A. INTRODUCTION: ONSET OF DEPOPULATION AND EMERGENCE OF THE MOST AGED SOCIETY IN THE WORLD

The population in Japan peaked in the period from 2004 to 2007 and gradually started to decline in 2008. Although the rate of decline as of October 2009 is very low—less than 0.2 percent—according to the UN projection, Japan will have lost 20 percent of its current population by 2050 (in fact, according to the latest official population projection in Japan (IPPS projection), Japan will lose 26 percent of the population in the same period. This discrepancy is mainly due to different assumptions on fertility rate). This depopulation will advance at a higher pace each year: Japan will lose more than 500,000 people every year from 2017 to 2038, and more than 1 million people per year from 2039 and onward (IPPS projection).

Not only is this rate of decline remarkable in absolute terms, it is also exceptionally high when compared internationally. Considering only countries with populations of 10 million people or more in 2005, the percentage of the population Japan will lose from 2005 to 2050 is second only to Ukraine (according to the UN projection. The Japanese rate of reduction is the highest in the world according to the IPPS projection). As a result, the share of the Japanese population out of the entire population of the world will decrease by half, from 2.0 percent in 2005 to 1.1 percent in 2050. The primary cause for this striking decline is the prospect that the current low Japanese fertility rates will persist in the future as well.

The aforementioned depopulation is deeply connected with a strong negative population momentum. Population momentum refers to the strength of birth rate and death rate trends intrinsic to a given age composition. In Japan, the scale of the generations who will become parents in the future is shrinking significantly due to low fertility rates – in fact, the fertility level has remained consistently below the replacement level fertility ever since 1974. On the other hand, deaths are being delayed due to a remarkable extension of the life expectancy in recent years, and as a consequence the population of the elderly has been increasing steadily. Put together, these factors will lead to a population composition with an accelerating tendency toward lower birth rates and higher death rates. In fact, the vital statistics of Japan is about to form a phenomenal so-called "Japanese cross" due to the reduction of the number of live births and increase of the number of deaths (figure 1).

At this moment, Japan is positioned just around the cross. The significant downward trend in the number of live births in the future shown in the figure is the result of a spiral of continuing reduced reproduction caused by persistent low fertility rates. Meanwhile, the increase of the number of deaths occurs in spite of the fact that Japan maintains the highest life expectancy at birth in the world, which is somewhat paradoxical. Considering the fact that the natural growth of the population is obtained by subtracting the number of deaths from the number of live births, this figure illustrates clearly why the Japanese population will decline at an accelerating rate in the future.

Moreover, an additional recent fact related to the population in Japan deserving of special mention is that Japan has had the highest proportion elderly (percentage of the population of 65 years of age and older) in the world since approximately 2005. According to the projection by the UN, the proportion elderly in Japan was ranked 23rd in the world, the ordinary level among advanced nations, around the beginning of the 1990s. In 2005, only 15 years later, however, Japan had gone all the way to the top (the year in which Japan achieved the highest elderly population percentage in the world varies slightly by age group: 2003 for 60 years of age and older, 2006 for 75 years of age and older, and 2007 for 90 years of age and older). Moreover, according to the same projection, Japan will continue to have the highest proportion elderly in the world; it is projected to reach 37.8 percent in 2050 (high variant 33.7 percent, low variant 42.6 percent, IPSS projection 39.6 percent).

This advancement of the aging of the population can be seen in terms of the population decline mentioned above. While the part of the Japanese population less than 65 years of age is projected to decline by 44.5 million people by 2050 (9.4 million among the child population, 35.1 million among the working-age population), the population aged 65 years and up, on the contrary, is projected to increase by 11.9 million. Thus, although Japan is already the most aged society in the world, the full-scale aging has not even started yet; in fact, it will advance much further from now on.

Japan occupies such a peculiar position in terms of aging of population because of its characteristic dynamics of vital events. Japan has one of the lowest fertility rates in the world, which is a major driving factor of the aging of population. On the other hand, Japan has had the longest life expectancy at birth in the world since the first half of the 1980s, when both genders are combined and compared with other countries, and this condition is anticipated to hold for a while. As a consequence of this extreme combination of vital rates, the population has aged at a higher speed and to a higher level than any other country in the world, resulting in a very high percentage of elderly population.

This is clearly illustrated by the scatter plot of the UN projection shown in figure 2, which depicts the total fertility rate in each country of the world against the life expectancy at birth. Furthermore, since corresponding assumptions in population projections for 2045 to 2050 show that this trend is not going to change into the future, the peculiar position of Japan in this graph is not likely to change according to both the UN projection and the IPSS projection (the assumption of life expectancy at birth of 87.08 made by the UN (2009) is slightly higher than the IPSS projection of 86.54. The total fertility rate assumption of 1.60 in the UN projection is considerably higher than the value of 1.26 used in the IPSS projection, on the other hand. As a consequence, the proportion elderly of the IPSS projection is 1.8 percentage points higher than that of the UN projection).

This combination of low fertility rate and high longevity is the very cause of the internationally striking population changes of Japan. A straight illustration of this can be obtained by comparing aging of population between Japan and France. The life expectancy at birth in France is as high as that of Japan, but in contrast to Japan the fertility rate is at the replacement level. After several decades with these differing vital rates, the proportion elderly in 2050 will be 37.8 percent in Japan (ranked 1st) as compared to 26.9 percent in France (ranked 27th), and the median ages are 57.0 in Japan (ranked 1st) compared to 44.8 in France (ranked 41st). Thus, a comparison between the population projections of these two countries clearly shows that the actual cause of the exceptional aging of population of Japan is not – as is commonly believed – the world's fastest extension of lifespan.

As explained above, these two types of population changes, depopulation and aging of population, which will cause a wide variety of problems in the Japanese social economy in the future, are caused and promoted by the prolonged continuation of low fertility rates below the replacement level fertility, which Japan has been experiencing since the 1970s. Because of the population momentum, the course of these changes is already inevitable at this point, but the achieved level and pace of changes depend on the future fertility rates, albeit only slightly.

This paper first provides an overview of the trends of fertility rates in Japan and then examines the future prospects by analyzing recent trends, particularly the recently observed upturn of the fertility rates. In doing so, we intend to make use of the population projections as an effective tool for analysis of the fertility trends.

B. Trend of fertility rate and recent increase

1. *Brief history to the lowest low fertility in Japan*

The Japanese postwar years of the six decades up to 2005 may be divided into three phases in terms of fertility trends (figure 3). The first period is of the fertility transition consists of the postwar baby boom (1947-49) and subsequent rapid fertility decline (1950-59). The fertility reduction in this period is a part of the first demographic transition outside of the Western domain, and is characterized by a reduction of marital fertility.

The second is a period of post demographic transition (1960-74) with relatively stable fertility, which was at around the population replacement level. This period include a sudden drop of fertility in 1966 due to people's response to a superstition associated with "Hinoe-uma (fiery horse)" year followed by the second baby boom which is the echo of the post war baby boom. Though the total fertility rate (TFR) fell by one forth in the Hinoe-uma year, it was virtually not affected during the second baby boom.

The third is the period of below-replacement fertility since 1974, showing a persistent decreasing trend until it hit the bottom with TFR 1.26 in 2005. Though short upturns of fertility rate were observed during 1982-1984 and 1994, the overall trend was continued decline. The number of live births temporarily leveled off in the 1990s when the numerous second baby boomers became parents, but it has shifted to a downward trend again since year 2000.

This long-lasting fertility reduction since the mid 1970s and these lowest-ever figures in TFR have drawn wide public attention particularly since the so-called "1.57 shock" in 1990 (TFR in 1989 was less than the unusual lowest figure of the Hinoe-uma year, and public attention was drawn mainly by the mass media). Shortly after, the government coined a new term "Shoshika" which means a reduction in the number of children, or "child bust". Since then Shoshika became a standard word that expresses not only low birth rate but also every kind of unfriendly circumstances the society poses against family formation or childbearing.

After the government established an inter-ministerial liaison committee for "Creating an environment where people can bear and rear healthy children" in 1990 (Atoh 2002), it started to take policy responses to low fertility issues with the series of policy measure packages such as the so-called "Angel Plan" (the 1995-1999 period) and "New Angel Plan" (the 2000-2004 period) both of which aimed at improving and expanding childcare services. See table 1 for other major policy packages toward the low fertility situations.

In spite of a series of measures and escalating public awareness, fertility continued to decline until it fell into so called the lowest low level for the first time in 2003, and reached the ever lowest TFR of 1.26 in 2005. The number of live births, which exceeded 2.09 million in 1973, had decreased by nearly half, to 1.06 million, in 2005—again the lowest number recorded since the Second World War.

