforms.

PENMOD contains three simulation modules (Figure 5.1): (1) past records, (2) life events, and (3) pension finance. Since panel data that covers long-term contribution histories does

[144] These parameters on probability are collected from actual data. The MHLW conducts a special survey of the actual records (i.e., the original data of the Social Insurance Agency) for this purpose.
[145] Collaborative research by the Institute of Economic Research (IER) at the Hitotsubashi University and Mitsubishi Research Institute led to the development of PENMOD.

not exist in Japan, PENMOD commences its estimation with the past record module (Module 1). As part of the first module, dataset formation is conducted for the participant records from 1961 to 2004. The model develops annual sample datasets from official aggregate statistics. It connects these datasets over the years. New samples constitute artificial data, and the overall dataset is paradata in this context.[146] The life events module (Module 2) is the main component of PENMOD. The microsimulation of life events is conducted as a part of this module, and the future samples for pension contributions from 2005 to 2105 are obtained. The probability method is adopted, where each individual will experience life events such as employment and retirement. PENMOD concentrates on individual employment histories because it is the sole necessity of earning-related pension. Module 2 also simulates the pensioners' life events. The retired generation receives pension benefits annually. The pension finance module (Module 3) sums up the simulation results and converts pension estimates into public finance figures. The Policy effects are evaluated at this stage.

5.3.2 Data Sources

Pension Participants

PENMOD converts aggregate statistics into samples. The annual statistical report (JN, *Jigyo Nenpo*, 1961–2004) of the SIA is the basis of PENMOD. The number of participants in national pension (KN) and employees' pension insurance (KNH) are recorded in JN. The information of age categories (the aggregate for every five years) and salary data for both sexes can be obtained. However, JN does not provide information on the income distribution of cohorts (i.e., the age and salary categories).

The basic survey on wage structure (WC, *Wage Census,*[147] 1948–2006), which is

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[146] Each sample of the new dataset is fictitious; however, the overall tendency of the dataset is the maintenance of real figures, because the dataset is formulated from actual statistics. This is the first trial in the new model's development, and actual longitudinal data is desired for future study.

[147] The formal name of these statistics is *Chingin Kouzo Kihon Chousa*

surveyed by the MHLW presents cross-sectional data on age and income. The share values are calculated, and the JN statistics are divided by using WC data (see Table 5.2). The population census (PC, *Kokusei Chousa*) is also used for the categorical divisions based on age (i.e., annual data of each category).

When the pension participants are employees, there exist only two contribution types for them: (1) private employees' pension insurance (KNH) and (2) public servants' pension insurance (KKH, *Kyousai Kumiai Hoken*).[148] The model should register these two types within the sample, i.e., whether the individual is a private employee or a public servant. Such persons are referred to as "Type 2" (*Nigo*). On the other hand, in the case of national pension (KN), there are several contribution types such as self-employed, student, and housewife. The figures for each type can be obtained from the JN statistics. PENMOD creates samples from these statistics. The concrete participant types of KN are as follows:

- Type 1 (*Ichigo,* 1961–2004): Self-employed participants
- Type 3 (*Sango,* 1986–2004): Spouses of employees, mainly housewives; no premium burden
- Voluntary Participants (*Nin-I Kanyu*, 1961–2004): Earlier (1961–1985), students and housewives could participate in KN voluntarily. Recently (1986–2004), however, a person who wishes to earn pension benefit rights[149] continues to voluntarily pay his pension contributions after the age of 60.
- Statutory Exemption (*Houtei Menjo*, 1961–2004): Disabled persons and those requiring public assistance are enrolled as pension participants without having to contribute.
- Applicant Exemption (*Shinsei Menjo*, 1961–2004): Low-income individuals

[148] The public servants' pension insurance does not consist of a single scheme. In Japan, more than 50 occupational pension schemes are provided by the central and the local governments. KKH is a generic name for these schemes.
[149] In Japan, a person has to participate in a public pension scheme for more than 25 years in order to be eligible for pension benefit rights that ensure pension income during retirement.

can be exempted upon submitting an application. Partial exemptions were also introduced recently.

- Student Exemption (*Gakusei Menjo*, 1991–2004): School students (over the age of 20) can postpone their contributions until employed.

Another data source is required for public servants. The annual statistical report (JN) does not report the public servants' pension insurance (KKH). The other statistics referred to in this study are (1) statistics for the central public servants' mutual association (*Kokka Koumuin Kyousai Kumiai Jigyo Nenpou*) and (2) statistics for the local public servants' mutual association (*Chihou Koumuin Kyousai Kumiai Jigyo Nenpou*). Data on the number of participants and average incomes are collected from these data sources.

Pension Benefits

With regard to pension benefits, most data are recorded in the annual statistical report (JN, 1961–2004). The actual benefits are combinations of the following two types of benefits.

The first type is the insurer's type, which has already been referred to, namely, KN, KNH, and KKH. The second type is the benefit type: (1) old-age benefit (RN, *Rorei Nenkin*), (2) aggregate old-age benefit[150] (TRN, *Tu-san Rorei Nenkin*), (3) survivor's benefit (IN, *Izoku Nenkin*), and (4) disability benefit (SN, *Shougai Nenkin*).[151] Under the Japanese system, a retired person can be eligible for one or two types of pension benefits. For example, an employee who has worked for a private company for over 35 years can only receive KNH-RN benefits. A widow who has lost her husband can receive both KN-RN and KNH-IN benefits. A person who has worked for a private company for less than 25 years

[150] "Aggregate" refers to the summation of the years of participation in several pension schemes. Although the individual does not participate in the pension scheme for more than 25 years, when the total participation in the scheme exceeds 25 years, he/she will be classified as having satisfied the aggregate requirement, and will be eligible to receive pension.

[151] There is another type of pension provision: (1) first tier and (2) second tire. KN only provides for the first tier. However, KKN and KKH provide for both the first and second tiers.

and has been self-employed for more than 25 years can receive KN-RN and KNH-TRN benefits. The numbers related to and the average pension benefits for each type are obtained from the JN statistics. PENMOD constructs samples from the following information.

