Population Projections for Japan 2001-2050

With Long-Range Population Projections: 2051-2100

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I. Introduction

This report is a summary of twelfth round of the national population projections by the National Institute of Population and Social Security Research. These projections have been published periodically since the days of the former Institute of Population Problems. While the lst round of projections was based on the population levels from the 1995 National Census (the 1997 projections[1]), the projections contained in this report have been newly computed based on the results from the 2000 National Census, along with the vital statistics in the same year.[2]

This round of projections were made focusing on the annual population of Japan (the total population including non-Japanese residents) by age and sex for the 50-year period from 2001 through 2050. There are also additional long-range projections covering the period from 2051 to 2100.

The projection method used is the cohort-component method. In order to make population projections using this method, 5 components of data are required; (1) base population, (2) future fertility rate, (3) future survival rate, (4) future international migration numbers (rates), and (5) future sex ratio at birth. For this round projection, three variants have been assumed for the future trend of fertility rates. These are medium (in the long term the total fertility rate will shift to 1.39), high (shift to a total fertility of 1.63), and low (shift to a total fertility of 1.10) variant projections. For the other components, only one variant has been specified. Therefore, the population projection results in three variants , corresponding to the different assumptions for the medium, high and low-variants in fertility. In this report we focus on the medium variant estimate and introduce the main results of the new projection, while also outlining the concepts behind the selection of the various assumptions and the various assumed values for the new projections.

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[1] National Institute of Population and Social Security Research "Population Projections for Japan 1996 ~ 2050 : With long-range Population Projections: 2051-2100 (the 1997 projections)" January 1997

[2] These projections were made according to the methods and assumptions discussed at the 4 sessions of the Social Security Council Committee on Population held between August and December 2001, and were reported at the 5th session in January 2002.

For more detailed information regarding these meetings, refer to the Minutes and Materials for each meeting of the Social Security Council Committee on Population (available for viewing on the Ministry of Health Labor and Welfare Internet web site at http://www.mhlw.go.jp). The data reported by the Committee on Population is also posted on the National Institute of Population and Social Security Research web site (http://www.ipss.go.jp).

The reference materials on the projection results reported to the Council include, the National Institute of Population and Social Security Research " Population Projection for Japan" (Summary) (January 2002).

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II. Summary of Population Projections for Japan

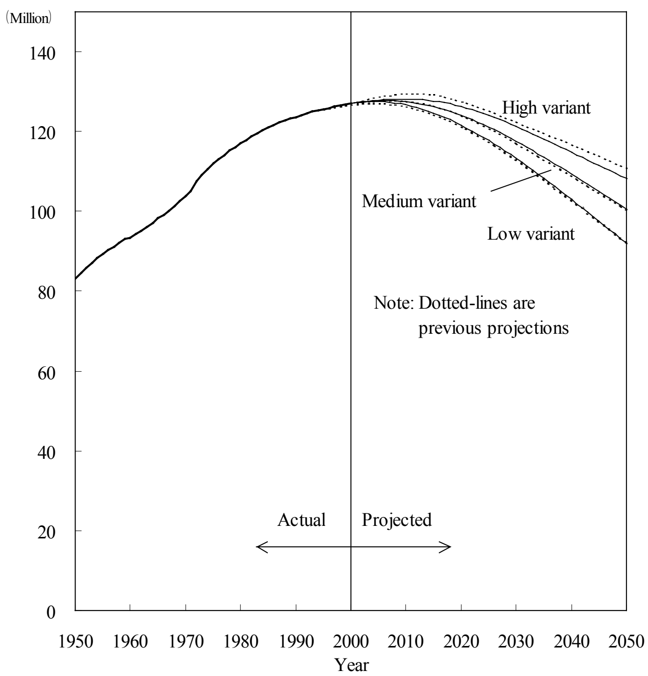
1. Overall Population Trends – The Era of Declining Population

According to the National Census in 2000, the base year for this round of projections, the total population in Japan was 126,930,000. Results based on the medium variant projection indicate that the total population will continue to increase gradually, reaching a peak of 127,740,000 in 2006, followed by a long period of population decline. The population is expected to return to today's levels by 2013, and continue decreasing to about 100,600,000 by 2050 (see Figure II-1).

Under the high variant projection, the peak total population of 128,150,000 will be reached in 2009, a little later than the medium variant projection. This is also expected to be followed by a downward turn, with the population dropping to 108,250,000 by 2050.

The low variant projection indicates that the population will peak in 2004 at 127,480,000, and then subsequently decrease to 92,030,000 by 2050.

Figure II-1 Actual and projected population in Japan, 1950-2050



These projections show that Japan is facing the beginning of an era of population decline, marking the end of the long upward trend in population. The fact that the fertility rate in Japan since the mid-70s has been well below the level needed to maintain a stable population (population replacement level, total fertility rate must be approximately 2.08) and the fact that low-fertility rates have been continuing for the past quarter-century make the population declines which will start early this century almost inevitable.

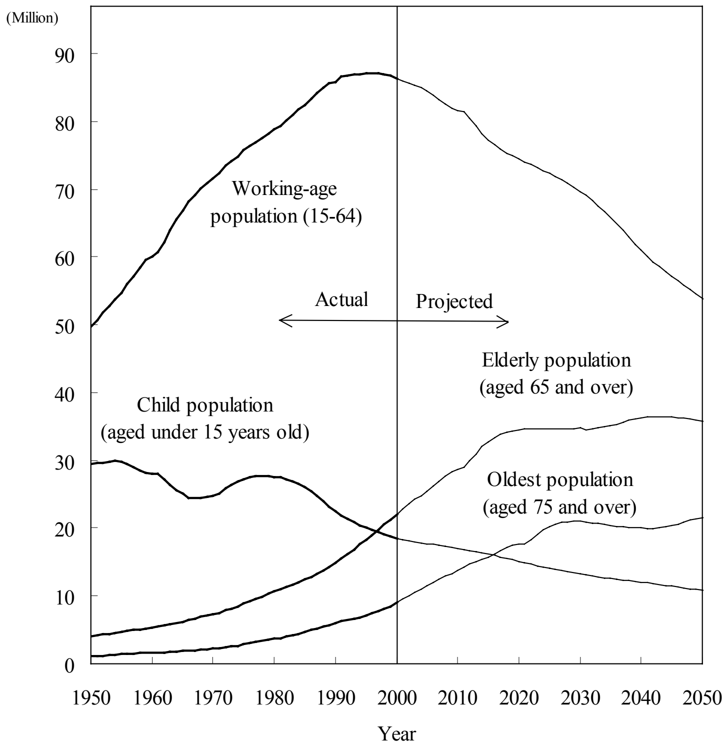
2. Child Population Trends – A Society with Few Children

The number of births has declined from 2.09 million in 1973 to 1.19 million in 2000. As a result, the population of children (age 0-14) has dropped from 27 million at the start of the 1980s to 18.51 million at the time of the 2000 National Census.

The medium variant projection indicates that the population of children will decrease to 17 million by 2003 (see Figure II-2). The decline will continue along with the low fertility rate, and the population of this age group is expected to fall below 16 million by 2016. The population of children in the final year of the projection, 2050, is expected to be 10.84 million.

The child population trends under the different assumptions of fertility rates show that the long-standing low fertility rates result in a decline in the number of children, even for the high variant projection. Under the high variant projection the child population will be about 14 million by 2050. Under the low variant projection, with an extremely low assumed fertility rate, a drastic drop in the child population is expected, whereby the current child population of 18 million will fall below 15 million by 2014, and eventually to 7.5 million by the middle of this century.

Figure II-2 Actual and projected population by major age group, 1950-2050: Medium Variant



The proportion of the child age group in the total population declines gradually, with less noticeable changes in the absolute numbers due to the concurrent decline of the total population over the same period. Under the medium variant projection the proportion will continue to decrease from the 14.6% in 2000, to below 14% in 2005, and to 12.9% by 2050. In comparison, under the low variant assumption the drop in the proportion of children is more rapid, falling below 14% in 2004, then below 10% in 2024, and 8.1% by 2050.

3. Working-age Population Trends – The Aging of the Working Population

The working-age population (age 15-64 years) consistently increased throughout the post-war years, reaching 87,170,000 in the 1995 National Census. Subsequently, there has been a decline, with a total of 86,380,000 working-age residents recorded in the 2000 National Census.

According to the medium variant projection, this age group reached its peak population in 1995and entered a decreasing phase. It is predicted that the total will fall below 70 million in 2030, continuing downward to 53.89 million in 2050 (see Figure II-2).

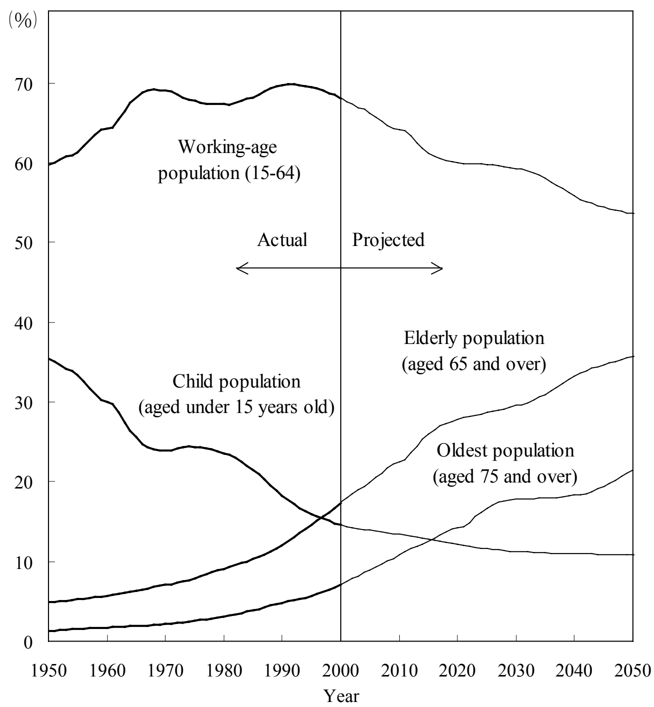
Let us consider the trends resulting from the differences in the estimated future fertility rates. For the high variant projection, the depopulation of the working-age group is rather slow, and the population is expected to fall below 70 million in 2033. The decrease continues down to 58.38 million in 2050. The working-age population based on the low variant projection is expected to fall below 70 million in 2028, below 50 million in 2049, and shrink to 48.68 million in 2050.

These figures show that there are differences in the degree and speed of the decrease in the working-age population, depending on the future fertility rate. However, under the current assumption of a continuing low fertility rate in the future, it is inevitable that the working-age population will tend to decline. These kinds of changes in the working-age population are likely to lead to decreases in the total labor force and the number of young workers and aging of the labor force.

4. Trends in the Elderly Population – An Advanced Age Society

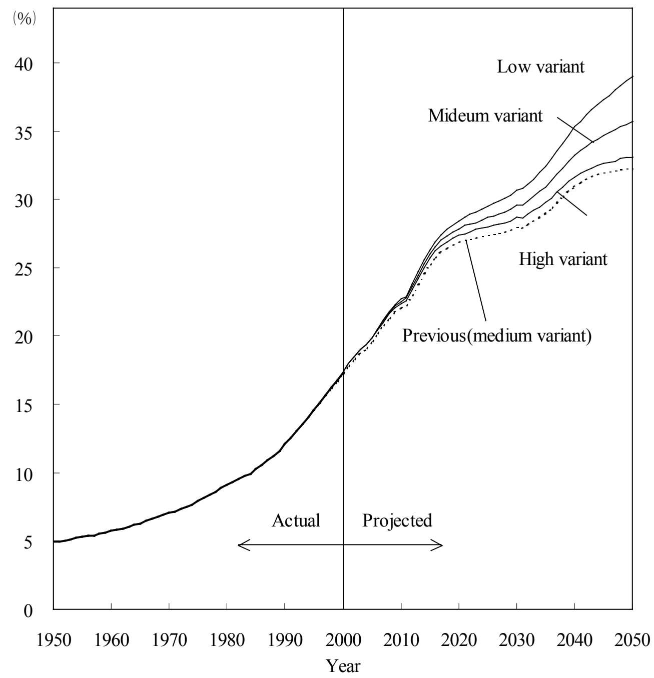
While, under the medium variant projection, the child population will continue to decline as will the working-age population, the elderly population (age 65 and over) will rapidly increase from the current level of 22 million to over 30 million in 2013 and to 34.17 million in 2018. In other words, the elderly population will continue to grow rapidly until the baby-boom generation (born between 1947 and 1949) is in the over-65 age bracket. Subsequently, the increase in the elderly population becomes slower as the generation from the reduced post-war fertility era enters this age group. The peak elderly population is expected to be reached in 2043 as the second baby-boom generation joins this age group. This is to be followed by a gradual decrease, arriving at an elderly population of 35.86 million in 2050. For the high and low variant projections, the results for the elderly population are identical to those from the medium projection, since the assumptions about future survival rates and international migration rates are the same.

Figure II-3 Percentage destribution of the population in major age group, 1950-2050: Medium Variant



The percentage of the total population that is elderly will increase from 17.4% in 2000 to about 25% in 2014, meaning that one out of every four people in Japan will be age 65 or older. This percentage will continue to rise, reaching 27.0% in 2017 (see Figure II-3). The elderly population will shift to a level of about 34 million people between 2018 and 2034, but the percentage of the total population will continue to increase due to the low fertility rate, exceeding 30% in 2033 and continuing upward to 35.7% in 2050. In other words, 1 out of every 2.8 people in Japan will be in the elderly age group.

Figure II-4 Percentage destribution of the population of the aged population, 1950-2050



The difference in the aging trend due to the different assumed future fertility rates as predicted under the high and low variant projections is fairly small until 2018. The difference is 1.5% in 2025 between the 29.5% under the low variant scenario and the 28% under the high variant scenario (see Figure II-4). This difference reveals the impact that future fertility rates have on the aging of society. This difference between the two scenarios continues to increase over time, with the high variant scenario leading to a projection of 33.1% in 2050, while the low variant scenario projects 39.0%, a difference of 5.9 points. This demonstrates how a low fertility rate continuing over a long period of time will advance the relative aging of society.

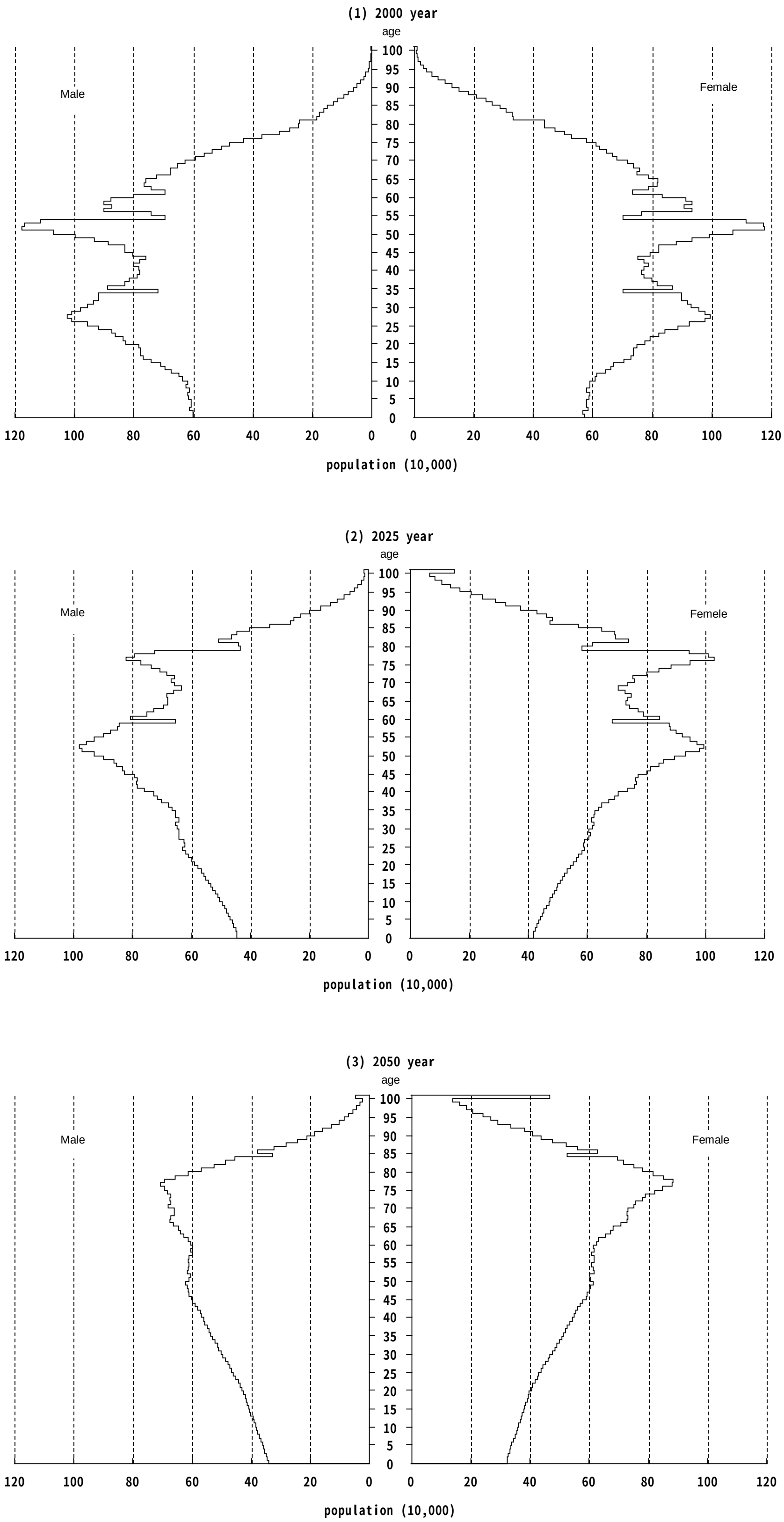
5. Changes in the Population Pyramid

The population pyramid for Japan continues to reflect the overall aging of the society, although it contains a jagged portion in the upper age groups that reflects the rapid variations in the fertility rate in the past (see Figure II-5). These include the sharp increase in the number of births between 1947 and 1949 (first baby boom) and the sudden drop in births between 1950 and 1957 (the "baby bust").

The population pyramid in 2000 has the first baby boom generation reaching their early 50s, and the second baby boom generation in their late 20s. By 2025 the first baby boomers will be in their late 70s, and the second baby boom generation will be reaching their early 50s. This makes it clear that the population aging up to 2025 will be primarily from the aging of the first baby boom generation. In comparison, the higher levels of elderly population in 2050 will be caused by a combination of the aging of the second baby boom generation and the contraction of the population in each generation due to the effects of the depressed fertility rate.

Hence, the population pyramid in Japan has shifted from its pre-war Mt. Fuji shape to its current temple bell shape and will continue to grow more top-heavy, becoming an urn shape in the future.