The year 2005 is a dividing ridge of population trends in several senses; first the population of Japan was announced to have decreased from the previous year for the first time after about hundred and fifty years of rising trend since the closing period of the Tokugawa era, secondly the proportion of population aged 65 and above exceeded one fifth or 20.2 percent marking the highest in the world, and thirdly the number of birth and TFR were recorded as the lowest.

Nevertheless, fertility made an upturn immediately after in 2006 and onward. The TFR rose by 0.06 to 1.32, which is the largest amount of increase since 1970s. It kept rising to 1.34 in 2007, and 1.37 in 2008. It is since 1982-1984 that uprising continues for more than three years. Although the extent of the increase is minor and the level still far below replacement, this recent upturn of fertility is a significant turnaround since it is unique in terms of magnitude and continuation. A detailed examination of this phenomenon is given later.

2. *Background factors of the low fertility*

Although the trend of declining fertility in Japan does bear some similarities to those of Western countries in terms of basic declining patterns and socio-economic backgrounds, clear distinctions are apparent. One of the prominent disparities is found in illegitimate births. The proportion of illegitimate births to all births has remained at around one percent for more than three decades, and was 2.03 percent in 2007. In other words, almost all births occur in wedlock in Japan. This low prevalence of illegitimacy is considered to be a reflection of low prevalence of cohabitation among youth, which is another major distinction from Western societies. The proportion of never married women aged 18 to 34 currently cohabiting is reported to stand at 2.3 percent according to a survey taken in 2005, steadily increasing however (Kaneko et al 2008).

In such a society where childbearing out of wedlock is negligible, a significant reduction in the proportion of married in the most reproductive age directly leads to a decrease of the fertility rate (Kaneko 1999). In 1975, 77.8 percent of women in their late twenties, the major child-bearers, had spouses; this ratio, however, had dropped down to less than half (38.2 percent) in 2005. This decrease in the proportion of married women is a result of massive marriage postponement. Furthermore, the percentage never married has been increasing among the population in their thirties or older as well; thus, the possibility of a tendency of not marrying at all, or an increase in the lifetime proportion of those never married (evaluated at age fifty), must be taken into account as well, although it has not risen significantly from the previous level of around five percent (7.25 percent in 2005). When looking at the recent changes in marriage behaviors, it is sensible to expect that the tendencies of marrying later and not marrying at all are advancing simultaneously.

Until 1990s, married couples tended to have children according to relatively stable, predictable patterns. However, looking at couples married in late 1980s and onward, some changes in these patterns can be observed as well. The result of the National Fertility Survey shows that the number of live births by couples who have been married five years or longer is on a downward trend (table 2). In fact, the cumulative number of live births among couples who have been married for 15 to 19 years, i.e., people who can be expected to have completed childbearing, has remained stable at 2.2 children per couple for more than 30 years since the 1970s; however, in the 2005 survey, this number decreased for the first time, to 2.09 children per couple. The numbers of children ever born among couples with shorter marriage duration also indicate decreasing tendency, which suggests continuation of marital fertility reduction in younger cohorts.

The marital fertility may be decreasing in accordance with changes in marriage behaviour such as postponement of wedding because the average children ever born to married women by certain age is dependent on duration within sexual union and would be reduced with increasing age at marriage. This marriage induced reduction in marital fertility is not seen as changes of marital reproductive behavior. In figure 4 the dotted lines represent the expected values which are those predicted from age at first marriage in keeping with the statistical relationships derived from the logistic regression of the age in a quadratic form on the number of children ever born by each age in senior cohorts born in 1935-1955. Though the dotted lines show some declining trends, the reduction is the marriage induced outcome. The actual values deviate from the expected and the reduction beyond it are the genuine changes in marital fertility from behavioural changes. The cohort trends of actual values indicate large reduction of the number of children within marriage up to age 30 and 35 of wives as compared to the marriage effects (expressed by the dotted lines), which means that there reduction in pace of having children.

Incidentally, the upward trend of the average number of children ever born up to age 20 is caused by increase in incidence of marital birth from pre-marital pregnancy which is prevailing in Japan particularly since late 1990s. The 26.7 percent of first births in Japan is estimated to be conceived prior to marriage in 2004 (MHLW 2005). This fact indicates the continuation of the deep-rooted social norms keeping a firm connection between childbearing and marriage in this society, which cause the aforementioned scarceness of illegitimacy in Japan.

Another subject worthy of attention when considering the various factors contributing to the lowering percentage of the married population is the increasing divorce rate that has been observed in recent years. The percentage of divorcees in their latter 40s, which was 3.8 percent in 1975, doubled to 8.1 percent in 2005. It should be noted that the effect of divorce prevalence on overall fertility depends on the trend of remarriage as well; it is necessary to establish a framework for ascertaining the trends of both and reflect them in the fertility projections at the same time. In the latest official population projection, it is attained by introducing a parameter that represents overall effect of divorce, bereavement and remarriage en bloc on fertility.

3. *On upturn of period fertility rate in 2006 and onward*

As already explained, the total fertility rate (TFR) in Japan reached its lowest value ever in 2005. In the following year, however, it showed a surprisingly strong recovery and has been increasing since, at least until 2008. Figure 5 shows the TFR trend together with the development of the population replacement level and different assumptions used for the Population Projections for Japan. In this graph, the values recorded in the three years from 2006 to 2008 are shown as dots. This reversal gives the impression that the constant decline throughout the years leading up to 2006 has suddenly turned around. In fact, the TFR values in 2007 and 2008 are higher than any of the fertility assumptions of the latest official population projections based on the values until 2005, even the high variant assumption.

In the past, such sudden upturns were also observed in the three-year period from 1982 to 1984 as well as in 1994. In the case of the upturn in 1982 to 1984, the TFR of 1.74 in 1981 had increased by 0.07 by 1984. In 1994, an increase of 0.04 was recorded in a single year. The increase observed from 2006 to 2008 amounts to 0.11, which is clearly a significant increase compared to these past upturns. Moreover, the increase of 0.06 in 2006 is the greatest increase observed in a single year since the

1970s.

In contrast, looking at the TFR in the years immediately following the periods of past increase, both 1985 and 1995 witnessed relatively sharp reductions of -0.05 and -0.08, respectively. It is not known if this most recent increase will follow the same profile as in the past, or if it might last for a relatively long period of time. However, looking at the monthly development shown below, some deceleration and signs of stagnation can already be observed in 2009.

Whether this recent upturn is temporary or caused by actual, substantive changes in the basic course is considered to be of significant importance when investigating the future fertility trend. The assumptions on fertility rate in the latest population projection, in particular, are based on the actual values measured until 2005, and in the medium-variant scenario the long-term TFR value is projected to end up at the very low level of 1.26. Since this assumption was established by projecting cohort fertility rates, a deviation of actual values in recent years does not directly mean that these assumptions are inappropriate. Nonetheless, if the deviation occurs as a result of more basic changes in the reproductive behaviors, the assumption must be reviewed for the future projections. Thus, this upturn is examined in more detail in the following.

From the mid-1990s to the beginning of the second millennium, one by one, the so-called lowest low fertility countries in Europe experienced reversals of their fertility rate trends. Indeed, as of the time of this writing, the majority of these countries have broken away from the lowest low fertility status (Goldstein et al. 2009). In fact, while the occurrence of reversal of fertility rate trend is not limited to low fertility countries, and the period and degree vary, it can be said that the US and most of the countries in Europe are currently experiencing a steady upturn in fertility rates.

To begin with, with few exceptions, the decline of fertility rates in these countries was generally caused by a general delay of childbearing known as "postponement transition" (Kohler et al. 2002, Sobotka 2004, Billari 2008); Goldstein et al. explain the fertility rate upturns in recent years were caused by the weakened tempo effects on the period fertility rate due to this transitional trend diminishing or dying out. They call this process "tempo transition" (Goldstein et al. 2009). One very important point in this perspective is the interpretation that the cohort fertility rates have not actually reached the level of 1.3, called the lowest low, in any of the countries and this level in the period TFR is a transient phenomenon due to the aforementioned tempo effect.