Insurer's type

- KN (*Kokumin Nenkin*): National pension
- KNH (*Kosei Nenkin Hoken*): Employees' pension insurance
- KKH (*Kyousai Kumiai Hoken*): Public servants' pension insurance

Benefit type

- RN (*Rorei Nenkin*): Old-age benefit
- TRN (*Tu-san Rorei Nenkin*): Aggregate Old-age benefit
- IN (*Izoku Nenkin*): Survivor's benefit
- SN (*Shougai Nenkin*): Disability benefit

Job Changes

People might change their job status during the course of their lives. When a person is employed by a private company, his contribution is of the KNH type. On the other hand, a student who benefits from student exemption under KN would change his contribution to the KKH type on becoming a public servant. Both modules (1) past record and (2) life events consider the employment histories. The probabilities of changes in job status are defined based on the actual statistics. The Employment Status Survey (SKKC, *Shugyo Kouzo Kihon Chousa*, 1956–2003) records the employment histories within a year; the probabilities for changes in job status are calculated based on the SKKC statistics.[152]

In the previous year (Year t), three types of pension participants exist: (1) Type 1 (self-employed), (2) Type 2 (employee), and (3) Type 1 (unemployed) and Type 3

[152] The SKKC is conducted by the Statistics Bureau every five (or three) years. The main purpose of the SKKC is to survey the employment status, for instance, information such as occupation and working hours.

(housewife).[153] In the next year, individuals may change their participation type in the following five ways (Year t+1). Nine types of changes in job status are defined in this model (see figure 5.2 and table 5.3).

- Continuation (Type 1 (self-employed) and Type 2 (employee) remain unchanged)
- Change (Type 1 (self-employed) moves to Type 2 (employee), or Type 2 (employee) moves to Type 1 (self-employed))
- Entry (Type 1 (unemployed) and Type 3 (housewife) move to Type 1 (self-employed) or Type 2 (employee))
- Exit (Type 1 (self-employed) or Type 2 (employee) stops working)
- Non-Job (Type 1 (unemployment) and Type 3 (housewife) remain unemployed)

Other Data Sources

The probabilities on mortality and marital status are defined based on the vital statistics (JDT, *Jinkou Doutai Toukei*) provided by the MHLW. The actual number of probabilities based on age-sex categories can be obtained from these statistics.

Review of the 2004 Actuarial Valuation of the Public Pension Plans (*Zaisei Saikeisan Houkoku*) by the MHLW presents various parameters for its pension cohort model. The wage schedule and disability probabilities are calculated from this review.

5.3.3 Model Description

Past Record (Module 1)

Module 1 produces samples for the past contribution records. The first step of Module 1 is to develop annual samples. For example, for participants of Type 2 (employee) who are 35

[153] Both the self-employed and unemployed are designated as Type 1 under KN (national pension).

years of age and have a monthly average income of ¥250,000, there are 280,000 persons for this category. PENMOD generates 30 samples for datasets in this category (i.e., the absolute vale of 280,000/10,000). The age group of 20–59 years accounts for about half of the total Japanese population. Around 4,000–6,000 samples are annually developed as part of PENMOD.[154]

The second step of Module 1 involves the development of a longitudinal dataset. Each sample will be individually connected to the next year's sample in the following manner: (1) PENMOD generates a random number for each sample, and it predicts the changes in participant types for the next year. The reference probabilities that are adopted from the official statistics are compared with the random numbers arbitrarily. (2) After the determination of pension type, an identical procedure is followed. That is, two groups of the same participant type are defined from both this year's and next years' samples. (3) A random matching among two sample groups is implemented. Finally, the employment histories can be obtained.

Life Events: Participant Histories (Module 2)

Module 2 deals with the future estimation from 2005 to 2105. Dynamic microsimulation estimates the next year's datasets on a yearly basis. For example, PENMOD estimates the dataset of 2005 by using the dataset of 2004; similarly, the dataset of 2006 is developed from the dataset of 2005. This implies that PENMOD uses the initial dataset of 2004, and operates dynamic microsimulation for the period from 2005 to 2105.

Since the pension scheme deals with two types of generations (i.e., the working generation and retired generation), Module 2 conducts two life events analyses for these two generations.[155] The first analysis is the estimation of participant histories for the working

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154 In 2005, the total Japanese population was approximately 127.8 million. The number of participant samples in PENMOD was 4,667 (in 1970), 5,491 (in 1980), 6,320 (in 1990), and 6,800 (in 2000).

155 PENMOD estimates both the working and retirement schedules. At the time of retirement, the sample of the working generation shifts to the sample of retired generation. The two types of generations are linked in this manner.

generation, and the second analysis is the estimation of the pension benefits for retirees. The concrete life events analysis of the participants is explained in this section (see figure 3).

Addition of New Samples

A sample of 20-year-olds in 2005 was 19 years old in 2004, and past records do not include this sample because the participants were restricted to those over 20 years of age. Therefore, new samples of 20-years-olds should be added annually to the participant records in this model.[156] Each sample of 20-year-olds contains dataset information on sex, age, and pension type. When this individual is already an employee (private or public), salary is also included in the dataset. The dataset on 20-year-olds is provided from external sources. The sample figures for each year (2005–2105) are calculated from the population projections of the NIPSSR (2006).[157] The pension types of the sample are set using the share parameters based on the JN statistics of 2004.

Determination of Death

Module 2 calculates the life event of mortality. Without determining mortality, all samples will continue to be alive in the next year, and this is unrealistic.[158] A very small number of samples will die annually, and the simulation decides which sample will die. A random number is generated for each sample, and this number is compared with the death probabilities of the relevant age-sex categories. If the random number is less than the death probability, the individual will die. The death probability figures are arranged on the basis of the vital Statistics of Japan (MHLW, 2005).

[156] More precise dynamic microsimulation estimates child birth within the model; however, for simplification, PENMOD sets the starting age as 20. New samples are based on external sources.
[157] NIPSSR (National Institute of Population and Social Security Research)
[158] Death is the basis of life insurance. With regard to pension insurance under the pay-as-you-go system, the death rate affects pension finance particularly from the perspective of benefit provision.

Changes in Marital Status

The life event analysis of marital status in PENMOD is peculiar to females. Marital status is an essential condition for determining Type 3 (housewife). There are few males of Type 3 in Japan, and for simplicity, PENMOD only examines females.

Module 2 determines whether a female will marry, divorce, or maintain her marital status until the next year. In reality, female participants of Type 3 (*Sango*)—housewives not making pension contributions—are common in Japan. This classification as Type 3 depends on marital status; therefore, PENMOD conducts marital simulations within the model. The marriage and divorce probabilities are arranged on the basis of the vital Statistics of Japan (MHLW, 2005). When a female gets married, PENMOD further simulates that she is either a Type 1 (i.e., the housewife of a self-employed individual) or Type 3 (i.e., the housewife of an employee). On the other hand, when a Type 3 housewife gets divorced, PENMOD simulates whether she becomes a Type 1 (self-employed) or a Type 2 (employee).