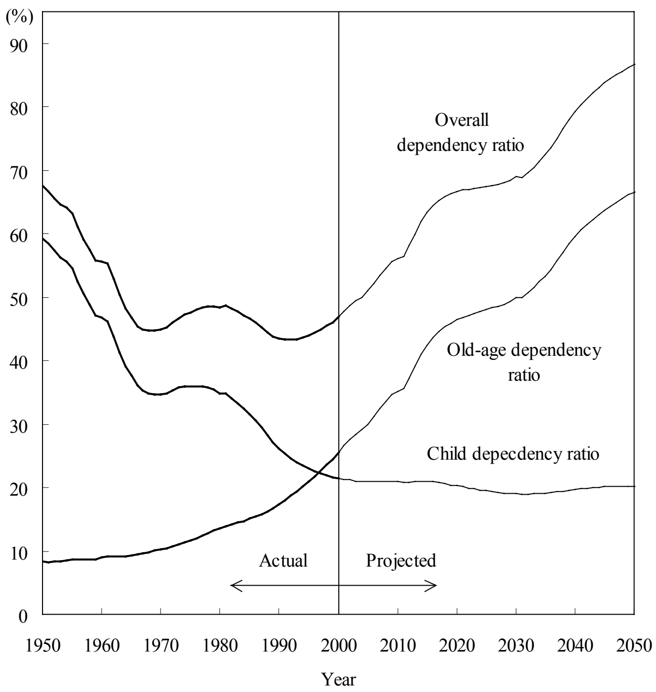
Figure II-5　Population pyramid: Medium variant



6. Population Dependency Ratio Trends

The population dependency ratio is used as an index to express the level of support from the working-age group, through comparison of the relative size of the child and elderly populations versus the working-age population. According to the medium variant projection, the elderly population dependency ratio (calculated by dividing the elderly population by the working-age population) is expected to rise from the current level of 26% (3.9 working-age people for each elderly person) to the 50% range in 2030 (2 workers for each senior citizen), continuing up to 67% (1.5 to 1) in 2050 (see Figure II-6). On the other hand, the child population dependency ratio (calculated by dividing the child population by the working-age population) is expected to shift from the current 21% (4.7 working-age people for each child) to a level between 19% and 21% in the future.

Figure II-6 Trends in age dependency: Medium Variant



Although the low variant scenario leads to a decrease in the population of children due to the low fertility rate, no large drop is expected in the child dependency ratio. This is because the working-age population that includes the parents of these children also declines.

The sum of the child dependency ratio and the elderly dependency ratio is called the population dependency ratio, which is an indicator of the total degree of burden on the working-age population. The overall population dependency ratio increases along with the increase in the elderly dependency ratio. As the working-age population contracts, the population dependency ratio is expected to rise from the current 47% to 67% in 2022, and to 87% in 2050.

7. Trends in Birth and Death Numbers and Rates

For the medium variant scenario, the crude death rate (mortality per thousand of population) continues to rise from 7.7‰ (per mil) in 2001, to 12.1‰ in 2020, reaching 16.2‰ in 2050 (see Figure II-7). The reason for the continuing increase in crude death rate in spite of the continuing increases in the life expectancy is the expected rapid aging of Japan's population means a rapid increase in the proportion of the elderly population, which has a high rate of mortality.

Figure II-7 Crude birth rate, crude death rate, and crude rate of natural increase: Medium Variant

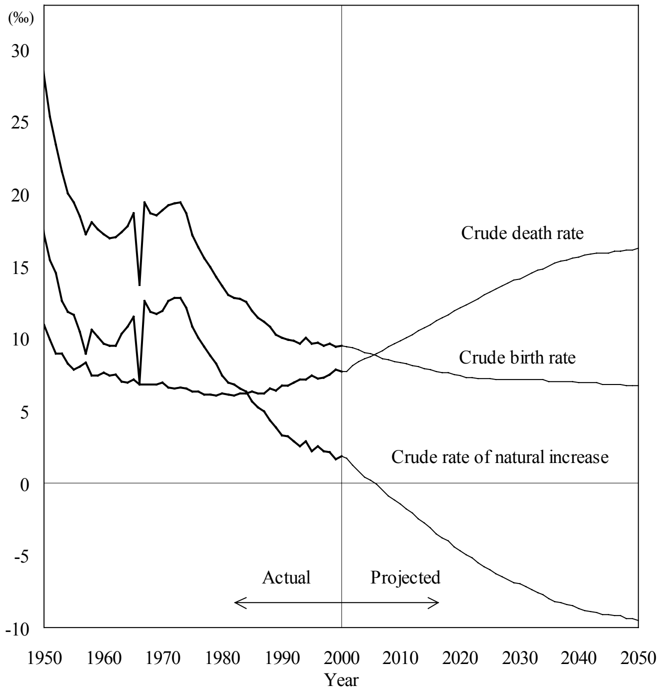
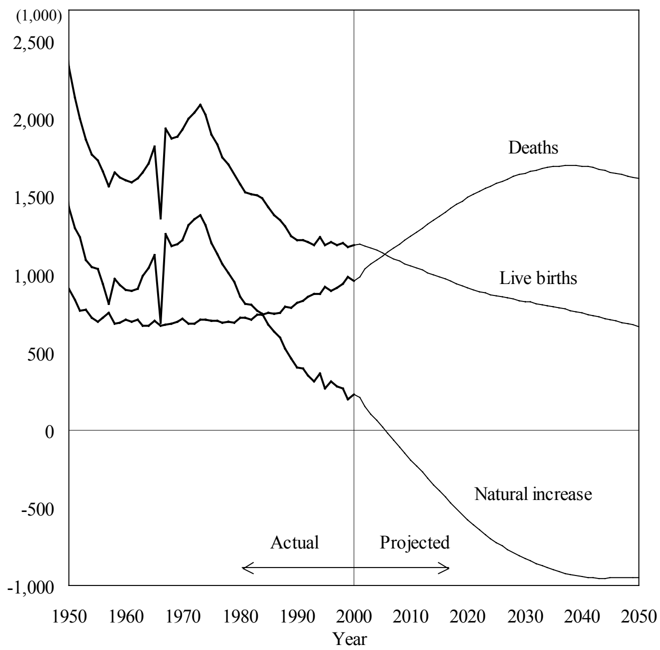


Figure II-8 Live births, deaths, and natural increase: Medium Variant



The crude fertility rate (births per thousand) is expected to decline from 9.4‰ in 2001 to 8.0‰ in 2013. The crude fertility rate will continue to decline in subsequent years to 7.0‰ in 2035 and 6.7‰ in 2050.

The crude rate of natural increase, which is the difference between the crude fertility rate and the crude death rate, is expected to remain positive for a while and was at 1.7% in 2001. In 2006, however, it is expected to become negative, eventually dropping to –9.5% in 2050.

According to this medium variant projection, it is expected that the number of annual births continue to decrease from the 1.19 million in 2001, falling below 1.1 million in 2008 and dropping below the million mark in 2014 to 670,000 in 2050 (see Figure II-8).

It is, on the other hand, expected that the number of deaths steadily increase from 980,000 in 2001 to 1.51 million in 2021, with peaking at 1.7 million in 2038. The subsequent annual numbers of deaths are expected to decrease slightly, reaching 1.62 million in 2050.

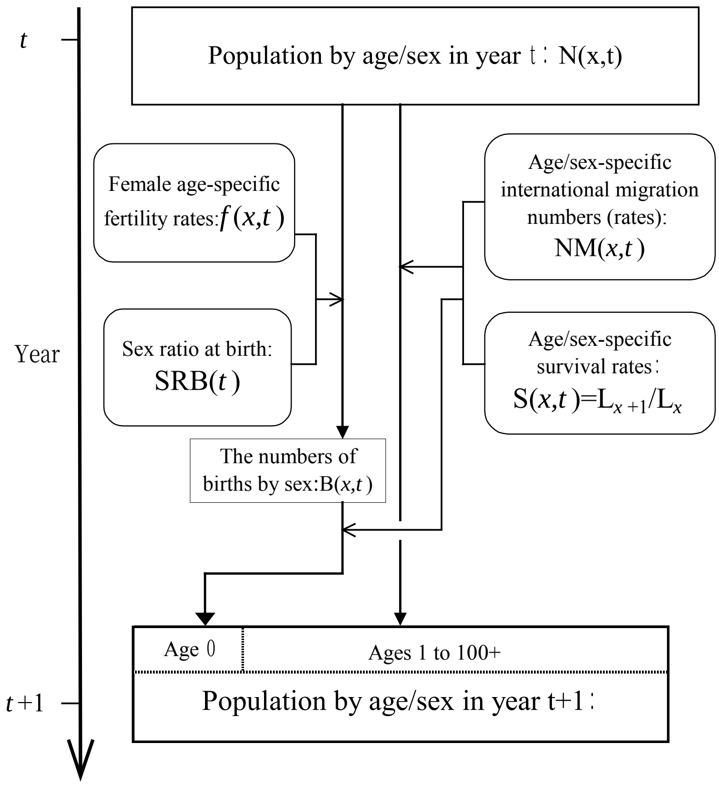
III. Projection Methodology and Assumptions

The future population size and age-sex distribution can be determined if the future number of deaths by age and sex, future births including sex ratio, and international migrations are all known. Therefore, the future population of Japan is projected by assuming values for the future mortality, fertility with sex ratio at birth, and international migration. The projection methodology and assumptions are described below.

1. Projection Method

The usual cohort component method has been used as the projection method. This method uses the population by age and sex in the base year as the starting point, to which the assumed survival rates by age and sex, international migration (rate) by age and sex, female fertility rates by age, and ratio of sexes at birth are applied to determine a future population. Figure III-1-1 shows the basic calculation procedure for the cohort component method.

Figure III-1-1 Procedures for projecting population



Let's consider the case of the calculation for the population in the next year (*t + 1*) based on the known population by age and sex in year *t*. First, the population aged one-year or more in year *t + 1* can be found by applying the corresponding survival and international migration rates to each age and sex classification in the population in year *t*. The number of new births of each sex is obtained by multiplying the number of women by their age-specific fertility rates, and applying the sex ratio at birth. The survival and international migration rates are then applied to determine the population by sex under age one in year *t+1*. The sum of these values is the projected population in year *t+1*.

Basically, the population that has reached each age of *x* years in the base year is multiplied by the assumed survival rate until age *x + 1*. This is then adjusted by the number (rate) of international migration of people for that age group. In this way the population as of October 1 the following year at age *x + 1* is determined (by sex and age for each whole year between 1 and 99, as well as for the "100 and over" group). For the population of those under 1 year of age, first the average population of reproductive-age women (15 - 49) in the base year and subsequent year is determined. The average population in each age group is multiplied by the age-specific fertility rate to obtain the number of births for that year. The numbers of male and female births are determined using the sex ratio at birth. Finally, by multiplying by the corresponding survival rates, and making the adjustments for international migration the population under age 1 year as of October 1 the following year is determined.

The future annual population projections by age and sex are made by repeating this procedure. Therefore, the data required for the cohort component method used for this projection are (1) base population by age and sex, (2) assumed age-specific fertility rates, (3) assumed age- and sex-specific survival rates, (4) assumed age- and sex-specific international migration numbers (rates), and (5) assumed sex ratio at birth.

2. Base Population

The base population that forms the starting point for the projection is the total population as of October 1, 2000 (including non-Japanese residents) classified by age and sex. This population is based on the age and sex-specific population data obtained from the 2000 National Census, with adjustments to include the "age unknown" population on the census. Therefore, there are slight differences between the numbers for the base population in each age group used for this projection and the official statistics reported by the National Census. This point should be kept in mind when making use of the projection values.

3. Fertility Rate Assumptions

When projecting a future population by means of the cohort component method, the number of live births for each future year is essential. Only the number of live births in each year is taken as the total number of infants borne by women of reproductive age (from 15 - 49 years) in that year. The number of births by females in each age group is calculated by multiplying the female population in each age group by the corresponding age-specific fertility rate. This section will explain the method for estimating the age-specific fertility rates for females.[3] However, fertility rate estimations are based on several assumptions about future trends in marriage and childbearing. For these assumptions to be accurate, we must understand the fertility trends in recent years in Japan. Therefore, let us begin with an overview of the recent fertility trends, and then consider the future prospects.

(1) Recent fertility trends

The Total Fertility Rate (TFR)[4] in Japan has declined each year since 1973, with a temporary increase between 1982 and 1984. In 1989 the TFR was 1.57, even lower than in 1966, which was an

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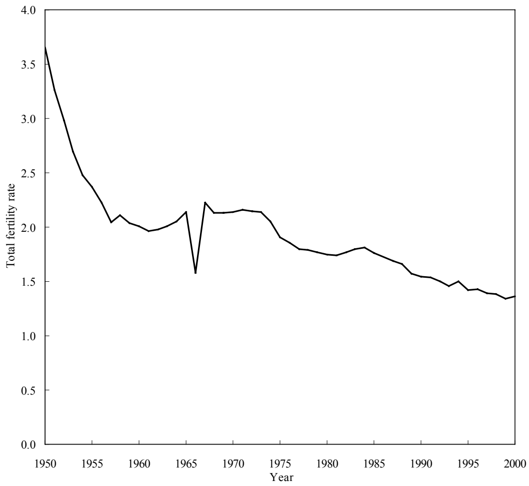
[3] The fertility rates used for the population projections are indices for the entire population, including non-Japanese residents (total population fertility rate). However, when setting the assumptions, since the official numbers from the past are only for Japanese citizens, it is made for Japanese fertility rates. The total population fertility rate calculation is discussed in section 5.

[4] Sum of female age-specific fertility rates observed in a certain calendar year. These fertility rates are equivalent to the average number of live births that are expected if the females remain fertile according to the given age-specific fertility rates of the year.

Figure III-3-1 The total fertility rate, 1950-2000

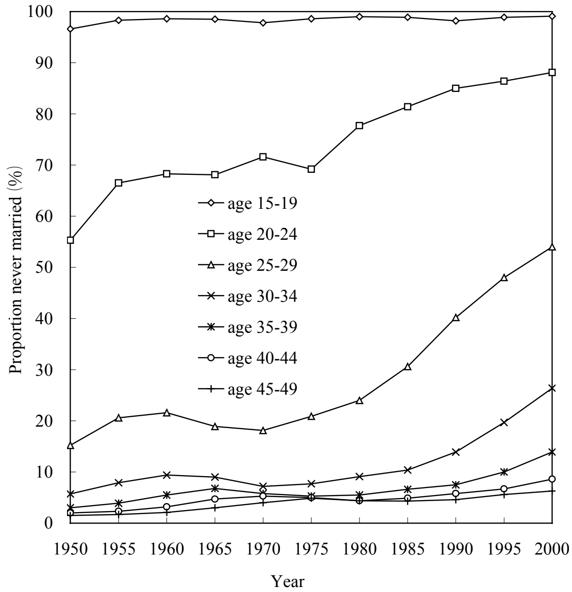


Source: Vital Statistics of Japan

inauspicious "Hinoeuma" year, and had previously had the lowest TFR since Japan began recording vital statistics. Since then, TFR has continued to sink, with some fluctuations, reaching 1.36 in 2000 (see Figure III-3-1).

In Japan there has been a sharp decline in the rate of marriage among the age groups in the main childbearing years. Since extra-marital childbearing is infrequent here[5], this drop in marriage rate can be considered the direct cause of the decline in fertility rates. Consider the group that has a large influence on TFR changes, women in their late 20s. In 1970, 80.3% of women in this group were married, but by 2000 this had dropped to 43.5%. The proportion of the widowed and the divorced can contribute to changes in the proportion married in general; in fact, the proportion of never married women soared from 18.1% in 1970 to 54.0% in 2000, while the percentage of the divorced or the widowed changed only from 1.5% to 2.5% over the same period, so it can be claimed that the sharp increase in the proportion never married is the cause of the drop in the proportion married (Refer to Figure III-3-2 regarding trends in the proportion never married). A primary factor in the increase in the proportion never married since the late 1970s is the large increase in the never-married population in their 20's, indicating a tendency to delay marriage, in other words, an increase in the mean age at first marriage. In the 1980s, however, since the proportion never married continued to show increases even among those in their 30's and older, it became more likely that there is a continuing trend of never marrying throughout life, that is, an increase in the proportion never married at age 50. This agrees with the observed trends in marriage in recent years, i.e., the increase of delayed marriage and never marrying tendencies.

Figure III-3-2 Population never married of women by age group, 1950-2000



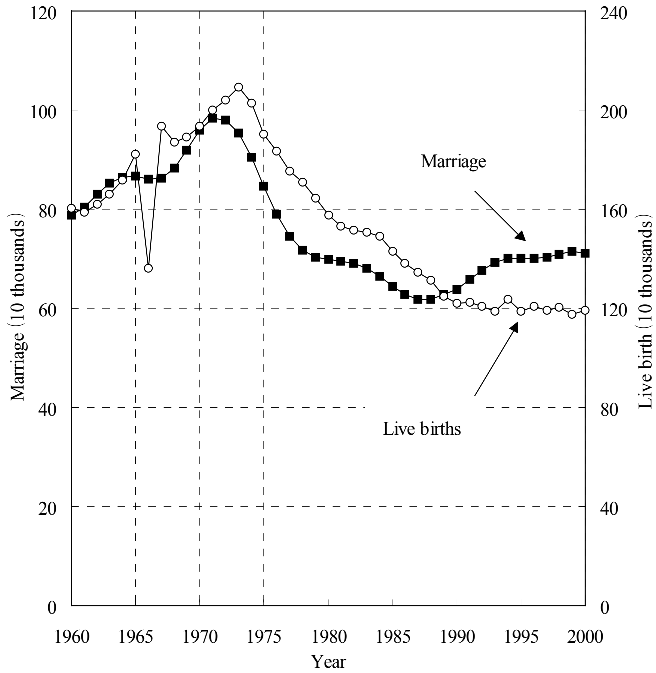
Souece : Census of Japan

Let us now consider the decrease in the number of children produced by a married couple along with the drop in the proportion married due to these marriage behavior trends as a cause of the decrease in the fertility rate. Figure III-3-3 shows the annual changes in the number of first

5 In 2000 only 1.6% of all births were extra-marital.

marriages overlapped with the annual changes in the number of live births. Up until the 1990s, the number of live births matched the trend in the number of first marriages, only delayed by a few years. During the 1990s, however, there was an increase in the number of first marriages, while the number of births continued to fall. This suggests that there have been some changes in the reproductive behavior of married couples since the mid 1980s. However, since the number of first marriages (rate) and the number of births (rate) for each year are affected by multiple generations with different behavior patterns, it is difficult to make quantitative interpretations of changes in the reproductive behavior of married couples based only on this overall movement. Therefore, we will derive the reproductive behavior of married couples for each generation (birth cohort), and attempt to verify the changes quantitatively below.

Figure III-3-3 The trends of the number of marriage and live birth

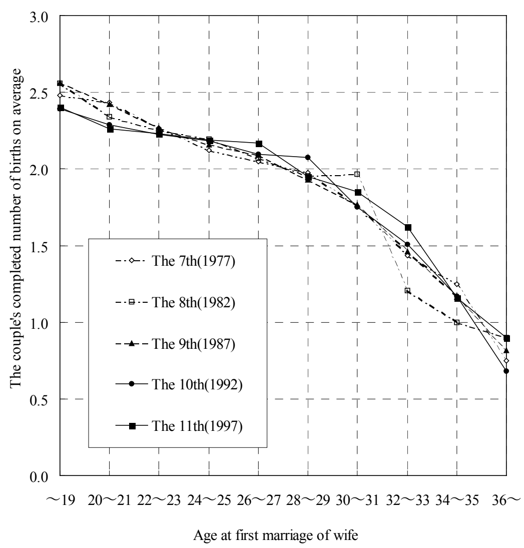


Source: Vital Statistics of Japan. As for the number of marriage, adjusted values considering "delayed notifications" and "January 2000 notification."