If this interpretation is correct and the fertility rate upturn in Japan observed since 2006 is caused by a mechanism similar to that of the trend observed in the US and countries in Europe, there is a possibility that the recovery may continue for a relatively long period of time in the same way as has been observed in the US and Europe, in which case it is unlikely that the future cohort fertility rate will drop below the lowest low level, as projected by the medium (and low) variant assumptions in the Population Projections in Japan.

a. Close look at the upturn – Examination of monthly data

In order to analyze changes in the various fertility rates in Japan in recent years more closely, the observed data is first plotted on a monthly basis. Figure 6 shows monthly fertility rates and their trends after making seasonal adjustments by birth order in the period from January 2002 to June 2009 (the latest values obtained as of November 2009). In the figure, fertility rates are indicated as annual values (corresponding to 365 days), obtained by adjusting the age-specific number of births in individual months to have the same number of days and dividing the values by the projected population by age in the middle of the given month. Moreover, seasonal adjustment is performed according to the U.S. Census Bureau's X-11 method. Please note that the annually published values of fertility rates in Japan use the population as of October 1, rather than the middle of the period, as the denominator. Thus the fertility rate values become slightly higher than the case here, where the population in the middle of a month is used.

First, looking at the monthly changes of the overall TFR by birth order, it is seen that the TFR began to drop suddenly from December 2004, and remained low for six months until May 2005. Then, however, after bottoming out at this point, the TFR shows a subsequent sharp rise. This rising trend accelerates from around December 2005, exhibiting the largest increase in March 2005. Although the rate of increase significantly drops from around June 2005, the rise itself continues steadily until

October 2008 and exhibits a local maximum in November. The TFR then declines slightly or levels off for seven months afterward.

The period where these changes occurred is divided into the following detailed phrases.

(1) December 2004 to May 2005 (6 months): Sudden drop
(2-1) June 2005 to November 2005 (6 months): Sharp rise
(2-2) December 2005 to May 2006 (6 months): Sharpest rise
(3-1) June 2006 to February 2007 (9 months): Level off for 1st and 2nd children
(3-2) March 2007 to November 2008 (21 months): Slow increase
(4) From December 2008 and onward: Level off or decline

Each of the four phases—(1) sudden drop, (2) sharp rise, (3) slow increase, and (4) level off or decline—shows significant change. The phases where the TFR rises, (2) and (3), can further be divided into two sub-periods each, according to the difference in pace. The most remarkable change in this period is the change from phase (1) to phase (2), where the TFR bottoms out in May 2005 and shifts from dropping sharply to rising sharply. The time period and pattern of this change are common to the TRF for all birth orders (except that the fertility rate of the first child does not bottom out until June 2005), and it looks as if a sudden restraint and release of childbearing occurred simultaneously among women of all parities.

The second most remarkable change is the change from phase (2) to phase (3), where the TFR of the first and second children sharply increases until December 2006 and then shifts to a slow rise, which continues until December 2008. Note that this pattern is not observed in the TFR of the third and more children; in this particular case, the trend continues to rise at a consistent pace until phase (4).

Since these children were conceived approximately nine months before each phase, it is necessary to retrace the timing of pregnancy for each phase in order to investigate the triggers of phase shifts. However, no obvious factors have been found so far (one significant event that occurred in August 2004, i.e., nine months before May 2005, where the greatest change was observed, is the 28th Summer Olympic Games held in Athens, Greece, from August 13 to 29; however, the influence of this event on pregnancy is unknown).

The leveling-off trend observed among all birth orders at the same time in December 2008 and onward in phase (4) may quite possibly signal the end of the rising trend and should be observed closely. Some care must be taken when computing seasonal adjustment according to X-11, as the method tends to generate instability at the terminal parts of time-series data (values may change due to addition of new data), but there can be no doubt that a new trend is beginning in this phase. This phase corresponds to the time period where the influence of the global financial crisis started to spread. However, the period of conception of those births is nine months earlier, where there were no obvious events that might have influenced childbearing to be found.

b. Examination of Tempo Effect – Is it Due to a Catch-up Effect?

The fact that the monthly changes in the fertility rates show the same patterns among all birth orders suggests that the driving force behind these changes is a period effect. That is, if each cohort goes through different changes, there must be some time lag in terms of the changes occurring among higher birth orders. The term period effect here refers to a change in fertility rates caused by certain temporary factors (usually meaning social economic events, such as times of war and economic crisis). In order to examine such changes in the following, it is necessary to define them more clearly.

One of the important points of a period effect is that it leaves little influence on the completed fertility of any cohorts involved, although it may bring about significant changes in annual fertility rates. Here, we will use this characteristic as the definition of a period effect for the time being. That is, a period effect is a fertility rate change observed in a certain period, which does not influence the cohort completed fertility (cohort TFR).

According to this definition, a period effect can be said to be a change in timing occurring in the childbearing schedule in terms of cohort fertility rates. A cohort is considered to have a unique childbearing schedule with a certain potential regularity, and a period effect is a change that causes the actual fertility rates to deviate temporarily from the original schedule without affecting the long-term balance. Not affecting the long-term balance of cohorts means that the change is redeemed by other periods.

It is possible to consider two different types of such changes in cohort childbearing schedules. The first is the case where the childbearing timing of a cohort as a whole shifts. In this case, a well-known tempo effect acts on the fertility rate for a period. That is, if the mean age at birth (MAB) of a cohort is rising, a tempo effect that pushes down the MAB acts on the period TFR. On the other hand, if the rise of the MAB stops or the MAB drops, a tempo effect that pushes up the period TFR comes into play. In this paper, these effects are called type-T period effects (see figure 7 for illustration).

The second type of change encompasses disturbances occurring only for parts of a cohort childbearing schedule. That is, this type encompasses fertility rate changes caused by a cohort reacting to certain events occurring in the environment and hastening or postponing its childbearing time period.

In fact, a case example that clearly shows the second type of change exists in recent Japanese history: the so-called Hinoe-uma (Fiery Horse) phenomenon, which occurred in 1966. The Hinoe-uma is a calendar event based on Chinese astrology occurring once every 60 years. Due to the superstition that girls born in that year would cause bad luck for their husbands, many couples avoided having children in that year, and the fertility temporarily dropped by one fourth from the average level (the TFR in 1966 was 1.58 or 75 percent of the average level over 1963 through 1969 except 1966). However, all the main cohorts involved in childbearing in this year (the cohorts born from 1923 to 44, who were 22 to 49 years of age at that time) compensated for this loss in the following years and no cohorts exhibited TFR values lower than 2.0. In other words, the Hinoe-uma phenomenon had little effect on the cohort TFR, making it an example of a pure period effect. This type of fertility rate change is called type-H period effects here.

It should be noted, however, that some fertility rate changes caused in reaction to changes in social economy do have lasting influence on the cohort completed fertility. Because they are changes in individual cohorts, it is appropriate to call them period-cohort effects or similar, considering them as a type of cohort effects induced by a certain period. However, whether this type of period changes is limited to pure period effects (i.e., type-H period effects) or is a period-cohort effect affecting the cohort's long-term balance, cannot be known until the affected cohorts complete their childbearing process. Moreover, in terms of the occurrence mechanism, it is irrelevant whether or not it affects a cohort's long-term balance. For this reason, there should be no problems in handling such period changes as type-H period effects from the viewpoint of investigating causes of the occurrence. Period-cohort effects may simply be considered to be the results of prolonged type-H period effects (hereinafter written as type-H').

Now, in recent fertility changes in Japan, it is speculated that type-H period effects are important because the same changes are seen among all the fertility rates by birth order, as explained above. Moreover, if the changes that occurred in this period are the results of type-T period effects, it would mean that low fertility rates before reaching the point of reversal were caused by tempo effects due to postponement transition of each cohort and that upturns of fertility rates would signify regression to cohort fertility level due to the shift in childbearing timing ending. However, this can be ruled out by observing the monthly MAB development simultaneously (figure 8). As can be seen, the MAB has been increasing without leveling off throughout the entire period of drop and upturn in the fertility rate since 2002 for the first and second children, who are the main force of fertility. Thus, it is unlikely that the reversal trend is a sign of reverting to the cohort level due to tempo effects dying out, i.e., "tempo transition."

Bongaarts and Feeney (1998) proposed an index that eliminates tempo effects from period TFR. Here, we will use this index to check the development of the effects acting on the period TFR in Japan and whether or not they are tempo effects[1]. The index proposed by Bongaarts and Feeney referred to as ATFRp in the following. Figure 9 illustrates the development of ATFRp along with the normal TFR. Tempo effects are represented as the differences between ATFRp and TFR. It is seen that relatively large tempo effects have been in action even after the start of upturn in 2006, reflecting the continuous rise of the MAB mentioned above. It can furthermore be seen that the tempo effects in 2006 and 2007 amount to 0.17 and 0.14, respectively, which are substantially larger than the value of 0.12 in 2005 when the TFR bottomed out. The value for 2008, 0.09, is only tentative, but at least it does not appear as if the rise of TFR since 2006 is caused by tempo effects dying out (here fertility rates are calculated with only births to Japanese women).

