Table 2. Coefficients of regression models of change in total fertility rates: first, second and third birth

Variable	Change in 1st birth TFR						Change in 2nd birth TFR						Change in 3rd birth TFR					
	Weighted least squares			Weighted spatial error model			Weighted least squares			Weighted spatial error model			Weighted least squares			Weighted spatial error model		
	β	β'	Std. error	β	β'	Std. error	β	β'	Std. error	β	β'	Std. error	β	β'	Std. error	β	β'	Std. error
Constant	-0.01		0.01	-0.01		0.01	0.01		0.01	0.01		0.01	0.01		0.01 *	0.01		0.00 **
Change in late fertility 1)	1.95	0.52	0.35 ***	2.03	0.54	0.34 ***	0.90	0.31	0.36 *	1.02	0.35	0.28 ***	1.75	0.52	0.47 ***	1.42	0.42	0.43 **
Change in TFR inflated by non-Japanese mothers	5.61	0.29	1.76 **	5.70	0.29	1.69 ***	5.74	0.39	1.41 ***	6.86	0.46	1.27 ***	3.00	0.10	3.59	5.67	0.19	3.57
Change in employment rate	0.78	0.18	0.35 *	0.81	0.18	0.34 *	0.18	0.07	0.22	0.13	0.05	0.20	-0.03	-0.02	0.20	-0.01	-0.01	0.20
Change in labor force participation rate among mothers having preschool children	-0.16	-0.22	0.07 *	-0.16	-0.22	0.06 **	-0.01	-0.02	0.04	-0.02	-0.06	0.03	-0.04	-0.15	0.04	-0.02	-0.06	0.03
Proportion of extended families 2)	-0.02	-0.07	0.02	-0.02	-0.07	0.02	-0.03	-0.25	0.01 *	-0.03	-0.25	0.01 **	0.02	0.26	0.01 #	0.02	0.23	0.01 #
Lambda (spatial autoregressive coefficient)				*0.15*						*0.43*						*0.25*		
Likelihood Ratio Test (H0: *Lambda*=0)				0.62						11.30 ***						1.02		
R-squared	0.80						0.68						0.34					
Adjusted R-squared	0.78						0.64						0.26					
AIC	-259.2			-257.8			-304.6			-313.9			-311.0			-310.0		
N	47			47			47			47			47			47		
Diagnostics for spatial autocorrelation																		
Moran's I (residuals)	0.10 #			0.05			0.36 ***			-0.03			0.10 #			-0.05		
Lagrange multiplier diagnostics for spatial autocorrelation																		
LM (error)	1.08						8.02 **						0.31					
LM (lag)	0.00						0.28						1.08					
Robust LM (error)	1.24						7.81 **						0.08					
Robust LM (lag)	0.16						0.08						0.86					
LM (SARMA)	1.25						8.10 *						1.17					

*** p<.001 ** p<.01 * p<.05 # p<.1

β represents a coefficient and β' represents a standardized coefficient.

1) For 1st birth model, late fertility rate represents fertility rates over age 33, for 2nd birth model, fertility rates over age 35, and for 3rd birth model, fertility rates over age 36.

2) Centered values are used.

5.3 Contribution of each factor to national TFR increase

Based on the regression coefficients estimated by the well-fit model, the contribution of each explanatory variable is summarized in Table 3. The increase of the national TFR from 2005 to 2008 can be decomposed into each contribution of factors using the model estimated. Estimating the in-crease using the national figure of each variable, the change of late fertility accounted for 98% of the increase in first-order TFR, and the increase of fertility inflated by foreign mothers accounted for 11%. The increase of employment rate explained 24%. Contrary to our expectation, the increase of employment rate of mothers with preschool children accounted for decrease in the TFR by 18%. It also shows 15% decrease as a common effect regardless of the change of each factor (see Table 3).

As for second-order TFR, in addition to the 20% common effect, the increase of late fertility accounted for 64% and increase in fertility inflated by foreign mothers accounted for 14%. Contribution of employment rate and mothers' employment rate were 7% and -4%, respectively.