Here, the average number of children produced in a lifetime by a couple is called the couple's completed number of births. We can assume it is possible to obtain the completed number of births from two factors; the distribution of wives' ages at first marriage, and the typical number of completed births for a couple based on the age at first marriage. As long as the levels for the completed number births based on the age at first marriage are stable, the overall completed number of births for married couples can be changed only by the shift in the distribution of age at first marriage, similar to that caused by a trend of delayed marriage.

Figure III-3-4 shows the completed number of births by age of wife at first marriage taken from the past five National Fertility Surveys. From these results, it can be said that the relationship between age at first marriage and the completed number of births is stable, at least up to the latest cohort in the

Figure III-3-4 The completed number of births by age of wife at first marriage: The 7th through 11th national fertility survey



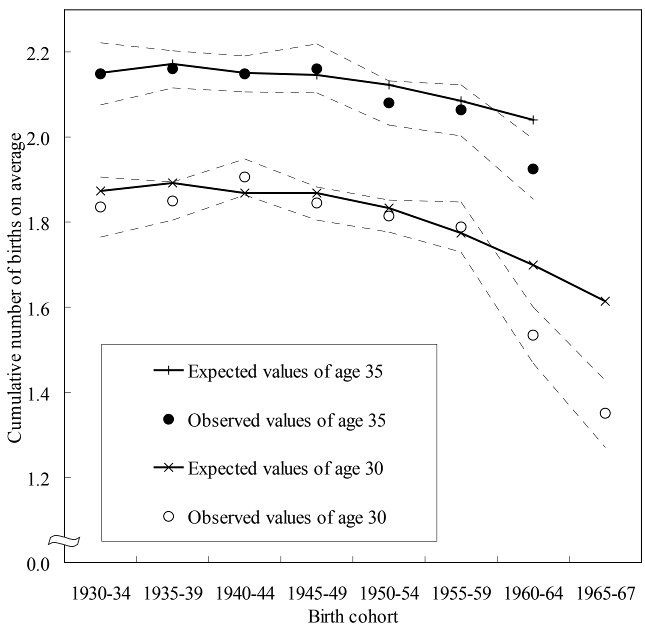
Note: For wives of first marriage couples aged 40-49 (for the 7th, wives aged 40-44).

graph (age 40 in 1997, namely the cohort born in the mid 1950's). If we can assume that this stable relationship is maintained in subsequent cohorts, then the completed number of births for the younger generations should vary only according to changes in the distribution of the age at first marriage, as has been the case in the past.

Will the relationship between age at first marriage and completed number of births actually be maintained among the younger generations? Let us calculate the expected values of the cumulative number of births by the younger generations, who are in the middle of the process of achieving their completed number of births, assuming that this stable relationship is continuing (calling this the expected cumulative number of births[6]), and compare this value to the actual observed cumulative number of births.

Figure III-3-5 shows the expected cumulative number of births at age 30 and 35 along with the average values and the 95% confidence interval for the actual observed cumulative births from the National Fertility Surveys. When we look at the results for the 35 years old, who in the 1997 data are the cohort born in the early 1960s, it is clear that the actual values are significantly lower than the expected value. This means that the total number of births by a couple is decreasing not only due to such structural changes as the delayed marriage, but also due to changes in the reproductive behavior of married couples. Since the cumulative number of births at age 35 can be considered fairly close to the completed number of births, for this cohort, there is an obvious drop in the completed number of births as a result of changes in reproductive behavior after marriage. Based on the similar observations at age 30, it is expected that the same kinds of changes will continue among married couples in subsequent younger generations.

Figure III-3-5 Expected and observed cumulative number of births at age 30 and 35: The 8th through 11th National Fertility Surveys



Note: Broken lines indicate the 95% confidence interval.

Changes in the reproductive behavior of married couples can also be confirmed from the trends in

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6 The expected births at age *x* for married females in the cohort born in year *t* is *EB(x,t)*; and is calculated with the following formula..

$$EB(x,t) = \int_{15}^{x} m_x(a,t)\, g_x(a)\, da$$

Where $m_x(a,t)$ is the proportion of age *x* married females in the cohort born in year *t* who were first married at age *a*, and $g_x(a)$ is the cumulative number of births at age *x* of married females who first married at age *a*, as modeled from the previous cohort.

cumulative births in each year of marriage. Table III-3-1 shows the cumulative number of births in the seventh year of marriage as well as the distribution of births. In order to exclude the effects of delayed marriage, the sample for this table was limited to couples in which the wife's age at first marriage was between 23 and 27 years. For the 1940's cohorts, the percentage of couples without any children after 7 years is roughly 4%, rising to 8.4% for the cohort born in 1960~1964. As a result, the cumulative number of births also dropped from 1.96 to 1.80.

Table III-3-1 Cumulative number of births in the seventh year of marriage: The 8th through 11th National Fertility Surveys

Wive's cohort	N	Mean age of first marriage	Cumulative number of births in the seventh year of marriage	Distribution(%)				
				None	1	2	3	4 or over
1935-39	950	24.5	1.86	3.9	20.2	63.2	11.7	1.1
1940-44	2,031	24.5	1.96	3.8	13.9	64.8	16.9	0.5
1945-49	3,346	24.4	1.93	4.4	14.8	65.0	15.2	0.6
1950-54	2,910	24.5	1.95	4.5	14.5	63.1	17.2	0.7
1955-59	1,755	24.5	1.88	7.4	14.5	61.1	16.6	0.4
1960-64	833	24.5	1.80	8.4	19.3	57.0	14.8	0.5

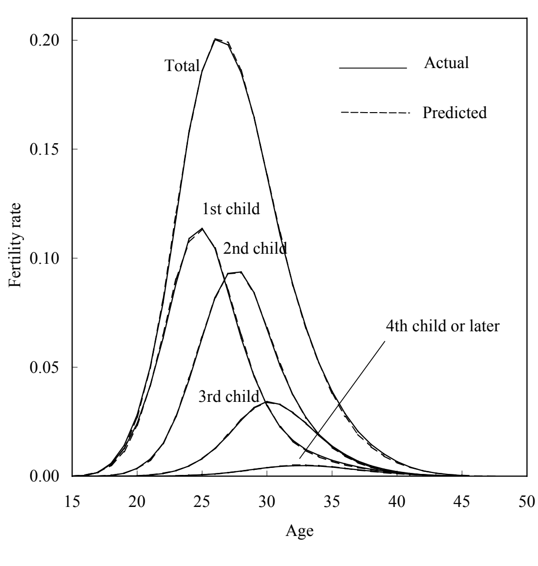
Note : For the first marriage couples in which the wife's age at marriage was between 23 and 27 years and the marital duration was 7 years or over.

Based on the investigation above, estimates of the future fertility rates cannot only assume delayed marriage and a trend to not marry, but must also take into account that there will be changes in the reproductive behavior of couples after marriage. The method for determining these future developments is discussed in III-3-(3). Before that, let us first consider how to obtain the future age-specific fertility rates if such assumptions are made.

(2) Age-specific fertility rate estimation method

Future age-specific fertility rates in each calendar year can be found by rearranging fertility rates for the corresponding female cohorts. Since the age-specific fertility rate at age x for a female in any given year is the age-specific fertility rate at age x for the female cohort born x years ago, the age-specific fertility rates covering all females of reproductive age (15 ~ 49) in that year can be obtained as a set of fertility rates for each age of the 35 cohorts born between 15 and 49 years ago. For this projection the age-specific fertility rates are estimated for each cohort, and then recombined to make the

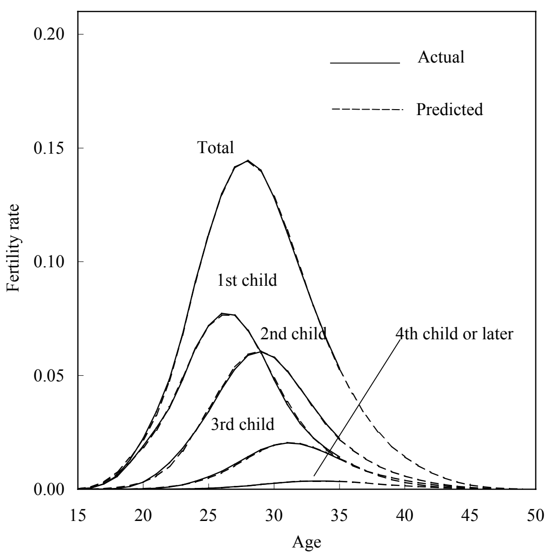
Figure III-3-6 Cohort age-specific fertility rates (actual and predicted values): Women born in 1955



age-specific fertility rates for each year (cohort fertility rate method). The reason for first estimating the cohort fertility rate is that the age patterns of fertility are generally more stable for the cohorts.

The age-specific fertility rates for a cohort are estimated using a suitable mathematical model with several parameters to represent the features of marriage and reproductive behaviors. Specifically, the fertility rates are estimated using a generalized log-gamma distribution model, with parameters such as the proportion never married at age 50 for the cohort, completed number of births, mean age at first marriage, and the mean age at birth for each birth order[7]. In this way we obtain a projection system that allows a representation of the basic patterns of change in the cohort fertility rate, including the most recent characteristics of reproductive behavior in Japan like delayed marriage, delayed childbearing, the anticipated future increase in the proportion of women who are never married at age 50, and the drop in the female completed number of births that reflects the drop in the number of children that couples have. Figure III-3-6～8 presents a comparison between the age-specific fertility rates for three

Figure III-3-7 Cohort age-specific fertility rates (actual and predicted values): Women born in 1965



[7] In this model, the fertility rate (f_n) for each birth order (n) is first given as a function of age (x). That is to say, the following expression is formed:

$$f_n(x) = C_n \cdot \gamma_n(x; u_n, b_n, \lambda_n)$$

Where

$$\gamma_n(x; u_n, b_n, \lambda_n) = \frac{|\lambda_n|}{b_n \Gamma(1/\lambda_n^2)} \left(\frac{1}{\lambda_n^2}\right)^{\lambda_n^{-2}} exp\left[\frac{1}{\lambda_n}\left(\frac{x-u_n}{b_n}\right) - \frac{1}{\lambda_n^2} exp\left\{\lambda_n\left(\frac{x-u_n}{b_n}\right)\right\}\right]$$

Γ and *exp* are a gamma function and an exponential function, respectively. C_n, u_n, b_n, and λ_n are parameters of each birth order (n). This formula is an extended version of the expression known as the Coale-McNeill Model, which is one type of generalized logarithm gamma distribution formula.

The birth order consists of four groups, the 1st through the 3rd child, and the 4th child or later. However, the method itself places limits on the reproducibility of actual age-specific fertility rates by age. Therefore, using error analysis with actual results of fertility rates in Japan, we have made some modifications by extracting a standard error pattern ($\varepsilon_n(x)$).

As a result, the ($f(x)$) fertility rate function by age of cohort can be calculated from the following expression:

$$f(x) = \sum_{n=1}^{4} C_n \cdot \left\{\gamma_n(x; u_n, b_n, \lambda_n) + \varepsilon_n\left(\frac{x-u_n}{b_n}\right)\right\}$$

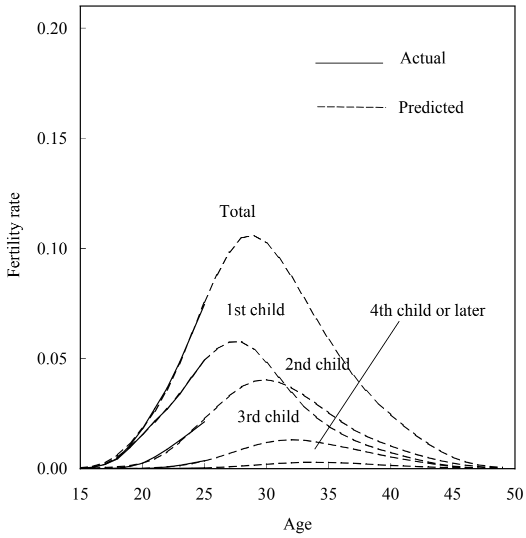
For more details, see the following reference: Ryuichi Kaneko, " A Projection System for Future Age-Specific Fertility Rates(in Japanese with English summary)", *Jinko Mondai Kenkyu（Journal of Population Problems）*, No.1, Volume 49, April 1993, pp.17-38.

cohorts simulated with this model and the actual values.[8]

The fertility rates are simulated according to birth orders (from 1st child to 4th child or later), and the sum is used to obtain the age-specific fertility rates. By using actual values available as of 2000, actual fertility rates for women up to age 45, age 35, and age 25, respectively, can be obtained for (a) the cohort born in 1955, (b) the cohort born in 1965, and (c) the cohort born in 1975.

For group (a), it is likely that fertility will have almost been completed, so the period remaining for the projection is rather short. Group (b), on the other hand, is now in the midst of their reproductive phase. Since the overall fitness of the model is considered to be quite good, and considering the general stability of age patterns of fertility, it is likely that future fertility rates (for subjects 36 years old or older) will not divert much from the predicted values of the model.

Figure III-3-8 Cohort age-specific fertility rates (actual and predicted values): Women born in 1975



For the (c) cohort, it is impossible to determine whether the model across the entire age range is good or bad from the fitness between the model and actual results so far. In fact, in cases (a) and (b), it is possible to identify model values (parameter values) using a formal statistics technique (maximum likelihood estimation method), and obtain relatively stable results. Applying the same method to the (c) group yields unstable results, and it is difficult to even specify a unique result. Obviously, this tendency is even more noticeable for younger cohorts who have experienced a shorter period of fertility. In order to estimate future fertility rates for these young cohorts, it is necessary to apply some external assumptions in order to compensate for the instability. In addition, for cohorts whose members are not even yet 15 years of age, it is impossible to determine future fertility rates using statistical methods because there are no actual fertility rate values. Consequently, for these younger (and still unborn) cohorts, assumptions have been made about the overall future fertility process. The method of specifying these assumptions is discussed in section III-3-(3).

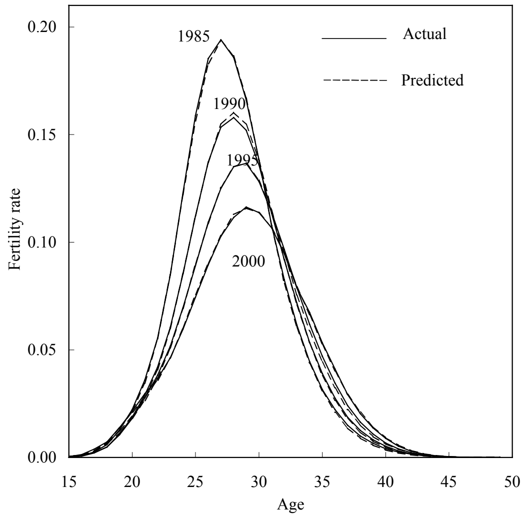
If age-specific fertility rates for a series of cohorts are estimated by the aforementioned methods, age-specific fertility rates for each calendar year can be obtained by rearranging them according to age. For example, the fertility rate for ages 15 to 49 in year 2000 can be obtained by combining the fertility rate for the cohort of 15-year olds born in 1985, the fertility rate for the cohort of 16-year olds born in

[8] The actual values of fertility rates used in the model estimation differ slightly from those released in the official vital statistics. For this model the total number of births between January and December was divided by the population on July 1, while the official statistics used the population on October 1 as the denominator. As a result of the annual adjustment of the age-specific fertility rate, coincidental variation and the inconsistencies in the denominators for the cohorts born in the Hinoeuma year (1996) were adjusted. Between 1966 and 1999 the populations used for the denominators were determined using backward projections based on the 2000 National Census data.

1984, and so on up to the fertility rate for the cohort of 49-year olds born in 1951.[9] Figure III-3-9 shows a comparison between the actual age-specific fertility rates for each year and those obtained with the model.

This then is the overview of the method for estimating the age-specific fertility rates. This method, however, assumes that the future values (hypothetical values) for the parameters used for the cohort are suitable. The following section will explain how the hypothetical values for these parameters were determined.

Figure III-3-9 Period age-specific fertility rates (actual and predicted values): 1985,1990,1995,2000



(3) Long-term assumption of fertility for cohorts

1) Method of establishing assumptions

The fertility rate for a cohort is basically determined by the reproductive behavior of married females, which is affected by the distribution of age at first marriage for each birth cohort. In order to estimate the fertility level that is eventually achieved, in other words, the long-term Total Fertility Rate for the cohort, it is necessary to estimate the age-specific first marriage rate and a couple's completed number of births by age of wife at first marriage for the target cohort. As mentioned previously, there is a need to anticipate the progress of trends in delayed marriage and fewer marriages with regard to the estimates of the first marriage behavior, while also considering the new decreasing trend in births by couples for the estimate of the completed number of births.

Using these factors, the TFR for a cohort in the long-term assumption can be calculated from the following expression.

Table III-3-2 The Equation for the Cohort TFR

Cohort TFR	=	(1-Proportion never married)	×	Completed number of births par married couple			×	Adjustment for divorce/death
	=	(1-Proportion never married)	×	{ Expected births	×	Coefficient of marital fertility decline }	×	Adjustment for divorce/death

Note: The Proportion never married is the proportion of those who have not married by the age of 50, and is calculated by subtracting the cumulative value of the age-specific first-marriage rates (total rate of first marriage) from 1. The completed number of births is the average number of children born by married females at age 50. Adjustment for divorce/death is an adjustment for the effects of divorce, death and extra-marital childbearing, and is estimated from the completed number of births based on the National Fertility Surveys and the TFRs of past cohorts.

The adjustment for divorce/death is an adjustment factor for the effects of divorce, death of spouse and extra-marital childbearing. The coefficient of marital fertility decline is an adjustment factor for

[9] Technically speaking, age-specific fertility rates of the population under age x in year t include two cohorts, those who are born in year (t – x) and those born in year (t – x – 1).

the decrease in the completed number of births that is accompanying the previously discussed changes in reproductive behavior of married couples.

This yields the following expression.

$$CTFR(t) = (1 - PS_{50}(t)) \cdot CEB_{\beta}(t) \cdot w(t)$$
$$= (1 - PS_{50}(t)) \cdot (CEB_{\alpha}(t) \cdot k(t)) \cdot w(t)$$

For the cohort born in year *t*, *CTFR(t)* is the Cohort Total Fertility Rate, $PS_{50}(t)$ is the proportion never married, $CEB_{\beta}(t)$ is the completed number of births, and $w(t)$ is the coefficient of divorce/death. $CEB_{\alpha}(t)$ is the expected births based on the distribution of age at first marriage and the couple's completed number of births by age of wife at first marriage for the cohort, which is compensated using $k(t)$,the coefficient of marital fertility decline.

2) Target cohort

The cohort of females used for setting the estimates is comprised of those who were 15 years of age as of 2000, that is, born in 1985. The reason this cohort was selected as the target cohort is that the marriage and reproductive behavior of this cohort will be completed at age 50, which will be 2035, allowing for estimations of fertility rates over a long term. At the same time, the cohort of 15-year-old females should exhibit behaviors that do not deviate too greatly from the extensions of recent changes in marriage and reproductive behaviors. However, the changes in marriage and reproductive behaviors that become noticeable among women in their 30s are also underway among those in their 20's, so there is a high probability that this kind of change will continue in the cohorts born after 1985. Accordingly, we assumed that the forces of change did not completely halt in 1985 when the target cohort was born, and cohort fertility rates have been projected to converge on the cohort born in 2000. This year 2000 cohort is called the ultimate cohort. The cohorts born in 2001 and later are generations that were not born as of 2000. It would be difficult to predict the changes in marriage and birth behavior for these females based on the current changes in marriage behavior. Therefore, for these projections, for cohorts born in 2001 and later, the fertility rates will be fixed to the 2000 levels.