Now, the ATFRp approach estimates tempo effects under certain assumptions. That is, the age-specific period fertility rate is composed of age-specific fertility rates of a large number of cohorts, but the ATFRp index proposed by Bongaarts and Feeney assumes that the age-specific period fertility rate is composed of age-specific fertility rates of all cohorts who are experiencing the timing shift at the same speed, and then eliminates the tempo effects (or tempo distortion) caused by this shift (Bongaarts and Feeney 1988). The uniform timing shift speed $r(t)$ in year t is given as the change in the average age of childbearing in a given period compared to the previous year (in this paper, the average value of change from the previous year and the change to the next year is used).

This view implicitly allows the timing change speed of fertility rate $f(tc+a, a)$ experienced at a certain age (a) in a certain year (t) to fluctuate by age a (that is, for each year t) when focus is placed on a single cohort (birth year tc) and, instead, assumes that all cohorts involved have a common timing change speed within a given year (period-shift framework). That is: $\mathrm{ATFRp}(t) = \Sigma f(t,a) / (1 - r(t))$, where Σ is the sum for age a (note that this calculation is performed for each birth order and the value is obtained by summing up the results).

This view prioritizes harmonization among age-specific period fertility rates. However, in some cases it might be more appropriate to prioritize harmonization of age-specific cohort fertility rates; that is, a framework in which the timing change speed of fertility rate of a single cohort would be seen as characteristics unique to the cohort and tempo effects it has on the period as characteristics unique to the cohort as well (cohort-shift framework). This can be achieved by expressing the timing change speed of a cohort as a function of cohort birth year tc, the timing effect on the year for this cohort as $\tau(tc) = 1/(1 + r(tc))$ (van Imhoff 2001), and the period TFR with adjusted timing effects as $\mathrm{ATFRc}(t) = \Sigma f(t,a) / \tau(t-a)$, where Σ is the sum for age a (note that this calculation is also performed for each birth order and the value is obtained by summing up the results).

Note that in this calculation, in addition to actually measured age-specific fertility rates, the timing change for related cohorts is required, and has to be obtained from cohort fertility rate assumptions in the Population Projections. Please be aware that it is only the timing changes in future fertility rates that are required, and hence the fertility rates themselves are not used.

Figure 9 shows the result of calculating the ATFRc index from the fertility trend data recorded in Japan. In the period leading up to 2000, both ATFRp and ATFRc follow very similar paths. From 2000, however, they show slightly different behaviors. In particular, in 2000 and onward, ATFRc continues dropping alongside the TFR trend and also indicates a rapid increase at the upturn in the same way as for TFR. Assuming that the cohort-based timing change is essentially continuous, the period effects are filtered and show smooth development, but persistent tempo effects still appear clearly, suggesting that the true cohort TFR is actually higher than the values observed in each period.

The two adjusted TFR indices show upturn in the same way as for actually measured TFR, suggesting the increase in this period is not the recovery brought about by the elimination of type-T tempo effects, but is a substantive rise of type-H effects.

Now, the discussion above suggested that the main cause of the recent upturn in the fertility rate is a type-H period effect. However, it has also been confirmed that the MAB for the first and second children continuously rises, which means that tempo effects that push down the period TFR exist, as can also be seen from the development of the ATFRp and ATFRc indices for this period. The question is then, how the scale of type-H period effects can be measured while such effects exist.

We propose to apply a model based on the population projections. In the "Population Projections for Japan," a cohort model is used for formulating fertility rate assumptions. In particular, the childbearing schedule in the entire reproductive life course is projected for individual single year cohorts of women, and this schedule is then reorganized in order to project age-specific fertility rates on a yearly basis from the past into the future.

The projection model is particularly good at describing the age-specific cohort fertility rate, and is regarded as fully capable of describing and expressing regularities latent at the base of the cohort childbearing schedule (figure 10). Of course, there are cases where the achieved values deviate from the regularities in some ages. In fact, these deviations are exactly period effects of type-H. For this reason, the period effect can be obtained as the difference between the fertility rate achieved in a given year/age and the corresponding model value. On the other hand, type-T period effects caused by the shift of cohort childbearing schedule are included in the projected fertility rate and are thus excluded from the period effect obtained as the difference between the projected value and achieved value; only type-H period effects are captured in this way.

Under normal circumstances, the model fertility rates used in the Population Projections for Japan are future predictions that have not yet been achieved. In contrast, the method proposed here uses model values of years and ages in the past. How accurate the measurement result achieved by this method is, depends on the accuracy of the cohort model. The applicability of the cohort model is high and the model is accurate for cohorts who have completed their childbearing process up to significantly high ages, as shown in the graphs above. For young cohorts with little experience in the childbearing process, however, there are more speculative factors involved in their remaining childbearing schedule and the accuracy of the model is less well known. Therefore, the measurement values should be treated as provisional for the most recent years, where such cohorts contribute more.

Figure 11 illustrates the result of measuring type-H period effects using the method proposed above. Figure 11-a and figure 11-b shows projected values of type-H period effects by age group and by birth order as bar graphs, respectively (left scale). Both figures show the total period effect, i.e., period effects on TFR, as line plots (right scale) as well. Note that the right scale is twice as large as the left scale.

In the period up to 2005, the absolute value of period effects on the TFR (the scale on the right axis) exceeds 0.03 only in 1989 and 1994. In other years, the period effects, in general, amount to very little. In 1989 and 1994, some changes can be recognized also in the figures showing the annual TFR development (figures 5 and 9). 1989 is the year the TFR dropped below the value in the year of Hinoe-uma and recorded the lowest value in the history and the year of "Merkmal" that triggered the Japanese society's awareness of its low fertility rates. Note that the period effect value is -0.034; the absolute value is not very large. On the other hand, in 1994, the period effect value is 0.058, which is quite prominent in the period up to 2005. Although the cause of this effect is not certain, one possible cause that has been suggested is the marriage between Crown Prince Naruhito to Princess Masako Owada, who was a diplomat at the time, in June of the previous year, which attracted the attention of many citizens.

In other years, positive period effects are observed in the three-year period from 2000 to 2002, among the 20 to 24-year old women and for the first children only. Millennium effects were anticipated in this period, but the TFR itself did not show any significant rise. At closer inspection, it is noted that the fertility rates of the age group of 22 to 25 years of age for the first children show actual values higher than expected from the cohort model.

In the sections above, the relatively prominent changes that occurred up to 2005 were discussed. Compared to those changes, the recent three-year period from 2006 to 2008 shows a very strong rise in terms of period effects. The projected period effects are high, 0.065, 0.095, and 0.134, respectively, and indicate a yearly upward trend. Looking at the values by age group (figure 11-a), the upward effects in the 30s age group are outstanding in each year. In 2007 and 2008, the value shows a dramatic rise for the age group in the latter half of the 20s as well. Looking at the values by birth order (figure 11-b), the period effect seems to contribute to all orders roughly equally.

Table 3 shows the contributions of age-specific and birth-order-specific subgroups to the entire period effects for both 1989 and 1994, for the purpose of comparison. In 1994, which shows relatively large positive period effects, the relative contribution of the age group of 25 to 29 years of age is large, while in 2006 to 2008, the contributions of the age groups of 30 to 34 years of age and especially 35 to 39 years of age are dramatically high. Moreover, in terms of birth order, while the contribution of the first children is large in 1994, the contribution of the third and further children is large in 2006 to 2008. Taking these characteristics into account, the period effect patterns in these recent three years are clearly different from the past.

In general, the rise of fertility in this period is known as "last-minute birth" and similar terms. These terms generally imply that women who delayed in having children are now having more children while they are still able to. The age patterns of period effects show an upward movement in age groups from the middle of the 30s to the early 40s, which also supports this view. This generation includes the second baby boomers that were born in the period from 1971 to 1974. They tend to be promoters of lower fertility rates, who significantly postponed family formation and/or childbearing. For this reason, if they wish to have a fixed number of children in their lives, this period happens to be their last chance. If only period effect patterns are examined, however, they not only tended to give birth to the first and second children they felt compelled to have in order to avoid childlessness and only-child, but also gave an increasing number of births to the third and further children in a rather prominent manner. This suggests that the people who shifted towards more reproductive behaviors were not limited to those who had delayed family formation specifically, but encompassed a wider range of people as well. The significance of this will be examined in the subsequent discussion.

C. FERTILITY PROSPECTS IN THE LATEST POPULATION PROJECTION

The fertility assumptions in the population projection in Japan are constructed in the following manner. First the first marriage rates, fertility rates, marital fertility, and fertility of the divorced and bereaved are measured from the population statistics. Then cohort developments of the life cycle indices from the measurements are observed to extrapolate their trends into young and future cohorts. Though this approach does not promise to offer the realizing future fertility, of course, it provides an important reference point since it gives somewhat objective outcome from the actual measurements.