Job Changes

PENMOD calculates the participant histories of the working generation. Moreover, change in employment status among Type 1, Type 2, and Type 3 is the most important simulation procedure in the model. The working generation will change its contribution type in the following manner: (i) continue, (ii) change, (iii) entry, (iv) exit, and (v) non-Job (see section 3.2.3 and figure 2). For example, when a Type 1 self-employed individual continues with his/her job, it is classified as continue (from Type 1 to Type 1). When a Type 1 unemployed individual is hired by a private company, it is classified as entry (from Type 1 to Type 2).

The job change probabilities are calculated from SKKC (2003). In simulations of life events, a random number is provided to a sample, and PENMOD refers to the relevant probabilities in the sex-age-current job type categories. Based on the comparison between the random number and relevant probability, new participant types are determined.

Wage Determination

When a participant is a Type 2 (i.e., employee), his/her wage should be determined as he/she will receive earning-related pension on retirement. Wage determination depends on job changes. If a person remains an employee, the following two types of wage increases are observed: (i) wage increase along the age-wage curve, and (ii) wage increase along time. These two rates of increase are multiplied with the previous year's wages.[159] If the participant changes his/her participant type to Type 2 either from Type 1 or Type 3, a new salary will be earned, and PENMOD should determine the wage amount. With regard to private employees, 10 wage classes are defined. The determination of wage class is based on the probability technique.

To be precise, PENMOD does not estimate pension contributions as part of Module 2; rather, it only estimates wage amounts. Pension contribution can be calculated from the product of the wage and contribution rate;[160] however, the earning-related pension is calculated from the adjusted average of past salaries based on the Japanese pension formula. This implies that the model does not require pension contributions in order to estimate the pension benefits for each retiree.

A divorced Type 3 housewife should change her participant type from Type 3 to Type 1 or Type 2 as she is no longer eligible to enjoy the status of a housewife. The divergence of Type 1 or Type 2 is estimated on the basis of the probability technique, and she will earn her new wage if she selects Type 2 (employee).

Simulation Loop

The life events analysis of participant histories is repeated annually. The following year's dataset is formulated from the present year's dataset. From the viewpoint of an individual sample, each sample experiences life events every year, and the simulation results provide longitudinal datasets.

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[159] PENMOD divides wage increase into two components. In practice, the wage increase rate is a single figure; however, an employee experiences a shift in his/her wage curve and CPI adjustments in detail.

[160] The contribution rate is approximately 15% in Japan.

5.3.3.1 Life Events: Pension Benefits (Module 2)

The second part of Module 2 is the simulation of life events for the retired generation. PENMOD estimates which sample will retire, and also simulates how the pension benefits will vary during the retirement period.

Retirement Decision

The actual retirement mechanism is complex; it involves (i) the statutory pensionable age for pension benefits, (ii) the moving up or postponement of the statutory pensionable age, and (iii) the commencement of disability benefit or survivor's benefit. A legal order is not the only determinant for the implementation of pension schemes. The accumulated wealth of a person moves up his/her starting age as this person need not continue with his/her job. On the other hand, a person who has a job might choose to postpone his/her pension benefits. PENMOD simplifies the retirement decision; it basically conforms to the legal rules. PENMOD sets the pensionable age at 65 years with respect to basic pension (NK type). As for earning-related pension (KNH, KKH), the pensionable age varies between 60 and 65 years in accordance with the year of birth.[161] The concrete retirement decisions of PENMOD are as follows (see Figure 5.5):

- Calculation of the total number of years of participation: The minimum number of years of contribution in Japan is 25. The model adds the number of years of participation and evaluates whether or not he/she qualifies for pension benefits.
- Pension Type: The model determines the pension type: (i) earning-related benefits (KNH or KKH) or (ii) basic pension (KN). When the term of employment exceeds 25 years, he/she receives earning-related benefits.
- Pensionable age: The starting age is determined. Information related to sex, age,

[161] More precisely, the KNH's commencement age has been increasing during 2002–2030. In this model, a male born in 1945 starts earning pension benefits from the age of 63. On the other hand, a male born in 1949 starts earning pension benefits after attaining the age of 65. The actual legal rule sets different commencement ages for the first tier and second tier; however, this model only utilizes the first tier's age.

and pension type is considered. The KN type of benefit starts from the age of 65. KNH and KKH depend on conditions related to sex and year of birth.

Pension Benefits

First, PENMOD calculates pension benefits. The benefit calculations are identical to actual pension formulas. The multipliers are obtained from official documents. The earning-related pension benefits are calculated on the basis of pension and the years of participation. The basic pension benefits are only calculated on the basis of the years of participation. For example, suppose the annual basic pension is ¥780,900. When a self-employed person contributes flat-rate premiums for 30 years, his/her basic pension conforms to the following formula: (780,900) * (30/40) * (revision rate).[162]

Second, PENMOD calculates the annual increases of pension benefits. Under the current rule in Japan, existing pension benefits are reevaluated according to the annual increase in the CPI rate. PENMOD follows this rule and provides benefit increases to the dataset.

Life events Analysis

The life events analysis of pension benefits implements the following two estimations: (i) pension increase and (ii) determination of death (Figure 5.4). Once a retirement sample and his/her pension benefit are determined, that sample continues to receive his/her pension benefit until death. Every year, the model conducts mortality analysis and a pension increase is implemented if the participant is alive.

5.3.2 Pension Finance (Module 3)

Module 3 converts simulation results into aggregate figures. PENMOD formulates public pension accounts. At the revenue side of pension accounts, (i) the total contributions are summed up for the years 2005–2105, (ii) tax finances are estimated, and (iii) interest

[162] The revision rate adjusts the wage changes.

revenues are also calculated. With regard to tax finances, in Japan, one-third of the basic pension benefits are subsidized by general revenue.[163] Module 3 conforms to this rule.

On the expenditure side, total pension benefits are calculated for the years 2005–2105. Since the summary table expresses the debit and credit of pension finance, the expenditures are slightly complicated.

5.4 System

PENMOD uses database programming techniques for dynamic microsimulation. The following two programming techniques are used: (i) database design on Microsoft Access[164] and (ii) simulation programs on Visual Basic (VB).[165]

The system designs are as follows. First, a database is defined in a Microsoft Access table. The use of Access is convenient for database management in dynamic microsimulation. In the Access table, a sample is called a "record," and each record has several "fields." For example, the pension participant records have the following fields: (1) personal ID, (2) sex, (3) year of birth, (5) year of retirement, (8) marital status, (11) participant type in 2004, (118) monthly wage in 2004, and so on (See Table 5.4). Information on these samples is stored within these fields, and the collections of information comprise the pension participant records.