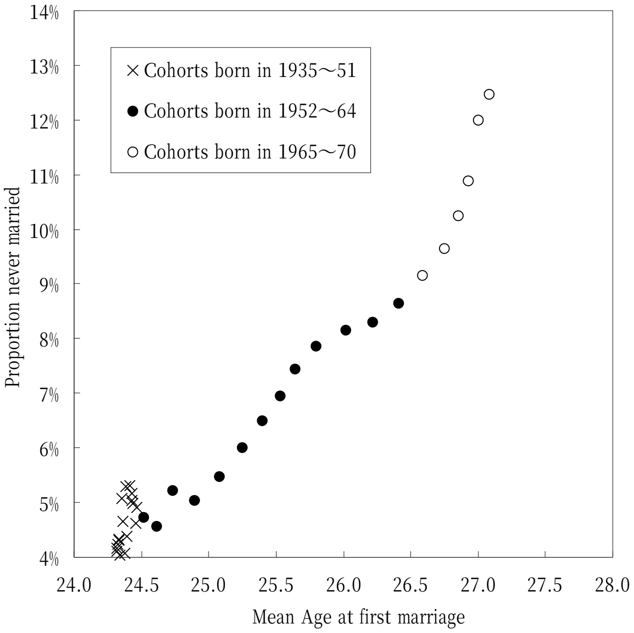
3) Estimating the proportion never married and the mean age at first marriage for the target cohort.

Before estimating the first marriage rates of the target cohort (cohort born in 1985), the age-specific first marriage rates for each birth cohort of females born in and after 1935 were calculated.[10]

Next, based on the first marriage rates for these cohorts, the mean age at first marriage and the proportion never married was estimated for each cohort. When making the projections, it is naturally possible that there will be a first marriage at a later age for members of cohorts that have not yet

[10] Since there is a delay in official registration of marriages in the number of first marriages obtained from vital statistics, we account for this delay in registration when calculating the age-specific first-marriage rates. The concentration of official registrations in January 2000 is considered a transient effect, and the first-marriage rate for 1999 and 2000 was modified by adjustment of the number of first marriages in December 1999 and January 2000.

Figure III-3-10 Mean age at first marriage and proportion never married for cohorts born in 1935 or later

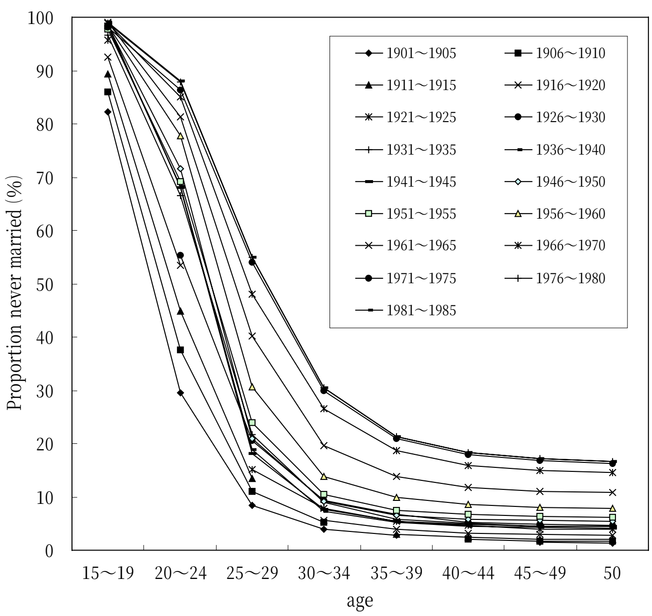


completed their marriage behavior, for example the cohort born in 1965, at age 35 in 2000. For these birth cohorts the first-marriage rate distribution for those age 35 years or older was estimated using a generalized log-gamma distribution model. The relationship between the mean age at first marriage and the proportion never married, for each cohort born from 1935 to 1965, is shown in Figure III-3-10

The points indicated by × in the figure are the mean age at first marriage and proportion never married for those born between 1935 and 1951. These show a stable pattern of nearly universal marriage at a young age, with a mean age at first marriage of about 24 and proportion never married of about 5%. The ● marks indicate the points for the cohorts born between 1952 and 1964. These cohorts show a gradual rise in both the mean age at first marriage and the proportion never married. The values for the cohorts born between 1965 and 1970, indicated by the ○ marks, show the same increasing tendency, but there is a change in the relationship between the two, with the proportion never married increasing at a more rapid rate. The future results for mean age at first marriage and the proportion never married for the cohort born in 1985 are expected to be along the extension of the line of the trends of changes displayed by the cohorts born between 1965 and 1970.

Assuming that the age-specific fertility rates for the target cohort (born in 1985) are an extension of past changes, it is then necessary to concretely specify either the mean age at first marriage or the proportion of permanently single. Here, the proportion never married is obtained from projections based on national vital statistics. That is, the rate of change in the never-married rate for each 5 year age grouping both nationally and by prefecture over the past 5 years (1995 to 2000) is extended to project the future proportion never-married at age 50 (cohort rate of change method). The proportion of

Figure III-3-11 Estimation of proportion never married of female by age group and birth cohort

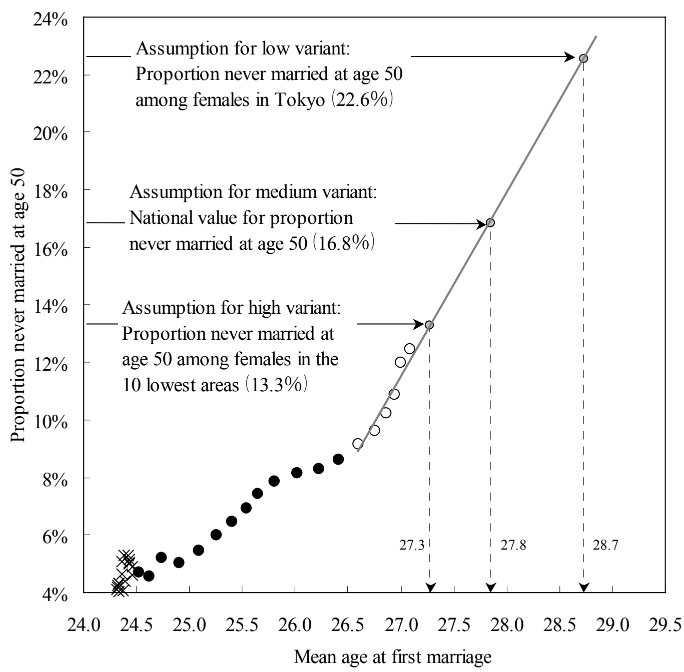


permanently single is taken as the average of the rates for the 45 ~ 49 year old group and the 50 ~ 54 year old group (see Figure III-3-11).

Since there are large uncertainties in the factors related to the trends for the mean age at first marriage and proportion of permanently single, three variants for the assumptions have been made, a medium, high, and low variant. First, the national value of 16.8% for the 1985 cohort[11] is adopted as the proportion never married at age 50 for the medium variant. The mean age at first marriage is obtained as 27.8 from the relationship between the proportion never married at age 50 and the mean age at first marriage for cohorts born since 1965.

For the low variant projection, it is assumed that there will be the greatest progress in delayed marriage and increases in the proportion never married. Among socioeconomic groups in modern Japan, the group with the highest mean age at first marriage is the female population of Tokyo. Assuming that the target cohort adopts the same marriage behavior as this group, this yields a proportion never married of 22.6%. For the mean age at first marriage, using the relationship between the proportion never married and the mean age at first marriage in the same way as for the medium variant, the value for the low variant is 28.7 years. For the high variant projection, the estimates are made based on the assumption that the changes in marriage behavior in the future will not progress to any great degree. For this case, the average of the 10 lowest values is used, yielding a proportion never married of 13.3%, leading to a mean age at first marriage of 27.3 years (Figure II-3-12).

Figure III-3-12 Mean age at first marriage and proportion never married for a cohort born in 1985



1) Yamagata, Fukushima, Ibaragi, Tochigi, Gunma, Fukui, Yamanashi, Gifu, Mie, Shiga

4) Calculation of expected completed births for the target cohort

Using the mean age at first marriage assumed for each of the medium, high and low variants, the expected completed births for married couples was calculated for the target cohort as described below.

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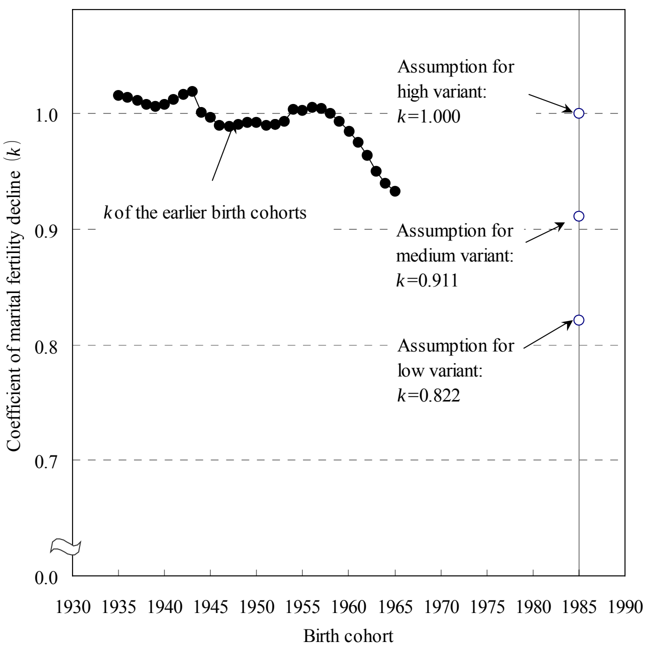
[11] The proportion never married for the cohort born in 1985 was estimated using the following expression with the proportion never married at age 50 for the 1976~1980 cohort and the 1981~1985 cohort.

$$ {}^{i}PS_{50}^{1985} \cong {}^{i}PS_{50}^{1981-85} \cdot exp\left(r \cdot (1985-1983.5)\right), \quad r = \frac{1}{5} \cdot ln\left\{ \frac{{}^{i}PS_{50}^{1981-85}}{{}^{i}PS_{50}^{1976-80}} \right\} $$

First, the average completed births according to age at first marriage obtained from the data from the National Fertility Surveys is used to generate a model by birth order, and a lifetime birth probability by age at first marriage and birth order is determined. Then, this probability and the previously projected distribution of ages at first marriage are used to determine the total completed number of births by married females in the target cohort.[12] With this method the expected births for the distribution of ages at first marriage for the target cohort, $CEB_{\alpha}(1985)$, is found to be 1.89 for the medium variant, 1.93 for the high variant, and 1.81 for the low variant.

5) Setting the coefficient of effect of divorce/death and the coefficient of marital fertility for the target cohort

Figure III-3-13 Coefficient of marital fertility decline of the earlier birth cohorts and a target cohort



After setting the fertility rates for the target cohort using the previously-discussed cohort total fertility rate formula, the remaining factors are the coefficient of effect of divorce/death and the coefficient of marital fertility. For the coefficient of effect of divorce/death, $w(1985)$, since the past values obtained from the Basic Fertility Surveys and vital statistics are stable across cohorts, the average value of 0.971 is used.

The coefficient of marital fertility $k(1985)$ is estimated as follows. First, a generalized log-gamma distribution model is used with various specified levels for $k(1985)$ to estimate the age-specific cohort fertility rates up through the cohort born in 2000. Next, the TFR for each calendar year from 1996 to 2003 is calculated by combining these cohort fertility rates. The $k(1985)$ with the smallest residual sum of squares between the model values and the actual values[13] is considered to be the most probable. In this way, a value of 0.911 was obtained. This was used as the coefficient of marital fertility decline for the medium variant (Figure III-3-13).

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[12] The expected number of completed births for the cohort born in 1985, $CEB_{\alpha}(1985)$, is found with the following expression.

$$CEB_{\alpha}(1985)=\sum_{n=1}^{4}\int_{15}^{50} m(a,1985)g_n(a)da$$

Where $m(a,1985)$ is the proportion of females in the cohort born in 1985 married by age 50 who first married at age a, and $g_n(a)$ is the lifetime probability of a women who first married at age a bearing an *nth* child.

[13] The actual values for 2001 are based on the predicted yearly number of births. For 2002 and 2003 the values used were obtained from an ARMA(2,1) model estimated using monthly data on fertility rates since July 1989.

The coefficient of marital fertility decline for the high variant is obtained by assuming that *k* for the cohort born in 1985 will return to a level of 1.00. In comparison, for the low variant, in consideration of the rapid decline in marital fertility since the 1965 cohort, it is assumed that *k* will be equal to the level for the medium variant minus the difference between the high variant and the medium variant, that is reaching a level of 0.822. Since the estimated completed number of births obtained from the distribution of age at first marriage is 1.89 for the medium variant, 1.93 for the high variant, and 1.81 for the low variant (III-3-(3)-4)), each of these values is multiplied by the corresponding value of *k* to obtain the completed number of births by a married couple of 1.72 under the medium variant, 1.93 under the high variant, and 1.49 under the low variant.

6) Estimates of the target cohort fertility rates

From the proportion never married, mean age at first marriage, expected number of births by a couple, and adjustment for divorce/death estimated for the target cohort, using the previously derived expression to calculate the total fertility rate for the target cohort leads to a value of 1.39 for the medium variant, 1.62 for the high variant, and 1.12 for the low variant. Tables III-3-3 and III-3-4 summarize the assumed values for each of the factors for the target cohort and the total fertility rates.

Table III-3-3 Assumed values for nuptiality and fertility as well as total fertility rates for female cohort born in 1985

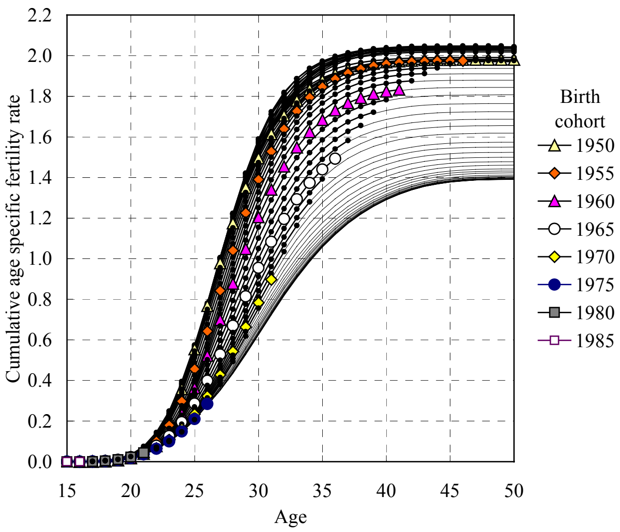
Assumptions	Proportion never married (%)	Mean age at first marriage	Completed number of births par married couple			Adjustment for divorce/death	Cohort TFR
				Expected births	Coefficient of marital fertility decline		
Medium	16.8	27.8	1.72	1.89	0.911	0.971	1.39
High	13.3	27.3	1.93	1.93	1.000	0.971	1.62
Low	22.6	28.7	1.49	1.81	0.822	0.971	1.12

Table III-3-4 Assumed total fertility rates and distribution of live births for female cohort born in 1985

Assumptions	Cohort TFR	Distrubution of live births (%)				
		None	1	2	3	4 or more
Medium	1.39	31.2	18.5	33.9	12.9	3.5
High	1.62	21.1	20.1	38.6	15.5	4.7
Low	1.12	42.0	17.5	29.1	9.3	2.1

After setting the cohort TFR for the target cohort, the target cohort TFR was decomposed into cohort TFRs by birth order according to the distribution of live births estimated beforehand. Under the restrictions of being able to reproduce the mean and deviation of age at childbirth for the given year, the parameters for a generalized log-gamma model were determined so that there was no contradiction with the trends in parameters of first marriage rate and in that of preceding cohorts. If the parameters can be determined, the generalized log-gamma model can be used to predict the future values of the age-specific fertility rates by order of birth. Figure III-3-14 shows the cumulative fertility rates for each cohort predicted under the medium variant assumptions. The various indicators related to the cohort fertility rates and first marriage rates estimated using the generalized log-gamma distribution model are listed in Table III-3-5.

Figure III-3-14 Actual and predicted values for cumulative age specific fertility rates: Medium variant



Note : Markers represent actual values.

Table III-3-5 Vrious indicators related to the cohort fertility rates and first marriage rates

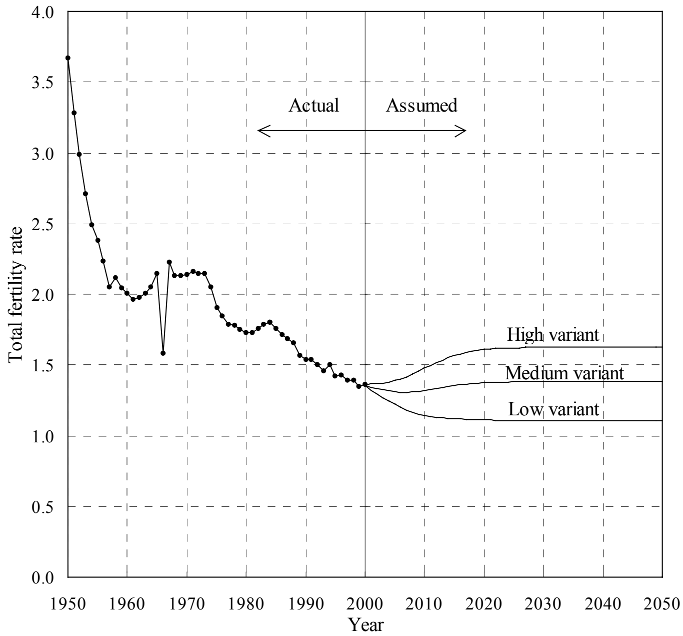
Cohort indices		Birth cohort										
		1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Proportion never married		5.0	5.0	7.4	9.2	12.5	15.8	16.6	16.8	16.9	17.0	17.0
Mean age at first marriage		24.4	24.9	25.6	26.6	27.1	27.6	27.8	27.8	27.9	27.9	27.9
Cohort TFR		1.98	1.97	1.84	1.65	1.50	1.42	1.40	1.39	1.39	1.39	1.39
Distribution	None	10.0	12.3	16.4	21.9	27.7	29.9	31.0	31.2	31.2	31.3	31.3
	1	12.4	11.7	13.6	15.6	15.8	18.1	18.4	18.5	18.6	18.6	18.7
	2	52.1	47.4	44.1	41.9	38.9	35.3	34.2	33.9	33.8	33.7	33.7
	3	21.0	23.4	21.1	16.4	13.8	13.0	12.9	12.9	12.9	12.9	12.9
	4 or more	4.5	5.1	4.8	4.2	3.8	3.6	3.5	3.5	3.5	3.5	3.5
Mean age at childbirth	All	27.6	28.1	28.7	29.5	30.1	30.7	30.9	31.0	31.0	31.0	31.1
	1st	25.7	26.3	27.0	27.8	28.4	29.0	29.2	29.2	29.3	29.3	29.3
	2nd	28.3	28.7	29.3	30.3	31.1	31.7	32.0	32.1	32.2	32.3	32.3
	3rd	30.8	31.2	31.6	32.3	33.1	33.7	33.9	33.9	33.9	33.9	33.9
	4th and more	33.1	33.6	34.1	34.7	35.1	35.3	35.4	35.4	35.4	35.4	35.4

Note : Figures are based on the values predicted by the generalized log-gamma distribution model.