In this section, I describe outline of fertility assumptions in the latest population projection, including prospects of reproductive life course of Japanese women as a by-product of the projection.

1. *Outline of population projection for Japan and its fertility assumption*

The official population projection in Japan is published every five years following publication of census results. The latest projection was announced in December 2006, based on the results of 2005 Census. Since the cohort component method is used for the projection, assumptions of future fertility rate with other components, i.e. future survival rate, and international migration as well as jump-off population, are to be build. Those assumptions are made through the projective method based on the actual trends of demographic indicators pertaining to each component.

Fertility assumptions underlying the projection were made on the basis of the cohort-fertility method, or the life course approach. That is a projection of age specific fertility rate of each female birth cohort including those who have not yet completed their reproductive processes, and it is done through statistical estimation and demographic projection of parameters indicating life cycle characteristics of fertility components. The components include timing and prevalence of first marriage, completed fertility of first-married couples and effect of divorce, bereavement and remarriage on fertility.

The projection uses cohort rate rather than period rate, because the former is expected to develop in a more stable manner in long in the view. Period fertility rate is subject to fluctuations caused by the period effects of type H which, by definition, do not reside in cohort rate. However the projection reflects the period effect of type T which is induced by timing changes of cohort fertility schedules. This property of the projected fertility rate makes itself a tool to detect period effects of type H as attempted in the previous section.

For the cohort age-specific fertility rate, an adaptive mathematical model is employed such that they are to be generated from parameters bearing timing and lifetime prevalence of first marriage and births by birth order[2]. This allows us to generate cohort fertility rates that reflect delayed childbearing tendencies as well as the increase in lifetime proportion of never-having marriage and birth of each order, which are characteristics of recent fertility trend in Japan and other low fertility countries in general.

For cohorts that had completed a substantial part of their reproductive processes, the entire processes were constructed by estimating the parameters of an empirically adjusted mathematical model through a statistical method, i.e. the maximum likelihood method. For younger cohorts for which scant or no data are available, the fertility schedules are generated through reconstruction of reproductive life course formed by the fertility components stated above.

Each of the components will be incorporated into the cohort total fertility rate of birth order n, $CTFR_n$, via the following calculation formula.

$$CTFR_n = (1-\gamma)\, C_n(\bar{x}_m)\, \delta_n \\ = (1-\gamma)\left\{C_n^*(\bar{x}_m)\, \kappa_n\right\}\, \delta_n$$

where γ is the proportion never married, C_n is the probability of having child of n-th order as a function of the mean age at first marriage $\bar{x}_m$, δ_n is the coefficient of divorce, bereavement and remarriage, and κ_n is the fertility variation coefficient of married couples. Besides C_n^* is a standard of the C_n expected from the first marriage schedule represented by $\bar{x}_m$. These parameter values are all evaluated at age 50 as the end of reproductive process. Note that cohort TFR is sum of the function over birth order n, or $CTFR = \sum_{n=1}^{k} CTFR_n$, where k is the highest birth order (the forth and higher order combined is used for the projection) . These parameter values for cohorts are obtained from extrapolation of the trends measured for older cohorts.

2. *Prospects of fertility components in the projection assumption*

Fertility prospects as projection assumptions are set up with the following four parameters of reproductive behaviours; (1) the mean age at first marriage, (2) the proportion of never married, (3) the completed number of births from married women, and (4) the coefficient of divorce, bereavement and remarriage. Each of the parameters is projected according to trend derived from recorded data compiled for cohorts.

The assumptions on those four parameters of the female cohorts born in 1990 are shown in Table 4 for three alternative projection variants, i.e. Medium, High and Low. All of the assumed values of the components change in the same direction for fertility reduction even in the high variant, resulting in substantial decreases of the total fertility rate[3].

a. Mean age at first marriage and proportion never married at age 50

The mean age at first marriage of women by cohort develops from 24.9 years of age for 1955 birth cohort to 28.2 years old for the 1990 birth cohort, and then grows slightly to 28.3 years of age for the 2005 birth cohort, and there will be no subsequent change. The lifetime proportion of never-married women changes from 5.8 percent for the 1955 birth cohort to 23.5 percent for the 1990 birth cohort and reaches 23.6 percent for the 2005 birth cohort; again, there will be no change thereafter.

b. Completed number of births from married couples

The expected completed number of births gradually declines from the actual statistical value of 2.12 children of the 1955 birth cohort according to the development of the medium-variant assumption of the distribution of age at first marriage, down to 1.87 children for the reference 1990 birth cohort, then mostly levels off until the 2005 birth cohort and will remain constant at 1.87 children thereafter. On the other hand, the fertility variation coefficient of married couples, which indicates changes in the reproductive behavior of married couples, declines from the reference value (1.0) observed for wife birth cohorts born in 1935 to 1954, through 0.906 for the reference cohort, reaches 0.902 in 2005 birth cohort and then remains constant afterward. The value obtained as the product of these factors, i.e., the completed number of births from married couples, will decline from 2.16 children for the 1955 birth cohort (statistical data), through 1.70 of the reference 1990 birth cohort, to 1.69 for the 2005 birth cohort, and there will be no changes afterward.

c. Effect of divorce and bereavement and remarriage on fertility

The coefficient of divorce, bereavement and remarriage on fertility rates, δ, indicates relative fertility level affected by those movements of marital status to that of women with no movement from first marriage. It can be expressed as an empirical function of the ratio of women who have experienced divorce. For example, the ratio of women who have experienced divorce in the 1955 birth cohort, for which actual statistics can be obtained, was 18.4 percent and the coefficient of divorce, bereavement and remarriage on fertility rates was 0.952. The ratio of women born in 1990 who will have experienced divorce by the time they reach the age of 50 is projected to be 36.0 percent for the medium-variant assumption, and the corresponding values of δ were found to be 0.925 (Iwasawa and Kaneko 2007).

3. *Life course perspectives*

Building assumptions through estimation and projection of cohort measures of life course components of fertility enables us to construct the projected life course in relation to the relevant life events. I constructed the multistate life tables for the projected life by family status. The results indicate that less-reproductive and non-familial lives prevail among today's young and future generations, reflecting rapid transformation of partnerships and family formation patterns observed in the current cohorts (Kaneko 2007).

In table 5, the woman's life time probabilities and distributions by family status are indicated for female birth cohorts born in every five years since 1950 through 1990. The cohorts born in 1950 and 1955 had completed their reproductive life processes by the time of projection, thus their figures are regarded as actually recorded. On the other hand, the cohorts born in 1960 and after have not yet completed the processes, and their figures are all for projected life by the assumption based on the trends of the projected fertility and mortality.

Life time probability of a woman to eventually marry, assessed at her birth, is 86.4 percent for those among cohorts born in 1950. The figure gradually decreases from a cohort to the next until 75.7 percent for a woman born in 1990. These figures are somewhat lower than those calculated from the nuptiality rate in the fertility assumption, since the former includes effects from premature death before marriage. The probability of never marrying, childlessness and having no grandchildren are 24.3 percent, 38.1 percent, and 50.2 percent respectively in cohorts born in 1990. If compared with those in preceding cohorts, these figures indicate rapid prevalence of less-reproductive and non-familial life styles toward an unprecedented level in this society. The life course prospects of reproductive aspects derived from the population projection are discussed in Kaneko (2007) at some length.

D. DISCUSSION

Due to its peculiar combination of population dynamics, in the coming years Japan will experience, a very rapid population decrease, and moreover will have the highest proportion of elderly in the world. In particular, the trajectory of the fertility rates will have a significant influence on the future population changes in Japan and the severe socioeconomic issues brought about by population changes largely depend on the future fertility trends.

The fertility rates dropped continuously until 2005, and Japan experienced the so-called lowest low fertility for a three-year period from 2003 to 2005, as the official TFR values dropped below 1.3. Currently, the latest Population Projections for Japan were updated by carrying over data up to 2005; the fertility rate assumptions used in these projections indicate that the TFR values will continue dropping from the actual TFR value of 1.96 among the cohort born in 1955 down to 1.20 among cohorts born in 1990 and onward (these values represent TFR for Japanese women only. According to the calculations based on current official values, the TFR assumption value for the cohort born in 1990 is 1.26).

However, from 2006 to 2008, an upward trend has been observed in the fertility rates, and the breadth of this upsurge is quite extraordinary. Considering how important the fertility trends are for the aforementioned social economies, it is highly interesting to consider whether or not the recent rise in fertility rates is likely to affect the long term outlook. For this reason, this paper investigated the nature of the upturn, by closely examining the monthly development of fertility rates in this period, attempting to estimate tempo effects caused by adjusted TFRs such as the index proposed by Bongaarts and Feeney, and by estimating period effects (type-H period effects) that exclude tempo effects.