Second, the VB programs execute the creation and storage of Access tables. The Access table does not conduct any data processing in PENMOD; instead, it is used as a notebook.[166] The Access table supports the database structure. For example, the past working histories are stored in the pension participant records. The VB program draws the data from these records and calculates the pension benefits; the results are once again stored in the pension benefit records.

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[163] The financial assistance ratio will become 0.5 (half of the basic pension) in 2009.
[164] Microsoft Office, Access 2007
[165] Microsoft Visual Studio, Visual Basic
[166] Access offers data management facilities; however, PENMOD does not use these functions. In PENMOD, data processing is a task performed by the VB program.

Third, the VB program conducts dynamic microsimulation. The VB program draws datasets from the Access table and executes operations related to pension analysis. Arithmetic operations such as multiplication and functions such as searching are repeated in PENMOD.

5.5 Simulation Results

PENMOD is currently being developed. In this section, I would like to present some preliminary simulation results. As already discussed, PENMOD simulates the future pension participants in the years 2005–2105. The number of participants in the employees' pension insurance (KNH) can be calculated from the simulation results. In 2005, there were 30.9 million KNH participants in PENMOD. The MHWL's cohort model estimates this figure as 32.3 million;[167] thus, the difference between these two results is –4.4%.[168] The difference rate expands along the years. In 2025, PENMOD estimates the KNH participants as 23.8 million, while the MHWL's cohort model estimates it as 29.6 million. The difference between these rates is –19.5% for 2025, and this difference increases to –27.5% in 2050 (see Figure 5.6).

The MHWL's cohort model uses population projection, and it divides each year's total population into participant categories. This implies that each year's estimation results exist independently and that the MHWL's cohort model can evade simulation errors related to time. On the other hand, PENMOD creates the relevant year's dataset based on that of the previous year, because the current year's sample is estimated from past histories. An estimation error appears to occur in this process. The simulation error is caused by the settings of the job change probabilities. An underestimation of PENMOD implies the following: (i) the sample tends to shift from Type 2 or (ii) the sample does not enter Type 2. Further considerations of job change probabilities are required.

[167] See MHLW (2004). This is the official estimation result of the Japanese government.
[168] The negative value implies that PENMOD underestimates the number of participants.

With regard to participant type estimation, PENMOD simulates the monthly earning for the private employees of Type 2. The pension contribution revenues can be calculated from the products of (a) monthly earning and (b) contribution (premium) rate.[169] In 2005, PENMOD estimated KNH's total contribution revenue as ¥22.1 trillion. The MHWL's cohort model estimates this figure as ¥20.8 trillion, and the difference rate is 6.1%.[170] The revenue estimation for 2025 is ¥35.1 trillion in PENMOD and ¥37.7 trillion in the MHWL's cohort model. In this case, the difference rate becomes negative, namely, –6.8%. The difference rate increases to –14.3% in 2050. The tendency of underestimation in the participant numbers and contribution revenues is almost identical. This implies that the underestimation is due to the participant type simulation. On the other hand, the monthly earning estimation appears to be suitable. The monthly earning is calculated using the wage increase rate for a "continue" employee; on the other hand, it is estimated using the probability technique for an "entry" employee. In the total participants group, the proportion of new entrants and retirees is relatively small, and the impact of these elements might be negligible. The simulation results reveal that the earning simulation performs suitably (see Figure 5.7).

5.6 Conclusions

This chapter has sought to explain the dynamic microsimulation techniques for pension analysis in Japan. The study on microsimulation has been progressing extensively in the U.S. and in European countries; the research field begins with a tax and labor supply analysis, and it indicates the various possibilities in terms of quantitative economics. The state of transition within the sample makes microsimulation a unique research tool and the historical sample formation is well suited to pension estimation, which requires information related to

[169] The premium rate of KNH was 14.288% in 2005; the rate is raised by 0.354% annually, and it becomes 18.3% in 2017. Employers and employees share this premium burden equally.
[170] Positive values imply overestimations in PENMOD.

lifetime earnings, marital histories, etc. PENMOD is the first trial model that applies dynamic microsimulation to the pension model in Japan. The research project is still being developed; model design, database construction, and system code programming have been conducted. The lack of longitudinal data requires hypothetical panel formation in order to obtain the employment histories. Since an actual person experiences job changes during his/her lifetime, the new model should develop job change probabilities. The preliminary study shows that the usage of dynamic microsimulation for pension analysis is possible in Japan, and that there is research potential in the upcoming policy discussions on pension reform.

References for Chapter 5

English

John Creedy, Alan Duncan, Mark Harris, and Rossanna Scutella (2002), *Microsimulation Modelling of Taxation and the Labour Market : the Melbourne Institute tax and transfer simulator*, Cheltenham: Edward Elgar

Leif Andreassen, Dennis Fredrkksen, and Olav Ljones (1996), "The Future Burden of Public Pension Benefits: A Microsimulation Study" in Ann Harding ed. *Microsimulation and Public Policy*, Amsterdam: North-Holland, Chapter 15

Carolne Bonnet and Roman Mahieu (2002), "Public pensions in a dynamic microanalytic framework: the case of France" in Mitton, Sutherland and Weeks ed. *Microsimulation Modelling for Policy Analysis: Challenges and Innovations*, Cambridge: Cambridge University Press, Chapter 8

Maria Evandrou, Jane Falkingham and Anne Scott (2004), "Imputing pension and caring histories to the base data in the SAGE dynamic microsimulation model" *SAGE Technical note no.8* (http://www.lse.ac.uk/collections/SAGE/pdf/SAGE%20TN8.pdf)

O'Donoghue (2000), "Dynamic Microsimulation: A Methodological Survey" mimeo, SAGE

Martin Feldstein and Jeffrey Liebman (2002), "Social Security" in Alan Auerbach and Martin Feldstein ed. *Handbook of Public Economics - volume 4*, Amsterdam: North-Holland, Chapter 32

Martin Feldstein and Horst Siebert ed. (2002), *Social Security Pension Reform in Europe*, Chicago: University of Chicago Press

Martin Holmer, Asa Janney, Bob Cohen (2007), *PENSIM Overview*, U.S. Department of Labor (DOL), Social Security Administration (SSA)

Lavinia Mitton, Holly Sutherland and Melvyn Weeks (2000), *Microsimulation Modelling for Policy Analysis*, Cambridge: Cambridge University Press