(4) Assumed Annual Fertility Rate

If the age-specific cohort fertility rates are projected based on the three sets of assumptions for the high, medium and low variants, it is possible to calculate the total fertility rate for a future period by making combinations of these cohort fertility rates. The year to year transitions are shown in Figure III-3-15. According to the projections based on the medium variant assumptions there will be a decrease from 1.36 in 2000 to 1.31 in 2007, followed by an increase to 1.39 in 2049. Under the high variant assumptions the TFR will immediately begin to rise from the 2000 level of 1.36, reaching 1.63 in 2049. The projections based on the low variant assumptions indicate that there will continue to be a drop from the 2000 level of 1.36 down to 1.10 in 2049.

Figure III-3-15 Actual and assumed total fertility rates, 1950-2050



4. Survival Rate Assumptions (Future Life Table)

(1) Methods of Estimating Survival Rates

In order to project a population for the following year using the cohort component method it is necessary to know the survival rates; meaning that future life tables must be generated from assumed future mortality rates. There are three main types of methods for assuming future mortality rates; the empirical method, the mathematical method, and the relational model method.

The empirical method makes use of the age-specific death rates that have been experienced in existing populations. An example of this is a "model life table" generated by classifying actual life tables with relatively high accuracy into similar groups, to estimate and also to project the life expectancy in developing countries where population statistics, including mortality data, are unreliable. The model life table method is still used to estimate the life tables in countries and regions that do not yet have adequately prepared population statistics.

In case of the population with the highest life expectancy at birth in the world, as is true in modern Japan, the problem with the empirical method is that populations as reference for the empirical values are limited. One way to get around this problem is the "best life table", which is a single life table composed by combining the lowest age-specific death rates achieved among several populations. Because these "best life tables" use age-specific death rates that are low but have already actually achieved in the real world, the future life tables are at levels that are likely to be achieved and are entirely realistic. To apply these best life tables to construct future life tables for Japan, it is necessary to come up with some innovation, e.g., combining the lowest age-specific death rates by the administrative areas of Japan, or combining the lowest age-specific death rates from the life tables of various countries throughout the world. For example, the "best life table" constructed using the life table classified by the administrative areas of Japan in 1995 shows the life expectancies of 79.27 years for males and 86.19 years for females. However, for any life table constructed by this method, the timing has to be specified when the life table that contains specific mortality rates will be achieved by the population of interest in the future.

For the mathematical method, the future mortality rates are estimated by fitting and extrapolating mathematical functions to the past mortality trends. Several variations exist according to what is used as the data for fitting functions. Simply fitting a mathematical function to the changes in life expectancy, however, does not allow us to generate the survival rates needed for population projection by the cohort component method. As explained below, other examples of estimating future mortality include extrapolation of age-specific mortality rates, extrapolation of age-specific mortality rates by cause of death, and extrapolation of standardized cause-specific mortality rates.

The age-specific mortality rates were extrapolated in the 1981 round of population projections for Japan. The age-specific mortality rate extrapolation requires fitting multiple trend lines corresponding to the number of age categories. In contrast, extrapolating age-specific mortality rates by cause of death is more detailed than extrapolating the age-specific all-cause mortality rate. In this detailed way, trend lines are fitted to the age-specific mortality rates for each cause of death. This has the advantage of considering different tends in each cause of death. However, implementation is not straightforward. Even when the age and cause of death are broadly categorized, the extrapolation exercise can be very tedious. For example, two sexes, 18 age groups (5 year ranges), and 13 to 15 causes of death demand about 500 curve fittings. Thus, extrapolation of the standardized mortality rates by cause of death, a simplified version of extrapolation of the age-specific mortality rates by cause of death, was implemented for the population projections in 1986 and 1992. The procedure was to estimate future parameters of age-standardized mortality rates for each cause of death, then to uniformly apply these parameters to obtain age-specific mortality rates by cause of death. However, for the 1997 projection, the age was divided into four groups (0-14 years, 15-39 years, 40-64 years, 65 and over), and the projections were made with more detail reflecting the future parameter estimates standardized for the different age groups.

There are several concerns for projections by cause of death. Not only is fitting likely to be tedious, but there are also problems with the stability and regularity for the causes with a small number of deaths, making it difficult to fit a function. Moreover, problems arise in the continuity of cause of death trends due to revisions in the classifications of cause of death statistics[14], requiring some adjustments. Since 1995, as a recent example, the 10th revision of International Statistical Classification of Diseases and Related Health Problems (ICD-10) has been implemented in Japan and modified the way that causes of death are classified. The Ministry of Health and Welfare (now Ministry of Health, Labour, and Welfare) created a conversion table between the reclassification of the 1994 mortality statistics into 130 items of ICD-10 and that into 117 items of ICD-9 (the 9th

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[14] It started in 1893 as the Bertillon Classification. For more details, see "Vital Statistics", Ministry of Health, Labour and Welfare.

Revision).[15] Evaluation is necessary, however, for the validity across all ages and whether it can be hold true to the past data. Besides the issues of gaps in the official classification, there can be changes in the cause of death recorded on death certificates as a result of changing ideas in society as certain causes of death were avoided or preferred for recording on death certificates due to social circumstances and/or stigma as well as the attitudes among the doctors.[16] Also, the advancements and the innovations of medical technologies allow clearer identification of the cause of death, which in the past may have been attributed to somewhat ambiguous and less specific causes of death, such as senility or heart failure. Furthermore, projections based on the cause-specific mortality separately have possibilities of underestimation compared with projections based on all causes mortality.[17]

The relational model method can be considered a combination of the empirical method and the mathematical method, applicable to generating future life tables. A relational model describes the relationship between several empirical life tables using a small number of parameters. The future projections are made by mathematically extrapolating these parameters.

Brass developed a two-parameter model that described the relationship between multiple life tables,[18] although the fit was not well for the very young and the older ages. Subsequently, there were attempts to improve the fit of model in the older age groups.[19] The major disadvantage of the Brass model, with two parameters, was that it could not express different levels of mortality changes in different ages, which explains the abovementioned lower fits for the both extremes of age. On the other hand, other models with many parameters had to estimate correspondingly more parameters to cover the entire age range. Thus, it may bring along more sources of errors, even if the fitting is not tedious.

Lee and Carter have developed a model that restricts the number of parameters to one while improving the fit of the mortality changes across the age.[20] By now a variety of applications have been studied. The Lee-Carter model is expressed as follows for age x at time t.++

$$\ln(m_{x,t}) = a_x + b_x k_t + e_{x,t}$$

Here, $\ln(m_{x,t})$ is the log of the age-specific mortality rate, a_x is the standard age-specific mortality schedule based on the average, k_t is the mortality level index, b_x expresses the age-specific change in

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15 Statistics and Information Department, Ministry of Health and Welfare [Dai 10 Kai Shuseisiintoukeibunrui (ICD-10) to Dai 9 Kai Shuseisiintoukeibunrui (ICD-9) no Hikaku].

16 For example, see Suyama Y. and H. Tsukamoto（1995）[Shi'in no Hensen ni Kansuru Shakaigakuteki Haikei] "Kousei no Shihyou" (Journal of Health and Welfare Statistics) Vol. 42 No. 7, pp 9-15.

17 Wilmoth, J.R. (1995), "Are mortality projections always more pessimistic when disaggregated by cause of death?" *Mathematical Population Studies*, 5, pp.293-319.

18 Brass, W. (1971), "On the scale of mortality," *Biological Aspects of Demography*, ed., W. Brass, London: Taylor and Francis.

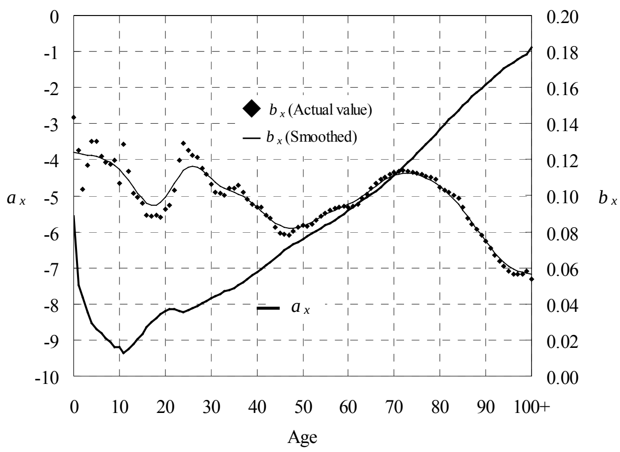
19 For example, Zaba, B. (1979), "The four-parameter logit life table system," *Population Studies*, 33, pp. 79-100. Ewbank, D.C., J. C. Gomez De Leon, and M. A. Stoto (1983), "A reducible four-parameter system of model life tables," *Population Studies*, 37, pp.105-127. Himes, C.L., S.H. Preston, and G.A. Condran (1994), "A relational model of mortality at older ages in low mortality countries," *Population Studies*, 48, pp. 269-291 etc.

20 Lee, R.D. and L.R. Carter (1992), "Modeling and forecasting U.S. mortality," *Journal of the American Statistical Association*, 87, pp.659-671.

the mortality for change in k_t [21], and $e_{x,t}$ indicates the residual. The advantage of this model is that it is possible to express a different rate of change for each age group simply by a single parameter k_t. Lee and Carter calculated the parameters using mortality rates in the United States for age groups of 0 years, 1-4 years, 5-9 years, … , 80-84 years and 85 years and older. Then, using the time-series analysis they determined the future values of the mortality index k_t from 1990 through 2065. Although ARIMA (1,1,0) model was marginally superior, (0,1,0) model was adopted for the sake of parsimony. After obtaining the future values for k_t, the death rates were then computed. Since the oldest age group was 85 years and older, the final death rates for the 75-79 years and the 80-84 year age groups were used to determine the death rates up to age groups 105-109 years by the Coale and Guo method.[22]

(2) Future Life Table Estimation

Figure III-4-1 Age-specific mortality schedule (actual and smoothed values) from Japanese female life expectancies



An attempt was made for this round of population projection by modifying and applying the Lee-Carter relational model to Japanese data to generate future life tables. The base data were the complete life tables and the abridged life tables for Japan since 1965 constructed by the Ministry of Health, Labour and Welfare (previously the Ministry of Health and Welfare). The abridged life tables by single year of age have been published since 1962, making it possible to directly use single years for the age ranges, and the 1965 life tables were the earliest complete life tables after 1963.[23]

The death rates for each sex for each age up to age 99 as well as age 100 years or older were obtained from those life tables, transformed by log, and used as data hereafter. To set recent age-specific death rates as the standard schedule of relation and to gain stability, the average values of 1999 and 2000 by age were used as the standard age-specific mortality schedule a_x. Since small fluctuations in b_x become large distortions in 50 year projection and should be avoided, b_x was smoothed. Figure III-4-1 shows a_x and b_x for Japanese females.

Although Lee and Carter adopted ARIMA(0,1,0) model for the forecast of the future values of the mortality index k_t in the US, using the same function as the US may not be appropriate to Japan. Japan has experienced a sharp improvement in mortality after World War II, catching up with the then-developed countries and having quickly reached the highest level in the world. Rather than

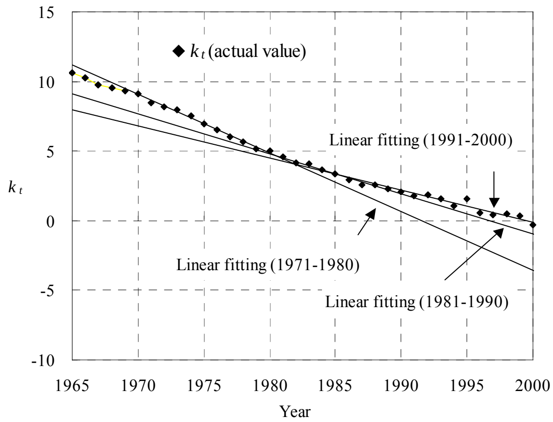
[21] As the left side of the equation is the log of the death rate, accurately speaking, the exponent of the right side is age-specific death rates, but it is shown here in this way for the sake of convenience for the explanation.

[22] Coale, A. and G. Guo (1989), "Revised regional model life tables at very low levels of mortality," *Population Index*, 55, pp.613-643.

[23] As abridged life tables prior to 1986 were not published by single ages for the highest age segment, the data for single ages were interpolated from the complete life tables.

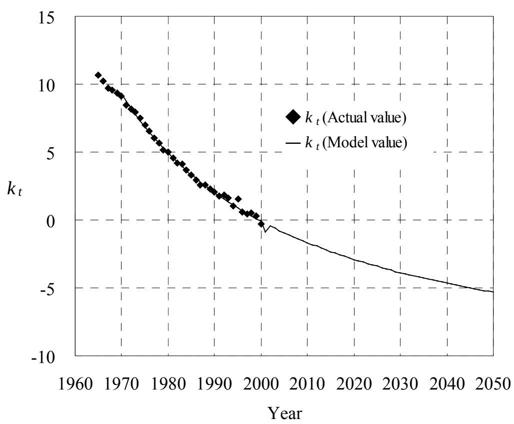
assuming that Japanese mortality will continue to improve more rapidly than in the other developed countries, it would be more natural to assume that Japan's trend will converge to gradual improvement as experienced elsewhere, as is the case in Sweden where low mortality has continued to improve with a modest change for the past 50 years.[24] In fact, a close examination of the change in the level of k_t of Japanese data indicates that the rate of improvement over the last 30 years has been slowing down (Figure III-4-2). Accordingly, functions are fitted to reflect this trend in the future estimates. One of the functions considered was a logarithmic function whose change gradually becomes smaller but continues without an asymptote.[25] Researchers who believe that life expectancy will continue to increase have been more vocal in the recent years, but a latest survey in Japan among population experts showed that Japanese experts tended to believe the increase in the life expectancy of Japanese would slow down and the life expectancy would be more or less around the level assumed in the previous projection.[26] Because no evidence is scientifically definitive to reject either of these two positions, two functions reflecting those positions were fitted, and the averages were used as the expected values. In addition, 1995 data were excluded to avoid the effects of the Hanshin Earthquake. Further, since the number of deaths in February 2001 reported by the time of the population projection was exceptionally low, the number of deaths was estimated separately for 2001, and the final function fitting was performed with this additional information. (Figure III-4-3)

Figure III-4-2 Trend of mortality level k_t (Japanese female)



Note: Slopes for the linear lines fitted to different periods were becoming flatter, from -0.4184 for 1971-80, -0.2876 for 1981-90, and -0.2295 for 1991-00.

Figure III-4-3 Estimated future value by fitting functions



Based on the parameters determined by the above procedure, the death rates by age and sex were calculated from 2001 to 2050, and the future life tables were constructed.

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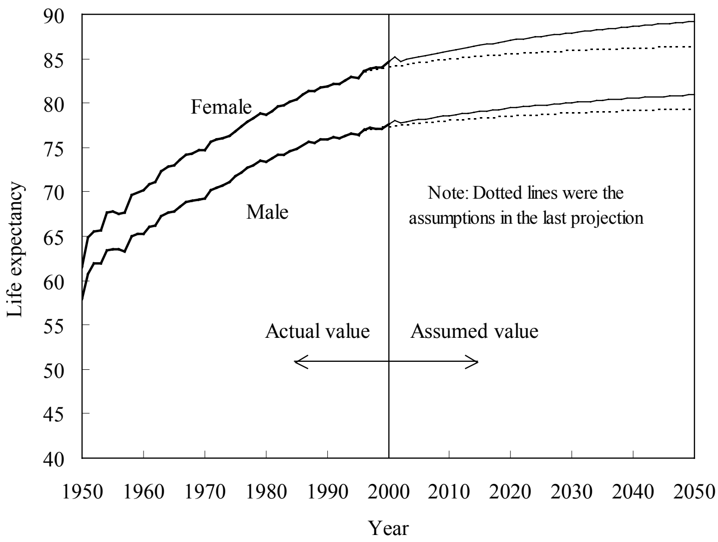
24 See Wilmoth, J.R. (1998), "Is the pace of Japanese mortality decline converging toward international trends?" *Population and Development Review*, 24, pp.592-600

25 The exponential function $k_t = \alpha_1 + \alpha_2 \exp\left(\frac{t+\alpha_4}{\alpha_3}\right)$ and the logarithmic function $k_t = \beta_1 + \beta_2 \ln(t+\beta_3)$ were fitted. Here, t is time and α_n and β_n are constants.

26 According to the survey on the future prospects of a low fertility society among population experts, presented at the 3rd Population Committee of the Social Security Council, 317 valid responses indicate that the life expectancy of males born in 2050 would be 79.3 years and 86.1 for females. These are slightly lower, by 0.1 year for the males and 0.4 year for females, than the assumptions for the previous population projection (1997).

(3) Future Life Table Estimate Results

Figure III-4-4 Trends of life expectancy for Japanese male and Japanese female (Actual and assumed values)



Life expectancy at birth by sex based on the estimated future life table is shown in Figure III-4-4. According to these results, life expectancies, which were 77.64 years for males and 84.62 years for females in 2000, will increase to 78.11 years for males and 85.2 years for females in 2005, to 79.76 years for males and 87.52 years for females in 2025, and eventually to 80.95 years for males and years 89.22 for females in 2050. The difference in life expectancy between males and females was 6.98 years in 2000, and gradually increases to 7.75 years in 2025 and to 8.27 years in 2050. The ratio of females to males in life expectancy is 1.09 and will remain at a level of 1.10 from year 2018.

The proportions of survival from birth to 20 years of age were 99.1% for males and 99.4% for females in 2000. These are expected to increase to 99.5% for males and 99.7% for females in 2050. The survival to age 65, 84.6% for males and 92.6% for females in 2000, gradually increases to 88.4% for males and 95.3% for females by 2050.

5. Calculation of Total Population Fertility Rates and Sex Ratio at Birth.

The projected population is the total population of Japan, including non-Japanese people residing in Japan. Therefore, it is necessary to include the number of births by non-Japanese residents.

The estimated values for the projected fertility rates described earlier are the rates of births of Japanese people in Japan. To use these values as is implies the assumption that the fertility rates of Japanese and non-Japanese people are identical. With regard to the fertility rate of Japanese people (birth rate of number of Japanese births from the Japanese population) and the fertility rate of the total population (birth rate of number of births including non-Japanese from the total population, including non-Japanese persons), looking at the situation in recent years, it is clear that these rates are not identical. The total population fertility rate is lower than the Japanese fertility rate for the population in their 20's through their late 30's.

Specifically, the ratio of the total population fertility and the Japanese population fertility for each age was determined, and the average of the values from 1990 to 2000 was defined as an adjustment factor for the calculation of the fertility rate of the total population. Then, this adjustment factor was multiplied by the estimated Japanese fertility rate to obtain a fertility rate for the total population. (Table III-5-1).

It is also necessary to estimate a sex ratio at birth (= number of male births/number of female births × 100) in order to divide the future number of newborns into male and female. Based on observations of past sex ratio at birth, the fluctuations between years is negligible. Therefore, for this projection, it was assumed that the mean value (105.5) of the sex ratio at birth from 1996 to 2000 would also remain constant from 2001 onward (Figure III-5-1).