As a result, it was estimated that the recent upturn of fertility rates could generally be explained by type-H period effects. That is, it was found that the upturn is an emergent change that cannot be reproduced by continuous changes in each cohort and which occurred in a manner deviating from the regularity of childbearing schedules of each cohort. For some cohorts in higher ages concluding their reproductive processes, however, it is likely the completed fertilities become slightly larger than previously estimated, from a windfall type effect of type-H'.

In the US and Europe, upturns of fertility rates have been observed since the 1990s in one country after another, and the majority of the countries experiencing lowest low fertility rates have already broken away from that status at the time of this writing. Thus, it is crucial to identify whether the upturn in Japan is similar to those observed in the US and Europe. However, whereas the upturns in the US and Europe are generally considered to have occurred because the period TFR returned to the long-term cohort TFR as tempo effects die out due to completion of postponement transition (Goldstein et al. 2009), it was suggested that the upturn being observed in Japan is of a different nature and is caused by other, peculiar causes.

From a long-term perspective, if the rise in fertility currently being observed is purely caused by type-H period effects, the period fertility rate should decline again within the next several years and will ultimately not significantly change the long-term outlook for the fertility rate. In fact, according to observation of the monthly development, fertility rates have already been turning around to a downward trend again for at least half a year since December 2008.

On the other hand, this downturn itself might have been caused by transient disturbances related to the financial crisis starting roughly in September 2008 (Goldstein et al. 2009) and may actually be indicative of a complicated situation where different period effects overlap in some way.

Meanwhile, if the circumstances that brought about the recent upturn also serve to keep the fertility rates at higher levels than in the past for an extended period of time, overcoming this transient period of decline, the end result will be a positive influence on the cohort fertility, where the long-term outlook will involve a higher fertility than in the past. In this case, current period effects are modified from type-H to type-H'.

Here, let us consider the causes of the upturn. According to the analysis of observed age-specific fertility rates, the main players in the recent reversal are the so-called second baby boomers, i.e., the generation born in the period from 1971 to 1974. The second baby boomers were expected to give birth to the third baby boomers in the latter half of the 1990s and onward. However, this event was never realized due to significant postponement of family formation and/or childbearing.

On the contrary, their fertility rates kept on falling in 2000 and onward as well and reached the lowest low level in 2003. However, eventually it likely became clear to them that if they wished to have a certain number of children in their lives, they were approaching the age limit to realize their desire. This childbearing urge should have reached super-saturation in 2003 and onward. Assuming these conditions hold, it appears that pregnancy and childbirth were further suppressed from 2004 to the first half of 2005 for some reason. One can thus imagine that excessive energy recoil had been accumulated.

Continuing this line of thought, it is possible that the changes in the social economic mood, which among other things involved a generally improved employment environment, triggered the sudden release of this accumulated energy among the second baby boomer generations to realize their urge. In other words, although the trigger itself was a very ordinary change, there is a distinct possibility that it led to abrupt, significant changes in the trend due to the combination with the circumstances of the players.

If that is the case, it means that decline of fertility from around 2003, particularly the drop in 2005, was caused by type-H period effects in the negative direction and the rise afterward occurred as a rebound to the decline, caused by type-H period effects in the positive direction. Note that the recent rise is actually accelerating and is exceeding the level of the rebound in 2004 to 2005, suggesting the possibility that additional factors are involved.

For example, the large-scale second baby boomer generation's growing desire to get married and/or have children itself forms a market and is likely to gather momentum through mass media and similar channels. Magazines targeting women aged 30 years and up began to feature many positive articles featuring marriage, pregnancy, childbirth, and childrearing, and fashionable new words related to such subjects are becoming commonplace[4]. Furthermore, the government and local governments are advertising their measures as well. Spearheaded by the mass media, such measures seem to form a positive feedback relationship with the increasing fertility. Namely the initial rise from rebound caused increase in media coverage about marriage and family, which promoted further marriages and caused additional births to occur.

What will happen to this reversal trend of fertility in the future? First, if the rise in most cohorts would end up as a simple type-H period effect from rebound and temporary boom, the fertility rates should regress on the line of previous prospect. In this scenario where the recent boom comes to an end soon and it becomes difficult to maintain the current level if the fertility starts to stagnate and the feedback cycle with society is cut. Signs hereof may be already beginning to show in the monthly development.

On the contrary, if boom continues for long enough to make rises type-H' to raise the levels of completed fertility, and if those age patterns are continually succeeded by the following cohorts, then it means that the shrinking trend of cohort fertility reverses and the long term prospects of fertility should be seen as high as improved level of cohort completed fertility. In this case, the feedback relationship would be maintained. It is possible the group of single people and families of under-parity has ballooned to a huge size by now, because it contains the second baby boomers.

There are several other factors affecting the future course of fertility, among which the new child allowance is particularly notable. The new government has promised the adoption of this policy, and it amounts to 26,000 yen (about 290 US dollar) a month per every child through junior high. The current plan is to enact half the amount of allowance in April 2010, and the full amount in April 2011. Though it may have a certain impact on fertility, it seems necessary that it be perpetual and reliable to alter the long term trends beyond just period fertility in the short term.

E. Conclusion

Due to its peculiar combination of population dynamics, Japan will experience, by international standards, a very rapid population decrease, along with the highest proportion of elderly in the world. The prospect of continuing low fertility is mainly responsible for these changes in population dynamics, and thus it is one of the most important key to the society's future.

The fertility rates have dropped continuously since the mid 1970s below the replacement level until 2005, and Japan experienced the so-called lowest low fertility for a three-year period from 2003 to 2005. However, in the recent three years from 2006 to 2008, an upturn trend has been observed in the fertility rates, and TFR became to 1.37 in 2008.

It is estimated that the recent upturn could mainly be explained by the period effect, which does not change cohort completed fertility, and particularly the effects that temporally works and would be redeemed in other period (termed as the period effect of type-H). For some cohorts in higher ages, however, it is likely the completed fertilities become slightly larger than previously estimated (the type-H' effect). These are the different in causes from the upturns seen in the US and Europe, where the period fertility rates have been reversed mostly by "the tempo transition"(Goldstein et al 2009) which is the completing phase of the "postponement transition"(Kohler et al 2002). This corresponds to the period effect of type-T in our terminology.

The upturn in Japan seems to be caused by a rebound of the short term too-low fertility in the lowest low period, or in 2003-2005, followed by a boom induced mainly by the media targeting the single's and family of under parity's market whose size is unprecedented these years, partly because it includes the second baby boomers.

It is possible that the long term prospects of fertility formed in the latest population projection, which are based on the data corrected by the year 2005, might be underestimated in light of the present situation. It depends on whether the rise in fertility schedules of cohorts in their mid-thirties and beyond in this period is continually succeeded by the following cohorts ending up with rises in their cohort completed fertilities.

In this article, the life course prospects with regard to family formation according to the population projection assumptions with the multistate life table techniques are described. For instance, the probability of never marrying, childlessness and having no grandchildren are 24.3 percent and 38.1 percent respectively in cohorts born in 1990. These figures indicate rapid prevalence of less-reproductive and non-familial life styles toward an unprecedented level in this society. Since the life course approach is effectual in explaining or testing the assumptions as well as in constructing, it should be more exploited in seeking long term fertility prospects or in population projections.

NOTES

---

[1] Since the fertility rate (i.e., including children with Japanese nationality born to non-Japanese women) and the total fertility rate (see the formula below) defined in the same way as in the Vital Statistics corresponding to the aforementioned fertility rate composition all depend on the demographic compositions of Japanese and non-Japanese women, they can be calculated as a result of population projection. Handling such individually defined fertility rates in the overall fertility rate assumptions of the future population projection makes the projection methodology considerably more complicated, though it is an indispensable mechanism for accurate reproduction of the future population status where international population exchanges have advanced.

Definition of the total fertility rate of the Vital Statistics;

$$\text{(Total fertility rate)} = \sum_{\substack{\text{Sum for ages} \\ (15\text{-}49)}} \frac{\text{(Number of births by Japanese females)} + \text{(Number of births with Japanese nationality born from non-Japanese females*)}}{\text{(Population of Japanese females)}}$$

* A child with Japanese nationality born from a non-Japanese female is a child whose father is Japanese.