Noriyuki Takayama (2003) "Pension Arrangements in the Oldest Country: The Japanese

Case" in Noriyuki Takayama ed. *Taste of Pie: Searching for Better Pension Provisions in Developed Countries*, Tokyo: Maruzen Co. ltd., Chapter 5

Japanese

Tatsuo Hatta and Noriyoshi Oguchi (1999), *Pension Reform: Moving to the Defined Contributions*, Tokyo: Nikkei Press

Sei'ichi Inagaki (2007), *Socio-Demographic Future Simulations in Japan: Microsimulation Analyisis*, Japan Statistical Association

Hideki Kawashima (2005), "The Life-cycle Model of the Individual Household in a Micro simulation: Creation of Algorithm" in *Studies in Contemporary Economics*, No.12 August 2005, The Western Association of Economics

Kohei Komamura (2005), *Pension Reform*, Japan Productivity Center for Socio-Economic Development

Ministry of Health, Labour and Welfare (MHLW) (2004), *Review of the 2004 Actuarial Valuation of the Public Pension Plans* (*Zaisei Saikeisan Houkoku*)

Takashi Oshio, Eiji Tajika, and Testuo Fukawa ed. (2006), *Income Distribution in Japan: Evidence and Policies for Tackling Widening Inequality*, Tokyo: University of Tokyo Press

Toshiaki Tachibanaki ed. (2007), *The Size of the Government and the Social Security System*, Tokyo: University of Tokyo Press

Statistics

Ministry of Health, Labour and Welfare (MHLW), *Wage Census* (The basic survey on wage structure)

Ministry of Health, Labour and Welfare (MHLW), *Jinkou Doutai Toukei* (The Vital Statistics of Japan)

Population Projections for Japan: 2005-2105 (2006), Tokyo: NIPSSR

Social Insurance Agency (SIA), *Jigyo Nenpo* (The annual statistical report)

Statistics Bureau, *Kokusei Chousa* (The population census)

Statistics Bureau, *Shugyo Kouzo Kihon Chousa* (The employment status survey)

Federation of national public service personnel mutual aid associations, *Kokka Koumuin Kyousai Kumiai Jigyo Nenpou* (Statistics for the central public servants' mutual association)

Federation of local public service personnel mutual aid associations, *Chihou Koumuin Kyousai Kumiai Jigyo Nenpou* (Statistics for the local public servants' mutual association)

Tables and Figures for Chapter5

Table 5.1 Dynamic Microsimulation Models for Pension Analysis

Name	Country	Summary
DYNAMOD I and II (NATSEM, University of Canberra)	Australia	An internationally renowned model used in life event modeling
Pension Model	Belgium	
DYNACAN, LifePaths, DEMOGEN (Statistics Canada)	Canada	Using 1971 dataset
DESTINIS	France	Basis: 1991 dataset Past estimation: 1945–1990 Future estimation: 1992–2040
Sfb3	Germany	
ANAC	Italy	Mainly analyzes household consumption
NEDYMAS	Netherlands	
MOSART	Norway	Basis: 1% sampling of 1967–
SESIM	Sweden	
PENSIM	U.K.	
SAGE (ESRC, Kings College and London School of Economics, University of London)	U.K.	The pension participants' histories are formed by using three basic types of data.
PENSIM/2	U.S.A.	
PRISM (Department of Labor)	U.S.A.	The model estimates participant histories and simulates the future outcomes

Source: O'Donoghue (2000)

Table 5.2 Cross data of Age and Income

Male (2004FY)	Age											
	--17	18--19	20--24	25--29	30--34	35--39	40--44	45--49	50--54	55--59	60--64	65--
Participants	20,952,395	:total										
category 1	6,185	105,723	482,674	392,628	192,580	105,299	89,906	94,723	145,330	178,081	198,756	103,339
category 2	140	7,028	256,152	622,247	436,577	193,265	117,783	102,014	123,369	128,124	81,645	26,911
category 3	23	996	78,340	442,327	567,280	311,891	181,233	139,925	147,865	147,262	60,309	17,800
category 4	0	514	32,023	254,307	533,674	389,218	263,136	193,943	183,600	171,007	56,442	17,378
category 5	0	0	14,577	136,692	433,440	437,144	323,335	245,260	230,042	207,519	51,415	15,846
category 6	0	0	5,512	72,715	298,446	427,667	371,664	315,467	300,475	252,999	41,768	8,523
category 7	0	0	2,293	34,998	180,576	377,323	404,031	377,689	372,938	297,308	38,344	9,750
category 8	0	0	772	25,525	125,015	318,963	395,503	415,549	418,686	343,266	39,557	12,386
category 9	0	0	1,737	17,300	67,526	210,202	375,020	438,023	509,154	410,916	52,137	13,198
category 10	0	0	0	10,698	48,519	159,476	286,424	447,716	553,384	459,967	96,828	32,221
Average Income (Monthly, Japanese yen)												
category 1	134,939	156,263	165,624	169,591	165,313	161,138	155,062	153,843	148,036	147,275	141,619	138,337
category 2	218,045	205,945	210,441	214,370	216,948	217,867	217,140	216,438	216,124	215,360	213,210	211,002
category 3	239,989	247,318	247,991	249,947	251,411	252,344	252,392	251,703	251,856	251,581	249,973	249,808
category 4	0	277,834	281,160	281,937	283,836	285,052	285,702	285,269	285,459	285,095	285,072	285,713
category 5	0	0	310,949	311,745	313,814	315,468	315,789	316,617	316,178	316,247	313,515	312,446
category 6	0	0	349,388	351,338	351,215	352,776	353,669	353,635	354,097	353,431	352,373	351,180
category 7	0	0	385,309	393,036	393,006	394,976	395,598	396,943	396,500	396,967	397,268	399,976
category 8	0	0	453,176	448,578	447,264	448,659	451,079	451,779	452,732	452,733	450,373	451,383
category 9	0	0	513,162	526,107	531,961	533,394	533,267	535,224	536,443	535,953	533,193	535,332
category 10	0	0	0	618,434	618,043	618,005	618,031	618,386	618,398	618,477	619,193	619,321

Note 1: This table is an example of a PENMOD dataset. It shows the number of males for the employees' pension insurance in the fiscal year 2004. The total number of participants is 21 million.

Note 2: The categorical data on age can be obtained from JN. By using the WC, the data is divided into 10 categories. Each category contains the number and average income of participants.

Note 3: The age category is further divided on a single-year age basis. Finally, PENMOD develops sample datasets.