Figure III-5-1 Sex ratio at birth

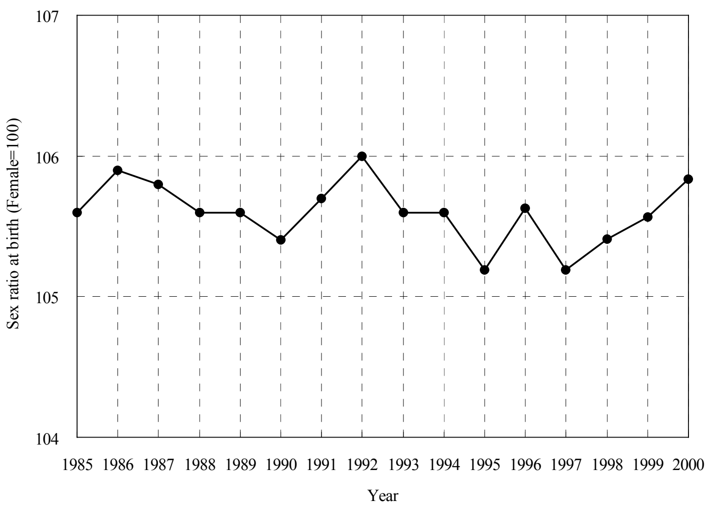


Table III-5-1 Adjustment for the total population fertility rate

Age	Average of age-specific fertility rate 1990-2000		Adjustment[3]
	Total population[1]	Only Japanese[2]	
15	0.00020	0.00020	1.03603
16	0.00087	0.00085	1.02369
17	0.00250	0.00247	1.01398
18	0.00530	0.00526	1.00725
19	0.01141	0.01137	1.00298
20	0.01887	0.01888	1.00001
21	0.02814	0.02820	0.99742
22	0.03817	0.03833	0.99537
23	0.05152	0.05186	0.99357
24	0.06930	0.06987	0.99194
25	0.08818	0.08902	0.99055
26	0.10758	0.10872	0.98952
27	0.12253	0.12392	0.98882
28	0.13115	0.13268	0.98842
29	0.13243	0.13399	0.98839
30	0.12400	0.12543	0.98875
31	0.11009	0.11126	0.98945
32	0.09363	0.09453	0.99039
33	0.07673	0.07738	0.99151
34	0.06092	0.06137	0.99284
35	0.04628	0.04655	0.99432
36	0.03429	0.03443	0.99589
37	0.02382	0.02387	0.99746
38	0.01624	0.01626	0.99906
39	0.01081	0.01080	1.00042
40	0.00673	0.00671	1.00152
41	0.00399	0.00398	1.00252
42	0.00220	0.00219	1.00317
43	0.00116	0.00116	1.00395
44	0.00056	0.00056	1.00694
45	0.00024	0.00024	1.01107
46	0.00009	0.00009	1.01740
47	0.00004	0.00004	1.02775
48	0.00001	0.00001	1.04349
49	0.00001	0.00001	1.06432

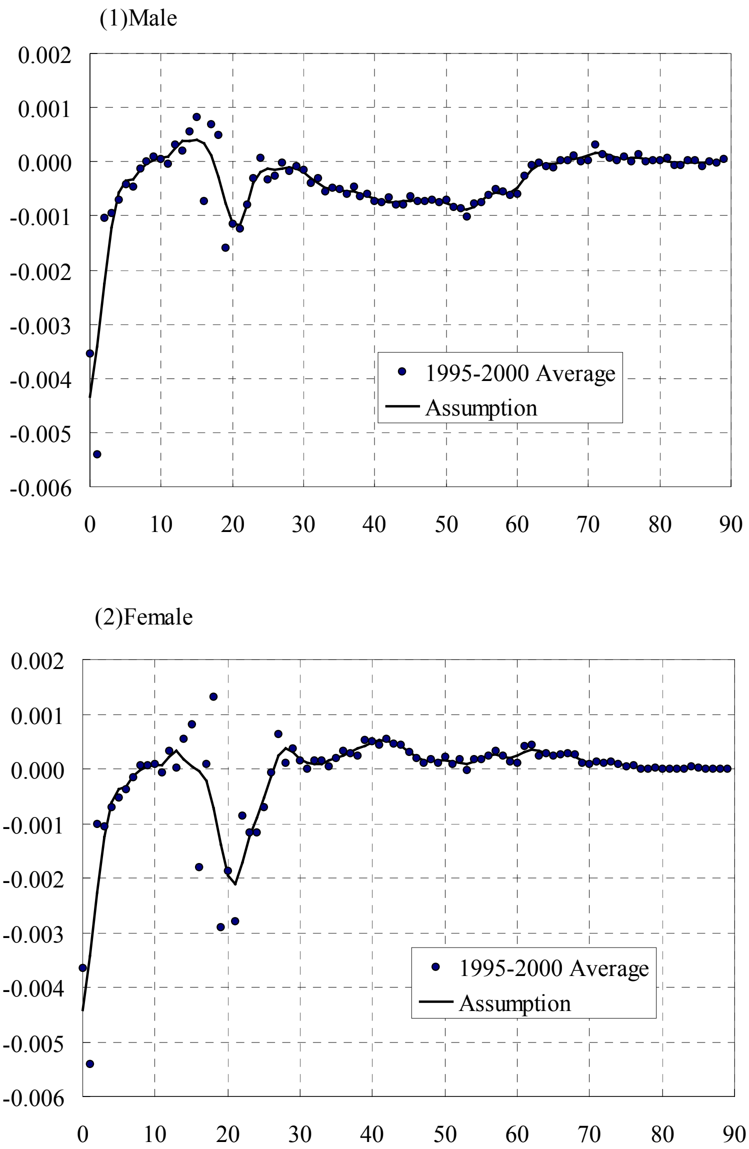
1) Total population fertility rate＝Live births included non-Japanese ／Total population
2) Japanese fertility rate＝Live births of Japanese／Japanese population
3) Adjustment＝Total population fertility rate／Japanese fertility rate
Average of the values of 1990-2000（Greville's method of smoothing）

6. International Migration Estimates

International migration has varied significantly in Japan along with the progress of internationalization and economic change. Furthermore, it is affected by government policy as well as the economic and social situations in other countries. The tendency in recent years, based on the net immigration to Japan, has not been stable over time and does not reveal any specific trend. However, if we separate the international migrations by Japanese people and by non-Japanese people, there is consistent net emigration by Japanese people, remaining relatively stable at about 40,000 a year since 1995. In comparison, there is generally a net immigration to Japan among non-Japanese people, and although this varies a great deal, in recent years there is an apparent increasing trend.

The estimates for international migration for previous population projections used constant values for net immigration rates by age and sex. However, there are differences in the international migration trends shown by Japanese and non-Japanese people. In addition, population migration, particularly the number of immigrants, does not depend on the population size or composition. Therefore, the conventional method of using sex/age-specific immigration rates cannot be used to explain the current changes.

Figure III-6-1 Assumption of net (entries minus exits) international migration rate for Japanese population



Here, we make separate assumptions regarding future international migration of Japanese and non-Japanese people. In other words, there will be 2 estimates; one for the net immigration of Japanese people, and another for the net immigration of non-Japanese people.

The international migration of Japanese people is relatively stable. Based on the net emigration (from Japan), the estimate is made as follows. First, the average of the values for the gross migration rates (net immigration rate) by age and sex between 1995 and 2000 are determined. Then, to eliminate the effect of coincidental changes, the adjusted rate is assumed to be constant from 2001 onward. (Figure III-6-1). Since the base value (population) for the number of migrations is the population of Japanese people, it is necessary to separately project the Japanese population. The proportion of the calculated future sex/age-specific population that is Japanese (age-specific population: 2000 National Census; births: 2000 Vital Statistics) is used to determine the population of Japanese people.

Next, for the international migrations of non-Japanese people, there is generally a net immigration into Japan. Since there is an increasing trend in recent years, regression lines were fitted for each sex for the data since 1970. However, around 1990 there were drastic changes, so the data from the years between 1988 and 1995 was omitted because of the large discontinuity with the overall trend. By performing extrapolation with a logistics curve, the future sex-specific net immigration of non-Japanese people was determined. (Figure III-6-2). The proportion of each age of immigrants is taken to be constant, as the average of the values between 1995 and 2000. (Figure III-6-3).

Figure III-6-2 Assumption of the amount of net (entries minus exits) international migrants for non-Japanese population

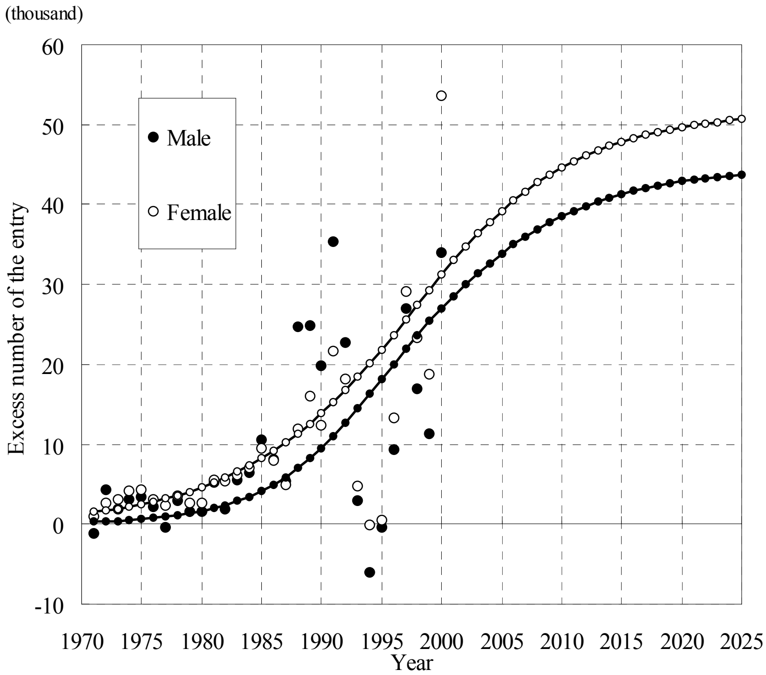
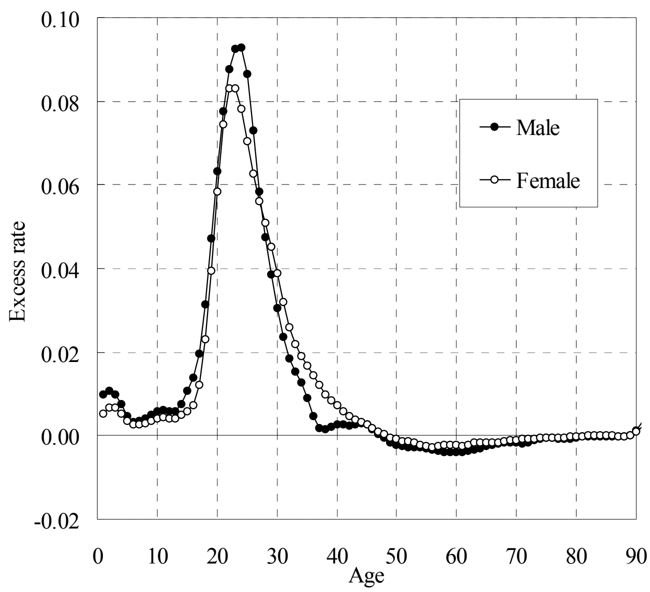


Figure III-6-3 Assumption of the age pattern of net international migration for non-Japanese population



Appendix

Table 1 Actual and projected total period fertility rate under the three variants

Year	Medium	High	Low	Year	Medium	High	Low
2000	1.35918	1.35918	1.35918				
2001	1.34277	1.36761	1.31671	2026	1.38214	1.62256	1.10603
2002	1.33240	1.36752	1.29344	2027	1.38253	1.62303	1.10527
2003	1.32344	1.37084	1.26896	2028	1.38304	1.62348	1.10475
2004	1.31686	1.37857	1.24511	2029	1.38361	1.62391	1.10441
2005	1.31076	1.38831	1.22074	2030	1.38420	1.62429	1.10419
2006	1.30696	1.40118	1.19843	2031	1.38477	1.62460	1.10404
2007	1.30622	1.41744	1.17963	2032	1.38528	1.62485	1.10392
2008	1.30816	1.43632	1.16432	2033	1.38565	1.62496	1.10375
2009	1.31166	1.45585	1.15156	2034	1.38599	1.62505	1.10363
2010	1.31786	1.47677	1.14260	2035	1.38629	1.62514	1.10356
2011	1.32471	1.49694	1.13555	2036	1.38654	1.62521	1.10351
2012	1.33225	1.51606	1.13025	2037	1.38673	1.62526	1.10347
2013	1.33929	1.53359	1.12556	2038	1.38688	1.62530	1.10344
2014	1.34688	1.55023	1.12258	2039	1.38699	1.62533	1.10342
2015	1.35370	1.56484	1.12022	2040	1.38708	1.62535	1.10340
2016	1.36028	1.57793	1.11880	2041	1.38714	1.62536	1.10339
2017	1.36509	1.58814	1.11677	2042	1.38718	1.62537	1.10339
2018	1.36881	1.59634	1.11469	2043	1.38721	1.62538	1.10338
2019	1.37303	1.60418	1.11407	2044	1.38723	1.62538	1.10338
2020	1.37522	1.60924	1.11222	2045	1.38725	1.62538	1.10338
2021	1.37673	1.61295	1.11039	2046	1.38725	1.62538	1.10338
2022	1.37890	1.61674	1.10983	2047	1.38726	1.62538	1.10338
2023	1.37992	1.61885	1.10857	2048	1.38726	1.62538	1.10338
2024	1.38091	1.62060	1.10769	2049	1.38726	1.62538	1.10338
2025	1.38191	1.62208	1.10713	2050	1.38726	1.62538	1.10338

Table 2 Actual and projected life expectancy at birth

(Years) (Years)

Year	Male	Female	Difference	Year	Male	Female	Difference
2000	77.64	84.62	6.98				
2001	78.08	85.18	7.10	2026	79.82	87.60	7.78
2002	77.76	84.73	6.97	2027	79.88	87.69	7.81
2003	77.88	84.89	7.01	2028	79.94	87.77	7.83
2004	77.99	85.05	7.06	2029	80.00	87.85	7.85
2005	78.11	85.20	7.10	2030	80.06	87.93	7.88
2006	78.21	85.35	7.14	2031	80.11	88.01	7.90
2007	78.32	85.50	7.18	2032	80.16	88.09	7.93
2008	78.42	85.64	7.21	2033	80.21	88.16	7.95
2009	78.52	85.77	7.25	2034	80.27	88.24	7.97
2010	78.62	85.90	7.29	2035	80.32	88.31	7.99
2011	78.71	86.03	7.32	2036	80.36	88.38	8.01
2012	78.80	86.16	7.36	2037	80.41	88.44	8.03
2013	78.89	86.28	7.39	2038	80.46	88.51	8.05
2014	78.97	86.40	7.43	2039	80.50	88.58	8.07
2015	79.05	86.51	7.46	2040	80.55	88.64	8.09
2016	79.13	86.63	7.49	2041	80.59	88.70	8.11
2017	79.21	86.73	7.52	2042	80.63	88.77	8.13
2018	79.29	86.84	7.56	2043	80.68	88.83	8.15
2019	79.36	86.95	7.59	2044	80.72	88.88	8.17
2020	79.43	87.05	7.61	2045	80.76	88.94	8.19
2021	79.50	87.15	7.64	2046	80.80	89.00	8.20
2022	79.57	87.24	7.67	2047	80.83	89.05	8.22
2023	79.64	87.34	7.70	2048	80.87	89.11	8.24
2024	79.70	87.43	7.73	2049	80.91	89.16	8.25
2025	79.76	87.52	7.75	2050	80.95	89.22	8.27

Table 3 Projected future population and proportion by age group, 2000-2050: Medium variant

Year	Population (thousand)				Proportion (%)		
	Total	0-14	15-64	65+	0-14-	15-64-	65+
2000	126,926	18,505	86,380	22,041	14.6	68.1	17.4
2001	127,183	18,307	86,033	22,843	14.4	67.6	18.0
2002	127,377	18,123	85,673	23,581	14.2	67.3	18.5
2003	127,524	17,964	85,341	24,219	14.1	66.9	19.0
2004	127,635	17,842	85,071	24,722	14.0	66.7	19.4
2005	127,708	17,727	84,590	25,392	13.9	66.2	19.9
2006	127,741	17,623	83,946	26,172	13.8	65.7	20.5
2007	127,733	17,501	83,272	26,959	13.7	65.2	21.1
2008	127,686	17,385	82,643	27,658	13.6	64.7	21.7
2009	127,599	17,235	81,994	28,370	13.5	64.3	22.2
2010	127,473	17,074	81,665	28,735	13.4	64.1	22.5
2011	127,309	16,919	81,422	28,968	13.3	64.0	22.8
2012	127,107	16,746	80,418	29,942	13.2	63.3	23.6
2013	126,865	16,558	79,326	30,981	13.1	62.5	24.4
2014	126,585	16,385	78,207	31,992	12.9	61.8	25.3
2015	126,266	16,197	77,296	32,772	12.8	61.2	26.0
2016	125,909	15,980	76,556	33,372	12.7	60.8	26.5
2017	125,513	15,759	75,921	33,832	12.6	60.5	27.0
2018	125,080	15,536	75,374	34,170	12.4	60.3	27.3
2019	124,611	15,314	74,918	34,379	12.3	60.1	27.6
2020	124,107	15,095	74,453	34,559	12.2	60.0	27.8
2021	123,570	14,881	74,026	34,663	12.0	59.9	28.1
2022	123,002	14,673	73,658	34,671	11.9	59.9	28.2
2023	122,406	14,471	73,242	34,694	11.8	59.8	28.3
2024	121,784	14,275	72,775	34,734	11.7	59.8	28.5
2025	121,136	14,085	72,325	34,726	11.6	59.7	28.7
2026	120,466	13,901	71,877	34,688	11.5	59.7	28.8
2027	119,773	13,724	71,397	34,652	11.5	59.6	28.9
2028	119,061	13,553	70,858	34,650	11.4	59.5	29.1
2029	118,329	13,389	70,275	34,665	11.3	59.4	29.3
2030	117,580	13,233	69,576	34,770	11.3	59.2	29.6
2031	116,813	13,085	69,174	34,554	11.2	59.2	29.6
2032	116,032	12,944	68,398	34,689	11.2	58.9	29.9
2033	115,235	12,812	67,608	34,815	11.1	58.7	30.2
2034	114,425	12,686	66,771	34,968	11.1	58.4	30.6
2035	113,602	12,567	65,891	35,145	11.1	58.0	30.9
2036	112,768	12,453	64,953	35,362	11.0	57.6	31.4
2037	111,923	12,341	63,962	35,619	11.0	57.1	31.8
2038	111,068	12,233	62,928	35,908	11.0	56.7	32.3
2039	110,207	12,125	61,919	36,163	11.0	56.2	32.8
2040	109,338	12,017	60,990	36,332	11.0	55.8	33.2
2041	108,465	11,908	60,126	36,432	11.0	55.4	33.6
2042	107,589	11,798	59,329	36,462	11.0	55.1	33.9
2043	106,712	11,686	58,555	36,471	11.0	54.9	34.2
2044	105,835	11,572	57,824	36,439	10.9	54.6	34.4
2045	104,960	11,455	57,108	36,396	10.9	54.4	34.7
2046	104,087	11,336	56,449	36,302	10.9	54.2	34.9
2047	103,213	11,215	55,800	36,198	10.9	54.1	35.1
2048	102,339	11,092	55,146	36,102	10.8	53.9	35.3
2049	101,466	10,967	54,498	36,001	10.8	53.7	35.5
2050	100,593	10,842	53,889	35,863	10.8	53.6	35.7