As for third-order TFR, the contribution of the common effect that cannot be explained by factors examined here is as high as 62%. The increase of late fertility explains 45% and fertility inflated by foreign mothers explains 5% of the increase in third-order TFR. Employment rate and mothers' employment rate were -2% and -10%, respectively.

As for fourth and higher-order birth TFR, the common effect is as high as 98%, indicating that there are important factors not examined here. The increase of late fertility accounts for 16% and fertility inflation contributed by foreign mothers accounts for 23% of the increase in fourth and higher-order TFR. Employment rate and mothers' employment rate accounts for -22% and -15%, respectively.

Based on these, we found19% of increase in all birth TFR is accounted by the common effect, 72% by the change in later fertility, 11% by the change in fertility contributed by foreign mothers, 11% by the change in employment rate, and -12% by the change of mothers' employment rate.

Table 3. Decomposition of change in total fertility rate in Japan from 2005 to 2008

	1st birth TFR (1)	2nd birth TFR (2)	3rd birth TFR (3)	4th+ birth TFR (4)	All birth TFR	All birth TFR (1)+(2)+(3)+(4)
TFR in 2005	0.62404	0.46433	0.13935	0.03238	1.26010	1.26010
TFR in 2008	0.67124	0.49340	0.16354	0.03879	1.36697	1.36697
Change from 2005 to 2008	0.04720	0.02907	0.02420	0.00641	0.10687	0.10687
Decomposition						
Common effect	-0.00710	0.00566	0.01489	0.00629	0.02068	0.01975
Change in late fertility (Declining tempo effect)	0.04644	0.01866	0.01092	0.00101	0.07274	0.07703
Change in TFR inflated by non-Japanese mothers (Contribution of immigration)	0.00494	0.00403	0.00127	0.00147	0.01128	0.01170
Change in employment rate (Ecomonic improvement)	0.01125	0.00193	-0.00056	-0.00140	0.01174	0.01121
Change in maternal LFP (Policy improvement on work/family reconciliation)	-0.00832	-0.00120	-0.00233	-0.00096	-0.00957	-0.01282
Contribution (%)						
Common effect	-15.0	19.5	61.5	98.2	19.4	18.5
Change in late fertility	98.4	64.2	45.1	15.8	68.1	72.1
Change in TFR inflated by non-Japanese mothers	10.5	13.9	5.2	22.9	10.6	11.0
Change in employment rate	23.8	6.6	-2.3	-21.9	11.0	10.5
Change in maternal LFP	-17.6	-4.1	-9.6	-15.0	-9.0	-12.0
Model used for predictions	Weighted LS	Weighted spatial error model	Weighted LS	Weighted spatial error model	Weighted spatial error model	-

Based on the regression coefficients and the correlation coefficients between explanatory variables and the dependent variable, we obtain the variance explained by the explanatory variables. For the all-birth TFR, late fertility rate explains approximately 33% of total variance on fertility change, 28 % by fertility inflated by foreign mothers, 5% by employment rate, 3% by mothers' employment rate, and 10 % by proportion of extended families (all explanatory variables explain 79% of total variance). The result suggest that demographic factors such as late fertility rate and fertility inflated by foreign mothers account for approximately 60% of the variation in change, the fixed effect of the proportion of extended families explains 10%, and economic improvement and policies on work and family reconciliation explain 5% and 3% of the variation, respectively. The remaining 20% of the variation is explained by other factors not included in our study.

6. Discussions

The goal of this study was to explore the explanations for the TFR upturn after 2005 in Japan, one of the "lowest low fertility" countries. We focused on the following factors based on previous studies in Europe: (1) diminishing tempo effect, (2) increase in foreigners, (3) economic improvement, and (4) policies initiative on work and family reconciliation, and (5) family culture. We estimated models to explain the prefecture-level variation of change in TFR from the variation of the relevant variables (change in late fertility, change in fertility contributed by foreign mothers, change in employment rate, change in maternal employment rate, and the proportion of extended family house-holds).