Table 5.3　Job Change Probabilities

Male 2002 fiscal ye	From (year t)	Type 1 (Self-employed)			Type 2 (Employee)			Type 1 (Unemployed) Type 3 (Housewife)		
	To (year t+1)	Continue (1→1)	Change (1→2)	Exit (1→1/3)	Continue (2→2)	Change (2→1)	Exit (2→1/3)	Non-Job (1/3→1/3)	Entry (1/3→1)	Entry (1/3→2)
age		100.0%			100.0%			100.0%		
Total	(1)	94.3%	0.6%	5.1%	94.3%	1.1%	4.6%	87.6%	5.2%	7.2%
15-19	(2)	78.4%	0.4%	21.2%	67.5%	17.8%	14.7%	89.5%	6.8%	3.7%
20-24	(3)	88.1%	1.0%	10.9%	86.3%	5.2%	8.5%	68.3%	12.5%	19.2%
25-29	(4)	93.0%	2.2%	4.7%	94.9%	1.2%	3.9%	55.8%	12.3%	31.9%
30-34	(5)	95.2%	1.8%	3.0%	96.6%	0.7%	2.7%	63.5%	11.6%	24.9%
35-39	(6)	96.5%	1.2%	2.3%	97.3%	0.5%	2.1%	65.6%	9.2%	25.2%
40-44	(7)	97.2%	0.8%	2.0%	97.6%	0.5%	1.9%	67.4%	10.8%	21.8%
45-49	(8)	96.8%	0.6%	2.6%	97.1%	0.4%	2.4%	70.8%	10.1%	19.1%
50-54	(9)	96.7%	0.5%	2.8%	96.8%	0.5%	2.7%	75.2%	8.4%	16.3%
55-59	(10)	95.0%	0.5%	4.5%	95.2%	0.5%	4.3%	77.7%	7.6%	14.7%
60-64	(11)	87.0%	0.3%	12.7%	86.3%	1.8%	11.9%	90.0%	5.1%	4.9%
65-	(12)	90.3%	0.0%	9.6%	89.1%	1.5%	9.4%	99.1%	0.5%	0.4%

Note 1: This table is an example of a PENMOD dataset. It shows the job change probability of males in the fiscal year 2002.

Note 2: <Example> Twenty-year-old males of Type 1 (self-employed) continue to be Type 1 with an 88.1% probability. The probability of shifting to Type 2 (employee) and the probability of discontinuing work (i.e., exit) are 1.0% and 10.9%, respectively. These probabilities are generated from the Employment Status Survey.

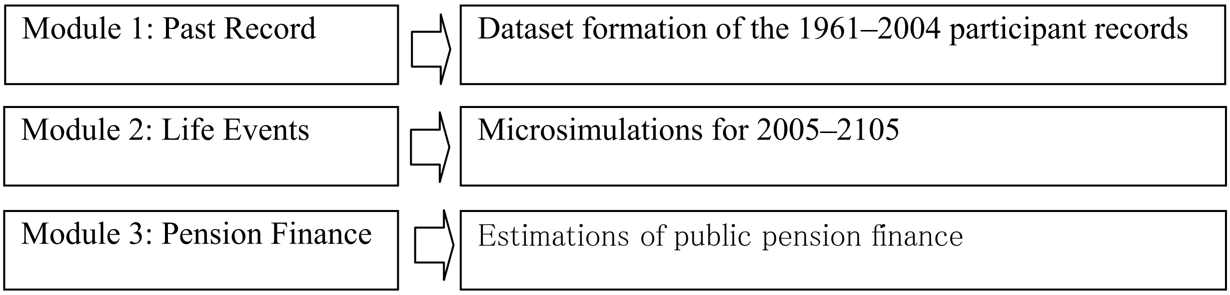
Table 5.4　Database Design (Participant Record)

	Field	Example	Explanation
0	Life	1 or 2	1: Alive, 2: Dead
1	Personal ID		ID number
2	Sex	1 or 2	1: Male, 2: Female
3	Year of Birth	1965	
4	Year of Death	2045	
5	Year of Retirement	2030	
6	Year of Commencement		
7	Marital Status (previous year)	1	1: Married, 2: Single or Divorced
8	Marital Status	1	
9	-		(preparation)
10	-		(preparation)
11	Participant Type 2004	7	3: Type 1 (self-employed) 6: Type 1 (housewife) 7: Type 2 (KNH) 8: Type 2 (KKH), etc.
12	Participant Type 2005	7	
117	Participant Type 2110		
118	Monthly Wage 2004	250,000	(Japanese Yen)
119	Monthly Wage 2005		
	:		
224	Monthly Wage 2110		

Note 1: This table is an example of a PENMOD database. It shows the Participant Record.

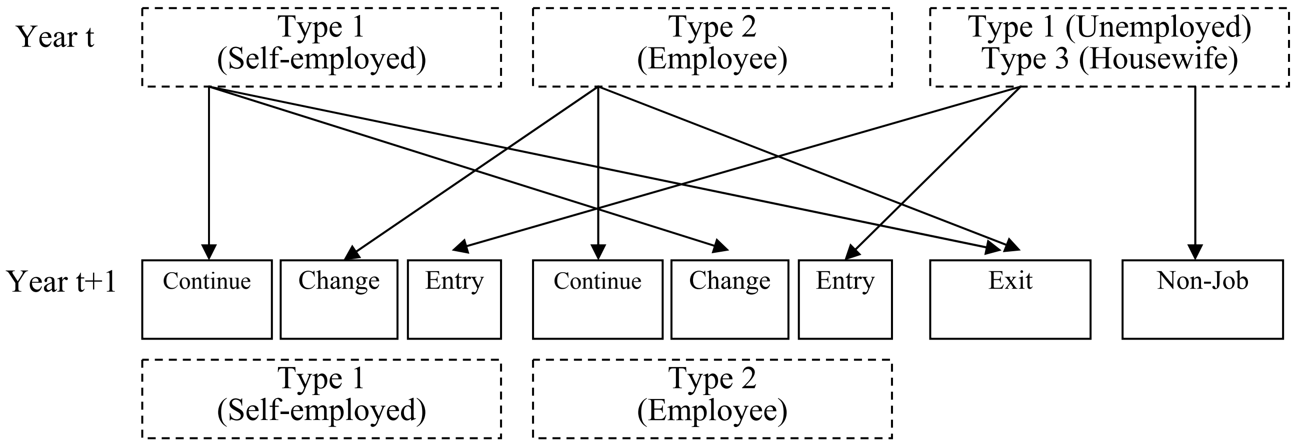
Note 2: Field 1 stores the Personal ID number; Field 2 stores the sex; and Field 3 stores the year of birth, etc.