Table 4 Projected future population and proportion by age group, 2000-2050: High variant

Year	Population (thousand)				Proportion (%)		
	Total	0-14	15-64	65+	0-14-	15-64-	65+
2000	126,926	18,505	86,380	22,041	14.6	68.1	17.4
2001	127,198	18,322	86,033	22,843	14.4	67.6	18.0
2002	127,419	18,165	85,673	23,581	14.3	67.2	18.5
2003	127,603	18,043	85,341	24,219	14.1	66.9	19.0
2004	127,762	17,969	85,071	24,722	14.1	66.6	19.4
2005	127,894	17,913	84,590	25,392	14.0	66.1	19.9
2006	128,000	17,882	83,946	26,172	14.0	65.6	20.4
2007	128,078	17,846	83,272	26,959	13.9	65.0	21.0
2008	128,128	17,828	82,643	27,658	13.9	64.5	21.6
2009	128,151	17,787	81,994	28,370	13.9	64.0	22.1
2010	128,145	17,746	81,665	28,735	13.8	63.7	22.4
2011	128,110	17,720	81,422	28,968	13.8	63.6	22.6
2012	128,043	17,683	80,418	29,942	13.8	62.8	23.4
2013	127,943	17,636	79,326	30,981	13.8	62.0	24.2
2014	127,809	17,609	78,207	31,992	13.8	61.2	25.0
2015	127,640	17,571	77,296	32,772	13.8	60.6	25.7
2016	127,435	17,491	76,571	33,372	13.7	60.1	26.2
2017	127,193	17,398	75,963	33,832	13.7	59.7	26.6
2018	126,914	17,293	75,452	34,170	13.6	59.5	26.9
2019	126,600	17,178	75,043	34,379	13.6	59.3	27.2
2020	126,250	17,053	74,638	34,559	13.5	59.1	27.4
2021	125,867	16,921	74,284	34,663	13.4	59.0	27.5
2022	125,453	16,781	74,001	34,671	13.4	59.0	27.6
2023	125,010	16,634	73,682	34,694	13.3	58.9	27.8
2024	124,539	16,481	73,325	34,734	13.2	58.9	27.9
2025	124,044	16,325	72,993	34,726	13.2	58.8	28.0
2026	123,526	16,166	72,673	34,688	13.1	58.8	28.1
2027	122,987	16,006	72,328	34,652	13.0	58.8	28.2
2028	122,428	15,849	71,929	34,650	12.9	58.8	28.3
2029	121,853	15,696	71,491	34,665	12.9	58.7	28.4
2030	121,262	15,550	70,941	34,770	12.8	58.5	28.7
2031	120,657	15,412	70,691	34,554	12.8	58.6	28.6
2032	120,039	15,284	70,067	34,689	12.7	58.4	28.9
2033	119,411	15,167	69,429	34,815	12.7	58.1	29.2
2034	118,774	15,061	68,746	34,968	12.7	57.9	29.4
2035	118,129	14,966	68,018	35,145	12.7	57.6	29.8
2036	117,477	14,882	67,233	35,362	12.7	57.2	30.1
2037	116,819	14,806	66,394	35,619	12.7	56.8	30.5
2038	116,156	14,738	65,511	35,908	12.7	56.4	30.9
2039	115,491	14,676	64,652	36,163	12.7	56.0	31.3
2040	114,824	14,619	63,874	36,332	12.7	55.6	31.6
2041	114,157	14,565	63,160	36,432	12.8	55.3	31.9
2042	113,490	14,512	62,515	36,462	12.8	55.1	32.1
2043	112,825	14,460	61,894	36,471	12.8	54.9	32.3
2044	112,163	14,407	61,317	36,439	12.8	54.7	32.5
2045	111,506	14,351	60,758	36,396	12.9	54.5	32.6
2046	110,852	14,291	60,258	36,302	12.9	54.4	32.7
2047	110,198	14,228	59,773	36,198	12.9	54.2	32.8
2048	109,546	14,159	59,285	36,102	12.9	54.1	33.0
2049	108,895	14,086	58,809	36,001	12.9	54.0	33.1
2050	108,246	14,008	58,375	35,863	12.9	53.9	33.1

Table 5 Projected future population and proportion by age group, 2000-2050: Low variant

Year	Population (thousand)				Proportion (%)		
	Total	0-14	15-64	65+	0-14-	15-64-	65+
2000	126,926	18,505	86,380	22,041	14.6	68.1	17.4
2001	127,165	18,290	86,033	22,843	14.4	67.7	18.0
2002	127,328	18,074	85,673	23,581	14.2	67.3	18.5
2003	127,431	17,871	85,341	24,219	14.0	67.0	19.0
2004	127,483	17,690	85,071	24,722	13.9	66.7	19.4
2005	127,482	17,501	84,590	25,392	13.7	66.4	19.9
2006	127,426	17,308	83,946	26,172	13.6	65.9	20.5
2007	127,315	17,084	83,272	26,959	13.4	65.4	21.2
2008	127,152	16,851	82,643	27,658	13.3	65.0	21.8
2009	126,937	16,573	81,994	28,370	13.1	64.6	22.3
2010	126,673	16,274	81,665	28,735	12.8	64.5	22.7
2011	126,362	15,972	81,422	28,968	12.6	64.4	22.9
2012	126,004	15,644	80,418	29,942	12.4	63.8	23.8
2013	125,601	15,294	79,326	30,981	12.2	63.2	24.7
2014	125,152	14,953	78,207	31,992	11.9	62.5	25.6
2015	124,661	14,593	77,296	32,772	11.7	62.0	26.3
2016	124,129	14,217	76,539	33,372	11.5	61.7	26.9
2017	123,556	13,850	75,873	33,832	11.2	61.4	27.4
2018	122,944	13,493	75,281	34,170	11.0	61.2	27.8
2019	122,296	13,150	74,767	34,379	10.8	61.1	28.1
2020	121,613	12,826	74,228	34,559	10.5	61.0	28.4
2021	120,898	12,522	73,713	34,663	10.4	61.0	28.7
2022	120,152	12,238	73,243	34,671	10.2	61.0	28.9
2023	119,379	11,975	72,711	34,694	10.0	60.9	29.1
2024	118,580	11,729	72,117	34,734	9.9	60.8	29.3
2025	117,755	11,500	71,529	34,726	9.8	60.7	29.5
2026	116,907	11,285	70,935	34,688	9.7	60.7	29.7
2027	116,037	11,083	70,301	34,652	9.6	60.6	29.9
2028	115,144	10,894	69,601	34,650	9.5	60.4	30.1
2029	114,231	10,715	68,851	34,665	9.4	60.3	30.3
2030	113,297	10,546	67,981	34,770	9.3	60.0	30.7
2031	112,344	10,384	67,406	34,554	9.2	60.0	30.8
2032	111,372	10,229	66,454	34,689	9.2	59.7	31.1
2033	110,381	10,079	65,487	34,815	9.1	59.3	31.5
2034	109,373	9,933	64,473	34,968	9.1	58.9	32.0
2035	108,349	9,789	63,416	35,145	9.0	58.5	32.4
2036	107,309	9,645	62,302	35,362	9.0	58.1	33.0
2037	106,255	9,501	61,135	35,619	8.9	57.5	33.5
2038	105,188	9,355	59,925	35,908	8.9	57.0	34.1
2039	104,112	9,207	58,741	36,163	8.8	56.4	34.7
2040	103,025	9,056	57,637	36,332	8.8	55.9	35.3
2041	101,932	8,903	56,597	36,432	8.7	55.5	35.7
2042	100,833	8,747	55,624	36,462	8.7	55.2	36.2
2043	99,732	8,589	54,672	36,471	8.6	54.8	36.6
2044	98,630	8,430	53,761	36,439	8.5	54.5	36.9
2045	97,529	8,269	52,863	36,396	8.5	54.2	37.3
2046	96,429	8,109	52,018	36,302	8.4	53.9	37.6
2047	95,328	7,949	51,181	36,198	8.3	53.7	38.0
2048	94,228	7,792	50,335	36,102	8.3	53.4	38.3
2049	93,129	7,637	49,491	36,001	8.2	53.1	38.7
2050	92,031	7,486	48,683	35,863	8.1	52.9	39.0

Table 6 Selected age-structure indices of future population, 2000-2050: Medium variant

Year	Mean Age (yr.)	Median Age (yr.)	Defining Productive Age as 15-64 Years Old				Defining Productive Age as 20-69 Years Old			
			Age Dependency Ratio(%)			Elderly-Children Ratio(%)	Age Dependency Ratio(%)			Elderly-Children Ratio(%)
			Total	Children	Old-age		Total	Children	Old-age	
2000	41.4	41.5	46.9	21.4	25.5	119.1	47.6	30.2	17.4	57.4
2001	41.8	41.8	47.8	21.3	26.6	124.8	48.0	29.9	18.1	60.7
2002	42.1	42.1	48.7	21.2	27.5	130.1	48.4	29.5	18.9	64.0
2003	42.5	42.4	49.4	21.0	28.4	134.8	48.8	29.1	19.6	67.4
2004	42.8	42.6	50.0	21.0	29.1	138.6	49.1	28.8	20.3	70.7
2005	43.1	42.9	51.0	21.0	30.0	143.2	49.6	28.5	21.1	74.1
2006	43.4	43.2	52.2	21.0	31.2	148.5	50.2	28.3	21.9	77.6
2007	43.7	43.5	53.4	21.0	32.4	154.0	50.8	28.1	22.7	80.9
2008	44.0	43.8	54.5	21.0	33.5	159.1	51.3	27.9	23.4	83.9
2009	44.3	44.2	55.6	21.0	34.6	164.6	51.6	27.7	23.9	86.2
2010	44.6	44.4	56.1	20.9	35.2	168.3	52.3	27.6	24.7	89.3
2011	44.9	44.7	56.4	20.8	35.6	171.2	53.2	27.6	25.6	92.7
2012	45.2	45.0	58.1	20.8	37.2	178.8	54.2	27.6	26.6	96.3
2013	45.5	45.4	59.9	20.9	39.1	187.1	55.1	27.6	27.5	99.6
2014	45.7	45.7	61.9	21.0	40.9	195.3	55.9	27.5	28.4	103.1
2015	46.0	46.1	63.4	21.0	42.4	202.3	56.1	27.4	28.8	105.2
2016	46.2	46.5	64.5	20.9	43.6	208.8	56.2	27.2	29.0	106.8
2017	46.5	46.8	65.3	20.8	44.6	214.7	57.6	27.2	30.4	111.7
2018	46.7	47.2	65.9	20.6	45.3	219.9	59.1	27.2	31.9	117.2
2019	47.0	47.6	66.3	20.4	45.9	224.5	60.7	27.3	33.5	122.5
2020	47.2	48.0	66.7	20.3	46.4	228.9	61.9	27.3	34.7	127.1
2021	47.4	48.4	66.9	20.1	46.8	232.9	62.8	27.2	35.6	131.1
2022	47.7	48.7	67.0	19.9	47.1	236.3	63.3	27.0	36.3	134.6
2023	47.9	49.1	67.1	19.8	47.4	239.8	63.7	26.8	36.9	137.6
2024	48.1	49.5	67.3	19.6	47.7	243.3	63.8	26.6	37.2	140.0
2025	48.3	49.8	67.5	19.5	48.0	246.5	64.0	26.4	37.6	142.4
2026	48.5	50.1	67.6	19.3	48.3	249.5	64.0	26.2	37.8	144.3
2027	48.7	50.4	67.8	19.2	48.5	252.5	63.9	26.0	37.9	145.9
2028	48.8	50.7	68.0	19.1	48.9	255.7	63.8	25.8	38.0	147.4
2029	49.0	50.9	68.4	19.1	49.3	258.9	63.9	25.6	38.2	149.1
2030	49.2	51.2	69.0	19.0	50.0	262.7	63.8	25.5	38.4	150.5
2031	49.3	51.4	68.9	18.9	50.0	264.1	63.8	25.3	38.4	151.7
2032	49.5	51.6	69.6	18.9	50.7	268.0	63.8	25.2	38.6	153.0
2033	49.6	51.8	70.4	19.0	51.5	271.7	63.9	25.1	38.8	154.4
2034	49.7	52.0	71.4	19.0	52.4	275.6	64.1	25.0	39.1	155.9
2035	49.9	52.2	72.4	19.1	53.3	279.7	64.5	25.0	39.5	157.9
2036	50.0	52.3	73.6	19.2	54.4	284.0	64.3	24.9	39.4	158.2
2037	50.1	52.5	75.0	19.3	55.7	288.6	64.9	24.9	40.0	160.4
2038	50.2	52.6	76.5	19.4	57.1	293.5	65.6	25.0	40.6	162.6
2039	50.3	52.8	78.0	19.6	58.4	298.3	66.3	25.0	41.3	165.0
2040	50.4	52.9	79.3	19.7	59.6	302.3	67.2	25.1	42.1	167.5
2041	50.5	52.9	80.4	19.8	60.6	305.9	68.2	25.2	43.0	170.4
2042	50.6	53.0	81.3	19.9	61.5	309.1	69.4	25.4	44.0	173.5
2043	50.7	53.1	82.2	20.0	62.3	312.1	70.7	25.5	45.2	177.0
2044	50.8	53.1	83.0	20.0	63.0	314.9	72.1	25.7	46.3	180.3
2045	50.9	53.1	83.8	20.1	63.7	317.7	73.2	25.8	47.3	183.2
2046	51.0	53.2	84.4	20.1	64.3	320.2	74.2	26.0	48.2	185.8
2047	51.1	53.2	85.0	20.1	64.9	322.8	75.0	26.0	49.0	188.1
2048	51.1	53.3	85.6	20.1	65.5	325.5	75.8	26.1	49.7	190.2
2049	51.2	53.4	86.2	20.1	66.1	328.3	76.5	26.2	50.3	192.2
2050	51.3	53.4	86.7	20.1	66.5	330.8	77.1	26.2	50.9	194.2

Table 7　Trends in live births, deaths, and natural increase, 2001-2050: Medium variant

Year	Crude number（thousand）			Crude rates(‰)		
	Birth	Death	Natural increase	Birth	Death	Natural increase
2001	1,194	982	212	9.4	7.7	1.7
2002	1,183	1,033	150	9.3	8.1	1.2
2003	1,170	1,068	102	9.2	8.4	0.8
2004	1,154	1,092	62	9.0	8.6	0.5
2005	1,137	1,117	20	8.9	8.7	0.2
2006	1,119	1,142	-23	8.8	8.9	-0.2
2007	1,102	1,168	-66	8.6	9.1	-0.5
2008	1,085	1,193	-108	8.5	9.4	-0.8
2009	1,070	1,219	-150	8.4	9.6	-1.2
2010	1,055	1,245	-191	8.3	9.8	-1.5
2011	1,041	1,272	-231	8.2	10.0	-1.8
2012	1,027	1,298	-272	8.1	10.2	-2.1
2013	1,013	1,325	-312	8.0	10.5	-2.5
2014	999	1,351	-352	7.9	10.7	-2.8
2015	985	1,376	-392	7.8	10.9	-3.1
2016	971	1,402	-431	7.7	11.2	-3.4
2017	956	1,426	-470	7.6	11.4	-3.8
2018	941	1,449	-508	7.6	11.6	-4.1
2019	928	1,472	-544	7.5	11.9	-4.4
2020	914	1,493	-579	7.4	12.1	-4.7
2021	902	1,514	-612	7.3	12.3	-5.0
2022	891	1,533	-643	7.3	12.5	-5.3
2023	880	1,552	-671	7.2	12.7	-5.5
2024	871	1,569	-698	7.2	13.0	-5.8
2025	863	1,585	-723	7.2	13.2	-6.0
2026	855	1,601	-746	7.1	13.4	-6.2
2027	847	1,615	-768	7.1	13.6	-6.4
2028	840	1,628	-788	7.1	13.8	-6.7
2029	834	1,641	-807	7.1	14.0	-6.9
2030	828	1,652	-825	7.1	14.1	-7.1
2031	821	1,663	-842	7.1	14.3	-7.3
2032	815	1,672	-857	7.1	14.5	-7.4
2033	808	1,680	-872	7.1	14.7	-7.6
2034	801	1,687	-886	7.1	14.8	-7.8
2035	794	1,692	-899	7.0	15.0	-8.0
2036	786	1,697	-911	7.0	15.2	-8.1
2037	778	1,699	-921	7.0	15.3	-8.3
2038	770	1,700	-930	7.0	15.4	-8.4
2039	761	1,699	-938	7.0	15.5	-8.6
2040	753	1,697	-944	6.9	15.6	-8.7
2041	744	1,693	-949	6.9	15.7	-8.8
2042	735	1,687	-951	6.9	15.8	-8.9
2043	726	1,679	-953	6.9	15.9	-9.0
2044	717	1,669	-952	6.8	15.9	-9.1
2045	708	1,659	-951	6.8	15.9	-9.1
2046	700	1,649	-950	6.8	16.0	-9.2
2047	691	1,641	-950	6.8	16.0	-9.3
2048	683	1,633	-950	6.7	16.1	-9.4
2049	674	1,624	-950	6.7	16.1	-9.4
2050	667	1,617	-950	6.7	16.2	-9.5

≪Result of Long-Range Projection≫

In order to project the population trend from 2000 to 2100, a long-range projection for the years between 2051 and 2100 was carried out. We assumed that the survival rate, sex ratio at births, and rate of international net-migration would remain constant for 2050 and thereafter, and the fertility rate would regress from the level in 2050 to 2.07, the population replacement level for 2050 to 2150

Reference Table 1　Projected future population and proportion by age group, 2051-2100: Medium variant