2) The model is based on the probability density function of the generalized log-gamma distribution, which is one of standard distributions in statistics. The fertility rate at age x for n-th birth is $f_n(x) : f_n(x) = C_n \cdot \gamma(x; u_n, b_n, \lambda_n)$

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

Here, γ and exp are the gamma and exponential functions, respectively. C_n, u_n, b_n, and λ_n are parameters of the fertility rate function of birth order n; this is an extension of the Coale-McNeil Model. The further adjustment is made so that it should reproduce the characteristics of Japanese age-specific fertility rate precisely. A standard pattern of errors (ε_n) was identified by comparison with the actual fertility rates and the modeled rates to adjust the model schedule. As a result, the function of cohort fertility rate by age x, $f(x)$ is given as follows. See Kaneko (2003) for the details.

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

[3] This construction is applied only for Japanese women. The fertility rates of women with foreign nationalities are produced in relation to those of Japanese, using the observed relationships to be fixed for the future.

[4] "Kon-katsu" (activities to look for marriage partners) - there is affirmative nuance for the activities. "Ara-for"(Around Forty) - a somewhat positive title for single women around age 40, who are typically active in work and romance. "Sosyoku-danshi" (herbivorous boy) – a label for young men who are passive to romance and marriage, suggesting that women should be active to make those come into existence.

Table 1 Major Actions Taken by the Government toward Declining Fertility Rate

Year	TFR	Action
1990	1.54	An inter-ministry committee "Creating a Sound Environment for Bearing and Rearing Children"established
1991	1.53	Childcare Leave Act enacted
1994	1.50	The Angel Plan or the"Basic Direction for Future Child Rearing Support Measures"(1995-1999) formulated. The"Five-Year Emergency Measures for Childcare Services"planned
1995	1.42	Childcare and Family Care Leave Act enacted
1998	1.38	The amendment to the Child Welfare Law enforced
1999	1.34	New Angel Plan (2000-2004) formulated
2000	1.36	Child Abuse Prevention Law enacted
2001	1.33	The amendment to the Employment Insurance Law enforced
2002	1.32	The"Measures to Cope with a Fewer Number of Children Plus One" reported to the Prime Minister
2003	1.29	The Law for Measures to Support the Development of the Next-Generation, the amendment to the Child Welfare Law, and the Law for Basic Measures to Cope with Declining Fertility Society enacted
2004	1.29	General Policies of Measures for an Falling Birthrate, Parenting Support Chilren Plan
2005	1.36	Local governments, Companies in the formulation and implementation of action plans
2006	1.32	New Falling Birthrate
2007	1.34	Work Life Balance Charter - Work Life Balance Principles for Promotion, "Japan to Support Children and Families"Strategic Priority
2008	1.37	New Waiting Children Operation Zero", One Worry of Five Plan - (3) Protect and Nurture the "Children"and Social Future Leaders, National Conference on Social Security Report
2010		Planned implementation of the Child Allowance (50% in the first year)

Source: Ministry of Health, Labor and Welfare, Annual Reports, Cabinet Office, White Paper on Birthrate-Declining Society 2009. NIPSSR (2004).

Table 2 Average Number of Births by Duration of Marriage

Duration of marriage	7th Survey (1977)	8th Survey (1982)	9th Survey (1987)	10th Survey (1992)	11th Survey (1997)	12th Survey (2002)	13th Survey (2005)
0-4	0.93	0.80	0.93	0.80	0.71	0.75	0.80
5-9	1.93	1.95	1.97	1.84	1.75	1.71	1.63
10-14	2.17	2.16	2.16	2.19	2.10	2.04	1.98
15-19	2.19	2.23	2.19	2.21	2.21	2.23	2.09
20 years or longer	2.30	2.24	2.3	2.21	2.24	2.32	2.30

Sources: Kaneko et al 2008. The first-marriage couples only.

Table 3 Contribution of Subgroups to Period Effects of Type H in Selected Years

a. Age groups (%)

Age group	Years whose "period effect" exceeds 0.03				
	1989	1994	2006	2007	2008
15-19	4.2	- 2.0	- 6.8	- 5.2	- 2.9
20-24	26.1	10.3	7.8	1.7	2.5
25-29	58.0	42.6	7.9	11.5	16.1
30-34	17.9	32.0	46.5	43.1	39.0
35-39	- 4.0	18.8	42.5	45.5	41.8
40+	- 2.2	- 1.7	2.2	3.4	3.5
Total (values)	100.0 (-0.034)	100.0 (0.058)	100.0 (0.065)	100.0 (0.095)	100.0 (0.134)

b. Birth orders (%)

Birth order	Years whose "period effect" exceeds 0.03				
	1989	1994	2006	2007	2008
1st birth	57.9	58.9	42.5	40.4	40.8
2nd birth	34.3	27.3	33.6	29.8	30.0
3rd birth	5.6	9.7	19.4	24.0	22.8
4th & higher	2.1	4.1	4.5	5.7	6.4
Total (values)	100.0 (-0.034)	100.0 (0.058)	100.0 (0.065)	100.0 (0.095)	100.0 (0.134)

Note: Comparatively outstanding values for the age groups and birth order are underlined.

Table 4 Assumptions of Fertility Component
and Total Fertility Rate for the Reference Cohort (born in 1990)

Measures of Fertility Components	Observed: cohort born in 1955		Assumptions of Population Projection: cohort born in 1990		
			Medium	High	Low
(1) Mean age at first marriage	24.9	⇨	28.2	27.8	28.7
(2) Proportion never married at age 50	5.8 %		23.5 %	17.9 %	27.0 %
(3) Couples' completed fertility	2.16		1.70	1.91	1.52
(4) Effect of divorce, widowhood and remarriage	0.952		0.925	0.938	0.918
Cohort Total Fertility Rate (Japanese women)	1.94	⇨	1.26 (1.20)	1.55 (1.47)	1.06 (1.02)

Note: The values are applied for Japanese women. The values in paresis for the cohort total fertility rates are those applied for Japanese women and babies with Japanese nationality.

Table 5 Woman's Life Time Probabilities and Distributions by Family Status: Perspectives from the Medium Variant for Cohorts Born in 1950-90

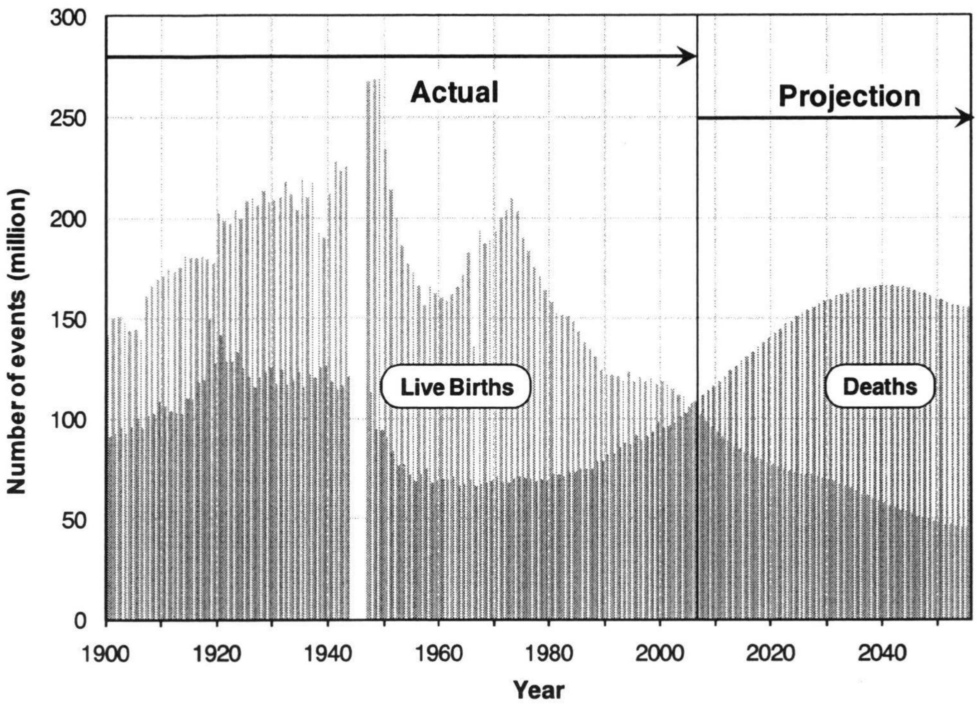
(%)