Figure 5.1 Basic Structure of PENMOD (3 modules)



Note 1: PENMOD has three modules. Module 1 forms the past record dataset. Module 2 conducts the life-events analysis. Module 3 estimates pension finance.

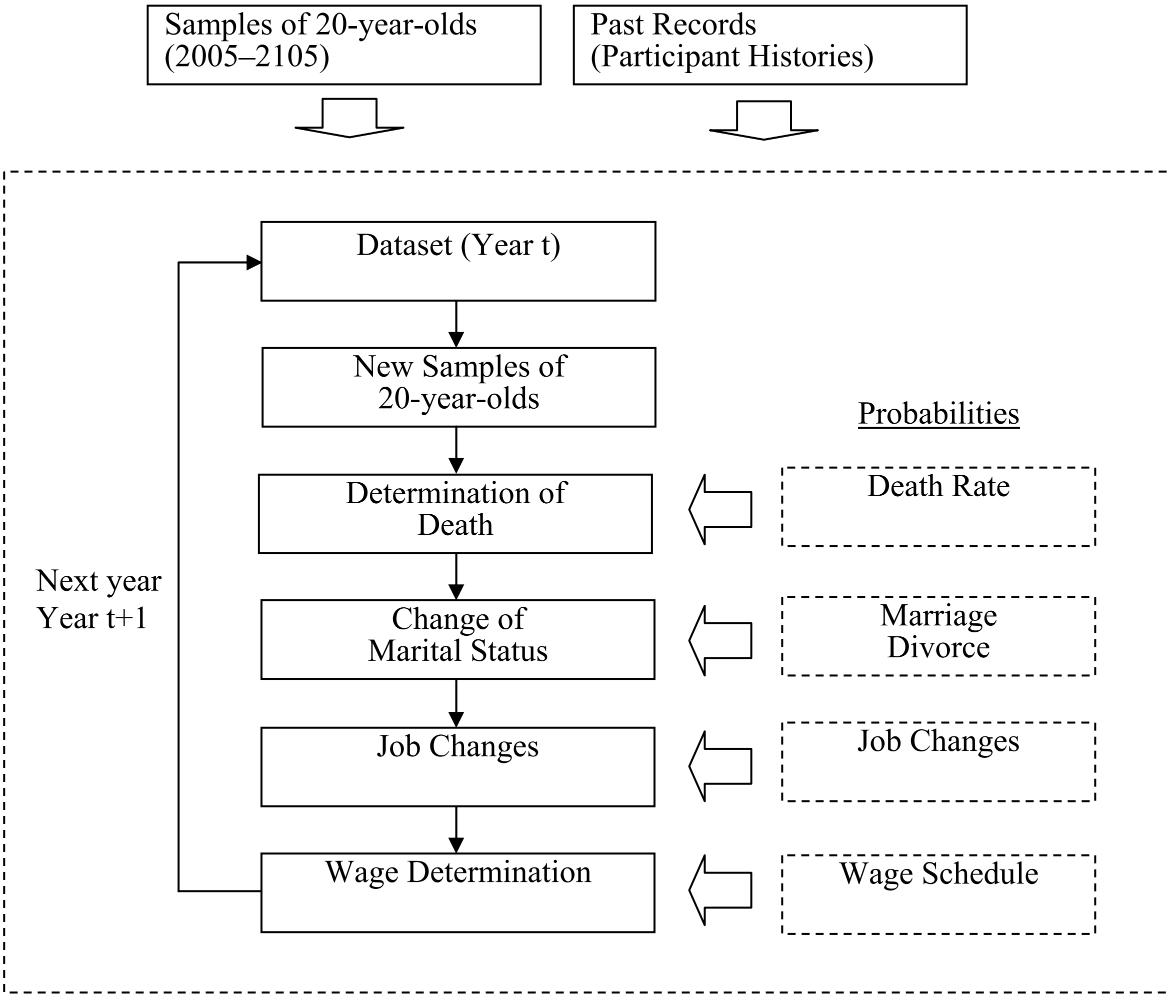
Figure 5.2 Types of Job Changes



Note 1: The job change probabilities are used for the simulation of life events.

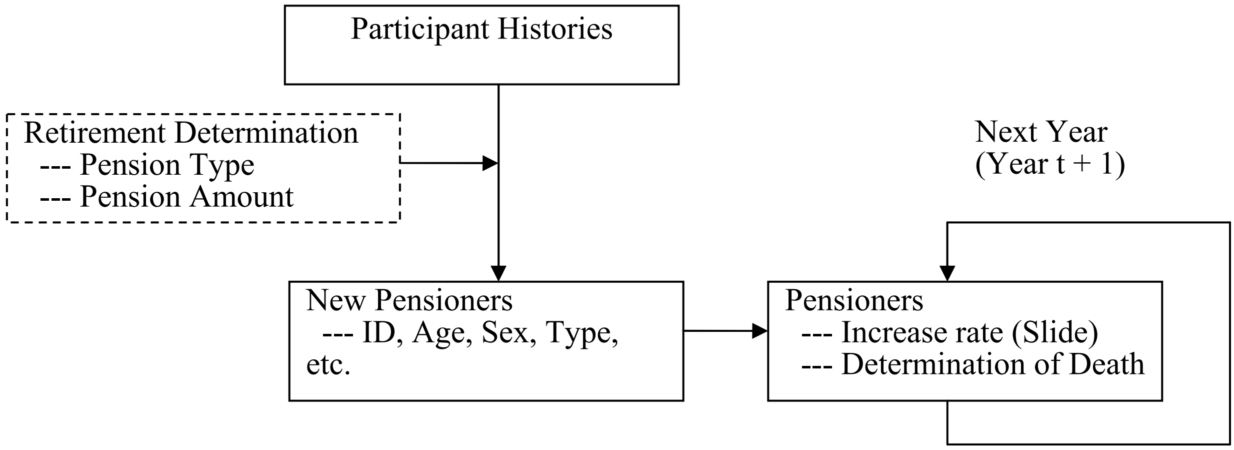
Note 2: There are three possibilities with regard to each participant in the next year. He/she may (1) continue, (2) change, or (3) exit. When the participant is unemployed or a housewife, there are only the following two possibilities: (1) entry or (2) non-job (continue).