Year	Population (thousand)				Proportion (%)		
	Total	0-14	15-64	65+	0-14-	15-64-	65+
2051	99,719	10,718	53,331	35,669	10.7	53.5	35.8
2052	98,840	10,599	52,787	35,454	10.7	53.4	35.9
2053	97,956	10,483	52,268	35,205	10.7	53.4	35.9
2054	97,067	10,372	51,787	34,907	10.7	53.4	36.0
2055	96,171	10,266	51,318	34,586	10.7	53.4	36.0
2056	95,268	10,166	50,865	34,237	10.7	53.4	35.9
2057	94,358	10,071	50,404	33,883	10.7	53.4	35.9
2058	93,442	9,982	49,952	33,508	10.7	53.5	35.9
2059	92,520	9,899	49,475	33,146	10.7	53.5	35.8
2060	91,593	9,822	48,993	32,778	10.7	53.5	35.8
2061	90,663	9,752	48,520	32,392	10.8	53.5	35.7
2062	89,732	9,687	48,035	32,010	10.8	53.5	35.7
2063	88,802	9,629	47,541	31,633	10.8	53.5	35.6
2064	87,875	9,576	47,064	31,235	10.9	53.6	35.5
2065	86,953	9,528	46,580	30,845	11.0	53.6	35.5
2066	86,039	9,483	46,077	30,479	11.0	53.6	35.4
2067	85,136	9,440	45,580	30,116	11.1	53.5	35.4
2068	84,244	9,398	45,091	29,755	11.2	53.5	35.3
2069	83,367	9,356	44,613	29,398	11.2	53.5	35.3
2070	82,506	9,316	44,147	29,043	11.3	53.5	35.2
2071	81,662	9,275	43,695	28,692	11.4	53.5	35.1
2072	80,837	9,234	43,256	28,347	11.4	53.5	35.1
2073	80,031	9,194	42,829	28,008	11.5	53.5	35.0
2074	79,244	9,152	42,416	27,676	11.5	53.5	34.9
2075	78,478	9,111	42,013	27,354	11.6	53.5	34.9
2076	77,732	9,069	41,622	27,041	11.7	53.5	34.8
2077	77,004	9,026	41,241	26,737	11.7	53.6	34.7
2078	76,296	8,983	40,872	26,441	11.8	53.6	34.7
2079	75,605	8,940	40,512	26,153	11.8	53.6	34.6
2080	74,931	8,897	40,164	25,870	11.9	53.6	34.5
2081	74,274	8,854	39,827	25,593	11.9	53.6	34.5
2082	73,631	8,812	39,500	25,319	12.0	53.6	34.4
2083	73,004	8,772	39,185	25,047	12.0	53.7	34.3
2084	72,390	8,732	38,880	24,778	12.1	53.7	34.2
2085	71,789	8,694	38,584	24,510	12.1	53.7	34.1
2086	71,201	8,659	38,298	24,244	12.2	53.8	34.1
2087	70,625	8,625	38,020	23,980	12.2	53.8	34.0
2088	70,061	8,594	37,748	23,719	12.3	53.9	33.9
2089	69,508	8,566	37,482	23,461	12.3	53.9	33.8
2090	68,966	8,540	37,221	23,205	12.4	54.0	33.6
2091	68,435	8,517	36,965	22,953	12.4	54.0	33.5
2092	67,914	8,497	36,713	22,704	12.5	54.1	33.4
2093	67,404	8,479	36,466	22,459	12.6	54.1	33.3
2094	66,904	8,464	36,222	22,218	12.7	54.1	33.2
2095	66,416	8,451	35,982	21,982	12.7	54.2	33.1
2096	65,938	8,441	35,746	21,750	12.8	54.2	33.0
2097	65,471	8,432	35,515	21,524	12.9	54.2	32.9
2098	65,015	8,425	35,288	21,302	13.0	54.3	32.8
2099	64,570	8,420	35,067	21,084	13.0	54.3	32.7
2100	64,137	8,415	34,851	20,871	13.1	54.3	32.5

Reference Table 2　Projected future population and proportion by age group, 2051-2100: High variant

Year	Population (thousand)				Proportion (%)		
	Total	0-14	15-64	65+	0-14-	15-64-	65+
2051	107,593	13,926	57,997	35,669	12.9	53.9	33.2
2052	106,935	13,843	57,638	35,454	12.9	53.9	33.2
2053	106,271	13,757	57,309	35,205	12.9	53.9	33.1
2054	105,600	13,671	57,022	34,907	12.9	54.0	33.1
2055	104,922	13,585	56,751	34,586	12.9	54.1	33.0
2056	104,236	13,499	56,500	34,237	13.0	54.2	32.8
2057	103,542	13,414	56,245	33,883	13.0	54.3	32.7
2058	102,841	13,331	56,002	33,508	13.0	54.5	32.6
2059	102,133	13,252	55,736	33,146	13.0	54.6	32.5
2060	101,421	13,176	55,467	32,778	13.0	54.7	32.3
2061	100,705	13,105	55,208	32,392	13.0	54.8	32.2
2062	99,989	13,040	54,939	32,010	13.0	54.9	32.0
2063	99,273	12,980	54,661	31,633	13.1	55.1	31.9
2064	98,561	12,926	54,400	31,235	13.1	55.2	31.7
2065	97,854	12,878	54,132	30,845	13.2	55.3	31.5
2066	97,158	12,834	53,830	30,493	13.2	55.4	31.4
2067	96,471	12,795	53,523	30,154	13.3	55.5	31.3
2068	95,798	12,759	53,213	29,825	13.3	55.5	31.1
2069	95,139	12,727	52,903	29,510	13.4	55.6	31.0
2070	94,498	12,697	52,592	29,209	13.4	55.7	30.9
2071	93,874	12,670	52,282	28,922	13.5	55.7	30.8
2072	93,269	12,644	51,973	28,652	13.6	55.7	30.7
2073	92,684	12,620	51,665	28,398	13.6	55.7	30.6
2074	92,118	12,597	51,359	28,162	13.7	55.8	30.6
2075	91,572	12,574	51,055	27,943	13.7	55.8	30.5
2076	91,045	12,551	50,754	27,741	13.8	55.7	30.5
2077	90,537	12,527	50,457	27,552	13.8	55.7	30.4
2078	90,046	12,503	50,167	27,376	13.9	55.7	30.4
2079	89,571	12,477	49,884	27,209	13.9	55.7	30.4
2080	89,111	12,450	49,610	27,050	14.0	55.7	30.4
2081	88,664	12,423	49,346	26,896	14.0	55.7	30.3
2082	88,231	12,394	49,093	26,744	14.0	55.6	30.3
2083	87,809	12,364	48,852	26,594	14.1	55.6	30.3
2084	87,398	12,333	48,622	26,442	14.1	55.6	30.3
2085	86,996	12,302	48,404	26,290	14.1	55.6	30.2
2086	86,603	12,271	48,197	26,135	14.2	55.7	30.2
2087	86,219	12,240	47,999	25,980	14.2	55.7	30.1
2088	85,841	12,210	47,809	25,822	14.2	55.7	30.1
2089	85,471	12,181	47,627	25,663	14.3	55.7	30.0
2090	85,106	12,154	47,450	25,502	14.3	55.8	30.0
2091	84,748	12,128	47,279	25,341	14.3	55.8	29.9
2092	84,394	12,105	47,111	25,179	14.3	55.8	29.8
2093	84,047	12,083	46,947	25,016	14.4	55.9	29.8
2094	83,704	12,064	46,784	24,855	14.4	55.9	29.7
2095	83,366	12,048	46,623	24,695	14.5	55.9	29.6
2096	83,034	12,034	46,463	24,537	14.5	56.0	29.5
2097	82,708	12,023	46,304	24,381	14.5	56.0	29.5
2098	82,387	12,014	46,145	24,228	14.6	56.0	29.4
2099	82,072	12,008	45,986	24,078	14.6	56.0	29.3
2100	81,764	12,004	45,829	23,931	14.7	56.1	29.3

Reference Table 3 Projected future population and proportion by age group, 2051-2100: Low variant

Year	Population (thousand)				Proportion (%)		
	Total	0-14	15-64	65+	0-14-	15-64-	65+
2051	90,933	7,342	47,922	35,669	8.1	52.7	39.2
2052	89,831	7,206	47,171	35,454	8.0	52.5	39.5
2053	88,727	7,079	46,443	35,205	8.0	52.3	39.7
2054	87,618	6,961	45,750	34,907	7.9	52.2	39.8
2055	86,504	6,852	45,065	34,586	7.9	52.1	40.0
2056	85,384	6,751	44,396	34,237	7.9	52.0	40.1
2057	84,259	6,659	43,716	33,883	7.9	51.9	40.2
2058	83,128	6,575	43,045	33,508	7.9	51.8	40.3
2059	81,992	6,499	42,347	33,146	7.9	51.6	40.4
2060	80,852	6,430	41,644	32,778	8.0	51.5	40.5
2061	79,710	6,368	40,950	32,392	8.0	51.4	40.6
2062	78,567	6,312	40,244	32,010	8.0	51.2	40.7
2063	77,425	6,262	39,530	31,633	8.1	51.1	40.9
2064	76,286	6,216	38,835	31,235	8.1	50.9	40.9
2065	75,152	6,175	38,133	30,845	8.2	50.7	41.0
2066	74,028	6,135	37,429	30,464	8.3	50.6	41.2
2067	72,914	6,095	36,747	30,072	8.4	50.4	41.2
2068	71,812	6,054	36,086	29,672	8.4	50.3	41.3
2069	70,725	6,013	35,450	29,262	8.5	50.1	41.4
2070	69,654	5,970	34,842	28,842	8.6	50.0	41.4
2071	68,602	5,927	34,262	28,413	8.6	49.9	41.4
2072	67,569	5,883	33,709	27,977	8.7	49.9	41.4
2073	66,557	5,838	33,183	27,536	8.8	49.9	41.4
2074	65,565	5,792	32,680	27,094	8.8	49.8	41.3
2075	64,596	5,745	32,198	26,652	8.9	49.8	41.3
2076	63,648	5,699	31,736	26,213	9.0	49.9	41.2
2077	62,721	5,652	31,292	25,778	9.0	49.9	41.1
2078	61,816	5,606	30,864	25,345	9.1	49.9	41.0
2079	60,931	5,561	30,453	24,917	9.1	50.0	40.9
2080	60,066	5,517	30,055	24,494	9.2	50.0	40.8
2081	59,220	5,475	29,671	24,074	9.2	50.1	40.7
2082	58,394	5,435	29,300	23,659	9.3	50.2	40.5
2083	57,585	5,397	28,940	23,248	9.4	50.3	40.4
2084	56,795	5,362	28,590	22,842	9.4	50.3	40.2
2085	56,022	5,330	28,250	22,442	9.5	50.4	40.1
2086	55,266	5,301	27,918	22,047	9.6	50.5	39.9
2087	54,527	5,275	27,593	21,659	9.7	50.6	39.7
2088	53,805	5,252	27,275	21,278	9.8	50.7	39.5
2089	53,099	5,233	26,963	20,904	9.9	50.8	39.4
2090	52,410	5,216	26,656	20,538	10.0	50.9	39.2
2091	51,737	5,202	26,355	20,181	10.1	50.9	39.0
2092	51,081	5,190	26,059	19,831	10.2	51.0	38.8
2093	50,441	5,181	25,770	19,490	10.3	51.1	38.6
2094	49,819	5,174	25,488	19,157	10.4	51.2	38.5
2095	49,213	5,169	25,213	18,832	10.5	51.2	38.3
2096	48,625	5,165	24,945	18,516	10.6	51.3	38.1
2097	48,055	5,162	24,686	18,208	10.7	51.4	37.9
2098	47,502	5,160	24,435	17,907	10.9	51.4	37.7
2099	46,967	5,158	24,195	17,614	11.0	51.5	37.5
2100	46,450	5,157	23,965	17,328	11.1	51.6	37.3

Reference Table 4　Selected age-structure indices of future population, 2051-2100:Medium variant

Year	Mean Age (yr.)	Median Age (yr.)	Defining Productive Age as 15-64 Years Old				Defining Productive Age as 20-69 Years Old			
			Age Dependency Ratio(%)			Elderly-Children Ratio(%)	Age Dependency Ratio(%)			Elderly-Children Ratio(%)
			Total	Children	Old-age		Total	Children	Old-age	
2051	51.4	53.5	87.0	20.1	66.9	332.8	77.6	26.2	51.4	195.8
2052	51.5	53.6	87.2	20.1	67.2	334.5	78.0	26.3	51.8	197.3
2053	51.6	53.6	87.4	20.1	67.4	335.8	78.5	26.3	52.2	198.8
2054	51.6	53.7	87.4	20.0	67.4	336.5	79.0	26.3	52.7	200.1
2055	51.7	53.7	87.4	20.0	67.4	336.9	79.3	26.3	53.0	201.1
2056	51.7	53.8	87.3	20.0	67.3	336.8	79.5	26.3	53.1	201.6
2057	51.8	53.8	87.2	20.0	67.2	336.4	79.6	26.4	53.2	201.9
2058	51.8	53.9	87.1	20.0	67.1	335.7	79.6	26.4	53.2	201.9
2059	51.8	53.9	87.0	20.0	67.0	334.8	79.4	26.4	53.1	201.4
2060	51.8	53.9	87.0	20.0	66.9	333.7	79.3	26.4	52.9	200.7
2061	51.8	53.9	86.9	20.1	66.8	332.2	79.0	26.4	52.6	199.6
2062	51.8	53.9	86.8	20.2	66.6	330.4	78.8	26.4	52.4	198.5
2063	51.8	53.8	86.8	20.3	66.5	328.5	78.5	26.4	52.1	197.1
2064	51.8	53.8	86.7	20.3	66.4	326.2	78.4	26.5	51.9	195.8
2065	51.7	53.7	86.7	20.5	66.2	323.7	78.2	26.6	51.6	194.4
2066	51.7	53.7	86.7	20.6	66.1	321.4	78.0	26.6	51.4	192.9
2067	51.6	53.6	86.8	20.7	66.1	319.0	77.9	26.8	51.2	191.3
2068	51.5	53.5	86.8	20.8	66.0	316.6	77.9	26.9	51.0	189.8
2069	51.5	53.5	86.9	21.0	65.9	314.2	77.8	27.0	50.8	188.1
2070	51.4	53.4	86.9	21.1	65.8	311.8	77.8	27.2	50.6	186.5
2071	51.3	53.3	86.9	21.2	65.7	309.4	77.9	27.3	50.5	185.0
2072	51.2	53.2	86.9	21.3	65.5	307.0	78.0	27.5	50.5	183.7
2073	51.2	53.1	86.9	21.5	65.4	304.6	78.1	27.7	50.4	182.4
2074	51.1	53.0	86.8	21.6	65.2	302.4	78.2	27.8	50.4	181.1
2075	51.0	52.9	86.8	21.7	65.1	300.2	78.3	28.0	50.3	179.9
2076	51.0	52.8	86.8	21.8	65.0	298.2	78.4	28.1	50.3	178.7
2077	50.9	52.7	86.7	21.9	64.8	296.2	78.5	28.3	50.2	177.6
2078	50.8	52.6	86.7	22.0	64.7	294.3	78.6	28.4	50.2	176.5
2079	50.8	52.5	86.6	22.1	64.6	292.5	78.7	28.6	50.1	175.4
2080	50.7	52.5	86.6	22.2	64.4	290.8	78.8	28.7	50.1	174.4
2081	50.6	52.4	86.5	22.2	64.3	289.0	78.9	28.9	50.0	173.4
2082	50.6	52.3	86.4	22.3	64.1	287.3	78.9	29.0	50.0	172.4
2083	50.5	52.2	86.3	22.4	63.9	285.5	79.0	29.1	49.9	171.4
2084	50.5	52.1	86.2	22.5	63.7	283.8	79.1	29.2	49.8	170.4
2085	50.4	52.1	86.1	22.5	63.5	281.9	79.1	29.4	49.7	169.4
2086	50.3	52.0	85.9	22.6	63.3	280.0	79.1	29.5	49.6	168.4
2087	50.3	51.9	85.8	22.7	63.1	278.0	79.1	29.6	49.5	167.3
2088	50.2	51.8	85.6	22.8	62.8	276.0	79.1	29.7	49.4	166.2
2089	50.2	51.8	85.4	22.9	62.6	273.9	79.1	29.8	49.2	165.0
2090	50.1	51.7	85.3	22.9	62.3	271.7	79.0	29.9	49.1	163.8
2091	50.0	51.6	85.1	23.0	62.1	269.5	78.9	30.1	48.9	162.5
2092	49.9	51.5	85.0	23.1	61.8	267.2	78.9	30.2	48.7	161.2
2093	49.9	51.4	84.8	23.3	61.6	264.9	78.8	30.3	48.5	159.8
2094	49.8	51.3	84.7	23.4	61.3	262.5	78.7	30.5	48.2	158.4
2095	49.7	51.1	84.6	23.5	61.1	260.1	78.6	30.6	48.0	157.0
2096	49.6	51.0	84.5	23.6	60.8	257.7	78.5	30.7	47.8	155.5
2097	49.5	50.9	84.3	23.7	60.6	255.3	78.5	30.9	47.6	154.0
2098	49.4	50.8	84.2	23.9	60.4	252.8	78.4	31.0	47.4	152.6
2099	49.3	50.6	84.1	24.0	60.1	250.4	78.4	31.2	47.2	151.1
2100	49.2	50.5	84.0	24.1	59.9	248.0	78.3	31.4	47.0	149.6

Reference Table 5　Trends in live births, deaths, and natural increase, 2051-2100: Medium variant

Year	Crude number（thousand）			Crude rates (‰)		
	Birth	Death	Natural increase	Birth	Death	Natural increase
2051	662	1,614	-953	6.7	16.3	-9.6
2052	658	1,615	-957	6.7	16.5	-9.8
2053	654	1,616	-962	6.7	16.6	-9.9
2054	650	1,618	-968	6.8	16.8	-10.1
2055	646	1,622	-975	6.8	17.0	-10.2
2056	643	1,625	-982	6.8	17.2	-10.4
2057	640	1,629	-989	6.9	17.4	-10.6
2058	637	1,633	-995	6.9	17.6	-10.8
2059	635	1,636	-1,001	6.9	17.9	-10.9
2060	632	1,637	-1,005	7.0	18.1	-11.1
2061	629	1,638	-1,008	7.0	18.2	-11.2
2062	627	1,636	-1,009	7.1	18.4	-11.4
2063	624	1,632	-1,008	7.1	18.6	-11.5
2064	622	1,626	-1,005	7.2	18.7	-11.6
2065	619	1,618	-999	7.2	18.8	-11.6
2066	617	1,606	-990	7.2	18.9	-11.6
2067	614	1,594	-980	7.3	18.9	-11.6
2068	611	1,578	-967	7.3	18.9	-11.6
2069	608	1,561	-952	7.4	18.9	-11.5
2070	605	1,541	-936	7.4	18.9	-11.5
2071	602	1,521	-919	7.4	18.8	-11.4
2072	599	1,499	-900	7.5	18.7	-11.2
2073	596	1,477	-881	7.5	18.6	-11.1
2074	593	1,454	-861	7.6	18.5	-11.0
2075	590	1,431	-841	7.6	18.4	-10.8
2076	587	1,408	-822	7.6	18.3	-10.7
2077	584	1,386	-803	7.6	18.2	-10.5
2078	581	1,365	-784	7.7	18.1	-10.4
2079	578	1,345	-767	7.7	18.0	-10.2
2080	576	1,326	-750	7.8	17.9	-10.1
2081	574	1,308	-734	7.8	17.8	-10.0
2082	572	1,291	-719	7.8	17.7	-9.9
2083	570	1,275	-705	7.9	17.6	-9.7
2084	569	1,260	-691	7.9	17.6	-9.6
2085	567	1,246	-678	8.0	17.5	-9.5
2086	566	1,232	-666	8.0	17.4	-9.4
2087	566	1,219	-654	8.1	17.4	-9.3
2088	565	1,207	-642	8.1	17.4	-9.2
2089	565	1,196	-631	8.2	17.3	-9.1
2090	564	1,184	-620	8.2	17.3	-9.1
2091	564	1,173	-610	8.3	17.3	-9.0
2092	564	1,163	-599	8.4	17.3	-8.9
2093	564	1,152	-589	8.4	17.2	-8.8
2094	564	1,142	-578	8.5	17.2	-8.7
2095	564	1,131	-567	8.5	17.2	-8.6
2096	563	1,120	-556	8.6	17.1	-8.5
2097	563	1,109	-545	8.7	17.1	-8.4
2098	563	1,098	-534	8.7	17.0	-8.3
2099	563	1,086	-523	8.8	16.9	-8.2
2100	563	1,075	-512	8.8	16.9	-8.0