	Birth year of woman's cohort								
	Recorded		Projected						
	1950	1955	1960	1965	1970	1975	1980	1985	1990
Life time probability of woman ... (at birth)									
Marrying	86.4	88.8	87.1	85.6	82.1	78.3	76.4	75.7	75.7
Having 1st birth	81.6	82.3	79.2	75.2	68.6	64.5	63.6	62.1	61.9
Having 2nd birth	70.4	71.1	65.8	58.6	49.8	45.7	44.8	43.9	43.9
Having 3rd birth	23.6	26.7	24.1	19.1	14.7	12.8	11.7	11.3	11.2
Having 4th and higher birth	4.2	4.7	4.5	3.8	3.2	2.7	2.3	2.0	1.9
Never marrying	13.6	11.2	12.9	14.4	17.9	21.7	23.6	24.3	24.3
Childless	18.4	17.7	20.8	24.8	31.4	35.5	36.4	37.9	38.1
Never having 2nd child	29.6	28.9	34.2	41.4	50.2	54.3	55.2	56.1	56.1
Never having 3rd child	76.4	73.3	75.9	80.9	85.3	87.2	88.3	88.7	88.8
Never having 4th child	95.8	95.3	95.5	96.2	96.8	97.3	97.7	98.0	98.1
Life time distribution of woman by number of child (at birth)									
Childless	18.4	17.7	20.8	24.8	31.4	35.5	36.4	37.9	38.1
Never married	13.6	11.2	12.9	14.4	17.9	21.7	23.6	24.3	24.3
Ever married	4.8	6.5	7.9	10.5	13.5	13.8	12.8	13.6	13.8
Only child	11.2	11.2	13.3	16.5	18.7	18.8	18.8	18.1	18.0
Two children	46.8	44.4	41.8	39.5	35.2	32.9	33.0	32.6	32.8
Three children	19.4	22.0	19.6	15.3	11.5	10.1	9.4	9.3	9.3
Four and more children	4.2	4.7	4.5	3.8	3.2	2.7	2.3	2.0	1.9
Net Reproduction Rate	87.5	90.0	84.5	76.3	66.3	61.2	59.6	58.1	57.9
No grandchild	22.2	21.2	25.6	31.6	41.2	46.8	48.1	50.0	50.2

Life time proportion of woman (without mortality effect = directly derived from fertility assumption)									
Never married	5.0	5.8	9.3	12.0	16.2	20.4	22.6	23.5	23.5
Childless	10.3	12.7	17.5	22.7	30.0	32.8	35.7	37.1	37.4
No grandchild	12.1	15.0	21.3	28.8	39.3	42.9	46.8	48.9	49.4

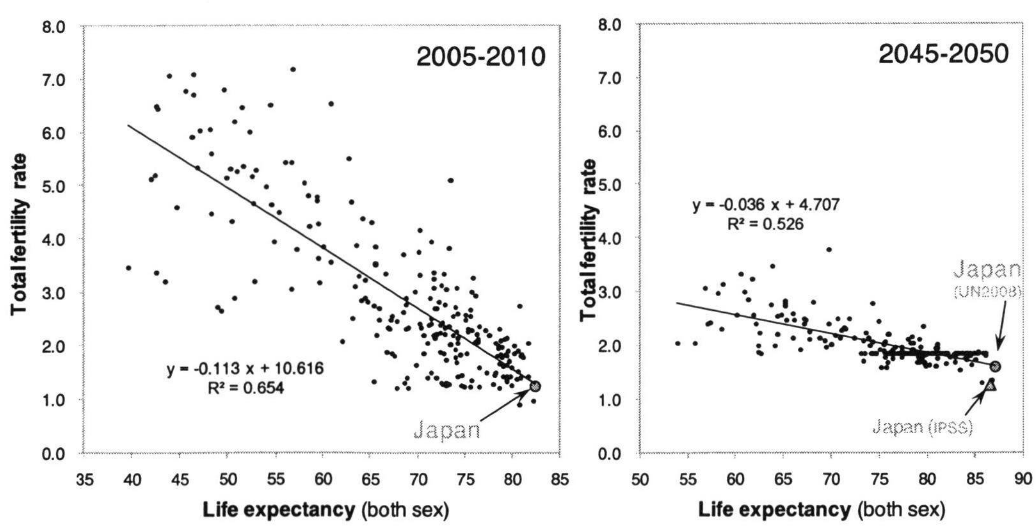
Source: From the projection 2006, medium-fertility and medium-mortality variant. The life time proportions of woman never married and childless (without mortality effect) are officially provided numbers. Other numbers are calculated by the author from the assumption. The sex ratio at birth for the net reproduction ratio is an officially provided assumption and is 105.4 (fixed value from average over year 2001-05).

Figure 1 Japanese Cross of Births and Deaths: Actual and Projection



Source: NIPSSR(2006).

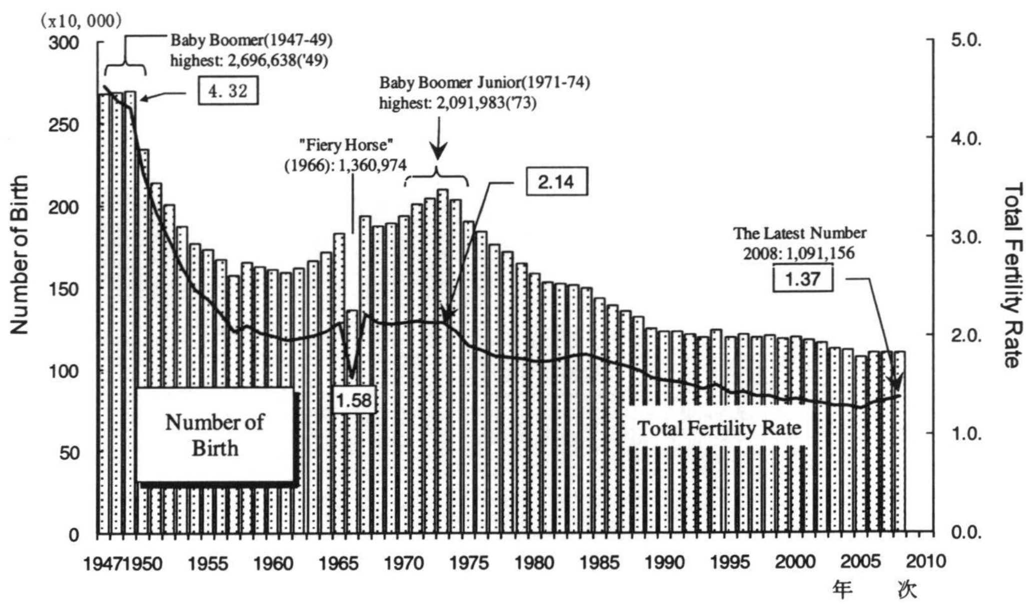
Figure 2 Japan's Distinguishing Position in Terms of Population Dynamics:
Current and Future Projections



Source: United Nations (2009), NIPSSR(2006).

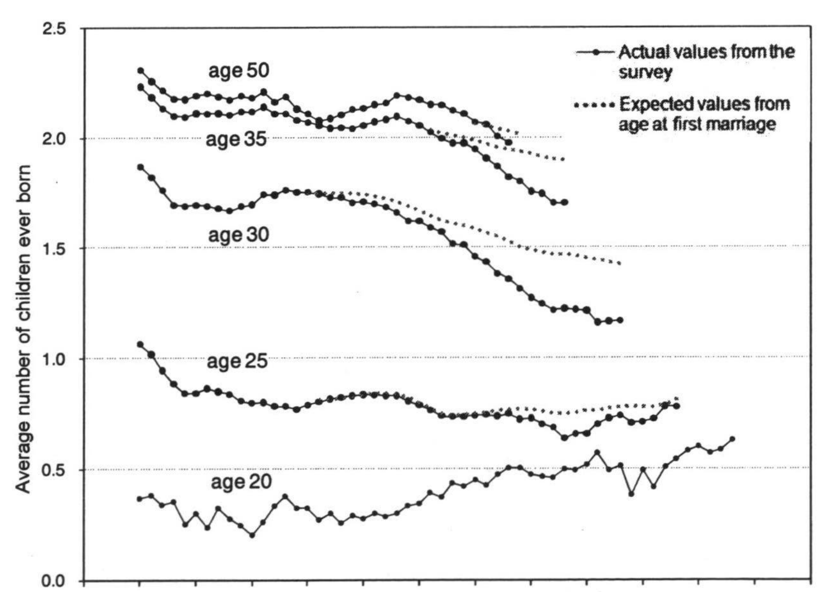
21

Figure 3 Numbers of Live Births, and Total Fertility Rate in Japan



Source: MHLW, The Vital Statistics

Figure 4 Cohort Trends of the Average Number of Children Ever Born to Married Women by Age: Actual and Expected from Age at First Marriage



Note: The actual values (lines with dots) are compared with the expected values (dotted lines) which are those predicted from age at first marriage in keeping with the statistical relationships derived from the logistic regression of the age in a quadratic form on the number of children ever born at each age.

Source: The National Fertility Survey (NIPPSR).

22