Figure 5.3 Life Events – Participant Histories (Module 2)



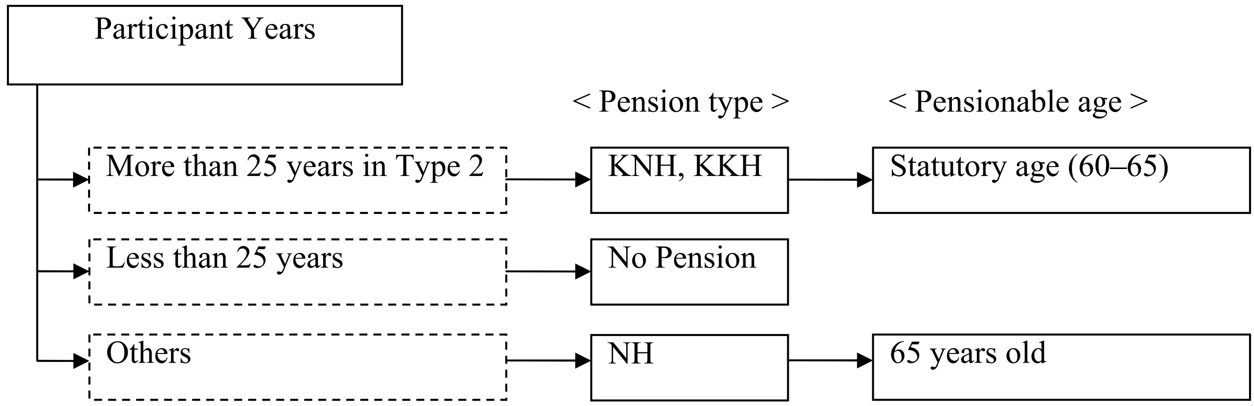
Note 1: This is a simulation procedure of life events. Every year, new samples of 20-year-olds are added to the dataset and the simulation begins. Determinations of death, determinations of marital status, and job changes are simulated in PENMOD. A random number is provided for each event and the comparison determines state transition.

Figure 5.4 Life Events – Pension Benefits (Module 2)



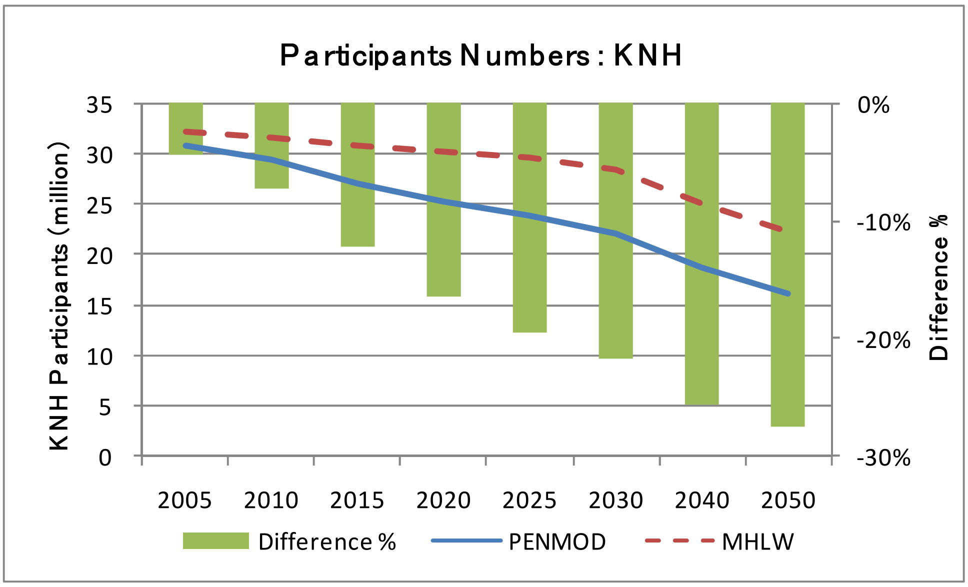
Note 1: PENMOD determines retirement based on the working histories. A new pensioner is registered along with properties. Existing pensioners experience benefit increases every year. The rate of increase (CPI) is referred to as "slide" in Japan.

Figure 5.5 Retirement Decision (Module 2)



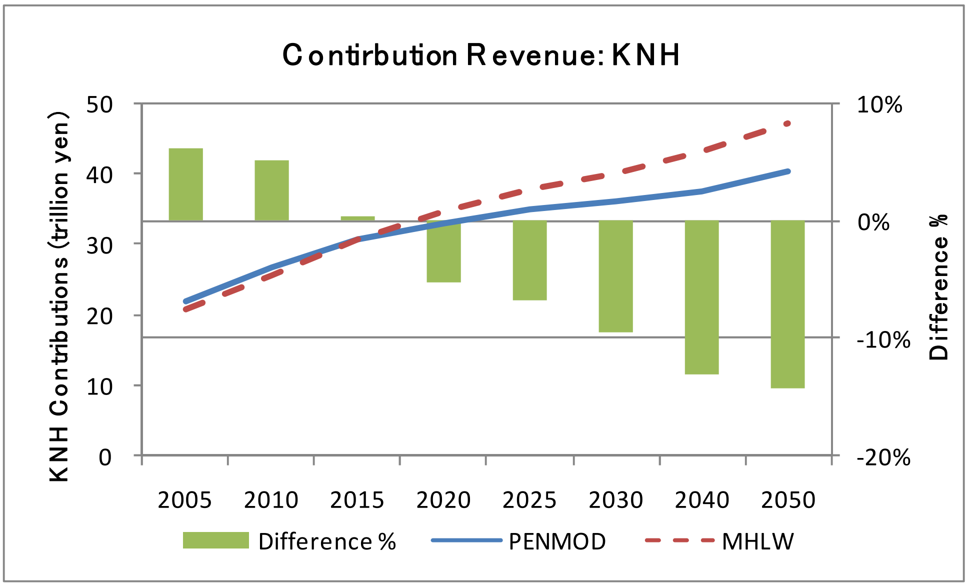
Note 1: PENMOD simplifies the analysis of the retirement decision. The pensionable age according to NH (the national pension) is 65. The pensionable age according to KNH and KKH depends on sex and the year of birth. The legal starting age of basic pension is adopted.

Figure 5.6　Simulation Results (Participant Numbers)



Note 1: The graph shows the number of participants in (KNH)
Note 2: PENMOD provides the simulation results. The MHLW data is obtained from MHLW (2004).

Figure 5.7　Simulation Result (Contribution Revenue)



Note 1: The graph shows contribution revenues of KNH.
Note 2: PENMOD provides the simulation result. The MHLW data is obtained from MHLW (2004).