The factors such as change in late fertility, change in fertility contributed by foreign mothers, and change in employment rate are positively associated with TFR change as we expected. The improving in employment rate of mothers with preschool children living in nuclear families, however, shows a negative relationship to the change in TFR. This suggests that the level of TFR has in-creased much in the area where the change in mothers' employment rate is smaller than other areas. The result suggests continuing difficulty for a working mother with children to have another child. Conversely, we may need to take into consideration the recent state of day-care centres in urban areas. The areas where TFR has increased since 2005 include prefectures including large metropolitan areas such as Tokyo, Kanagawa, and Miyagi. In these prefectures, the proportion of children on the waiting lists of day-care centres among all preschool children has significantly increased dramatically since 2006. It is speculated that there was an increase in the number of mothers who decided to have children hoping to raise children while working, but dropped out of the labour market because there were no vacancies at day-care centres. Therefore, if the shortage of day-care services in these areas can be resolved, it will not only reduce the number of children on waiting lists but also in-crease the employment rate of mothers from the present level so that potential jobseekers can be employed.

Whatever the case, as Neyer and Andersson (2008) suggested that, macro-analytical investigations based on aggregate indicators are considered to be insufficient to examine the impact of family policies on fertility, since macro indicators do not take fertility-relevant structuring effects of family policies into account and cannot reveal group-specific effects. Thus we need to have research de-signs and methods that enable us to grasp the impact of family policies on individual behaviour for a clearer assessment.

Other than short-term variable factors such as tempo effect, immigrant mother effect, economic effect, and policy effect above, 19% increase in TFR between 2005 and 2008 is estimated by the constant term of the model. However, these factors are not statistically significant in the all-birth model, although significantly in third birth and fourth and higher-order birth models. This is thought to be a common nationwide positive effect regardless of prefecture specific factors. It is possible that the idea that childbearing should be supported by society has been widely accepted and it encouraged the younger generations to have many children. If nationwide economic recovery is included in the common effect, the impact of a economic recession after 2008 could be larger than 0.01 reflecting only economic variation between prefectures.

Lastly, the proportion of extended families used as an indicator of family culture showed a negative impact in the all-birth and second birth models as in the case of Italy. Namely, the recent recovery of the fertility rate is weaker in areas such as the Tohoku region where strong family attitude remain strong.

Conversely, our results suggest that parenting has become easier even in urban areas where family culture is relatively weak. In these areas, conditions favourable to family formation other than family support may be established. Since proportion of extended families shows positive impact in third and higher-order birth models, economic or physical support from co-residing grandparents may play important roles even today.

In Japan, part of the TFR upturn since 2005 can be explained by short-term conditional change such as an increase in international marriages and economic recovery. Therefore, it is possible that the TFR will decline again in the near future. On the other hand, an increase in late fertility accounts for as much as 70% of the change in our analysis, suggesting there may be a moderate increase in TFR due to the elimination of the tempo effect for some time. However, whether such a catch-up behaviour is followed by subsequent generations depends on whether women in their 30s who finally had children can continue to work as they expected. Problems such as a recent increase of children on the waiting lists of day-care centres in metropolitan areas and "ikugyu-giri (firing due to taking parental leave)", which came to the surface in the economic recession since 2008, may negatively influence the TFR through increasing pessimistic views on working conditions for mothers. While urgent countermeasures are called for, it is necessary to carefully monitor the uptake of policies on work and family reconciliation when we foresee future trends of fertility.

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APPLYING A FERTILITY PROJECTION SYSTEM TO PERIOD EFFECT ANALYSIS: AN EXAMINATION OF THE RECENT FERTILITY UPTURN IN JAPAN[1]

Ryuichi KANEKO[2]

Abstract

Models of population projection play a significant role in analyzing current demographic processes as well as in forecasting their future course. In this study, I utilize a fertility projection based on the official population projection for period effect analysis of current fertility trends in Japan. The objective of the paper is threefold; first, I demonstrate the usefulness of population projection models in analyzing demographic processes in the past and present as well as in the future, secondly I classify and clarify the period effects in terms of the cohort fertility schedule so that causes and mechanisms of fertility changes can be identified, and thirdly I apply the framework to the recent peculiar fertility development in Japan, especially the upturn since 2006. Unlike previous upturns seen among countries in Europe and North America, the pure period effects that are separated from the tempo effect played a major role in the recent decline and subsequent rise in Japanese fertility, although the recuperation mechanism is also induced in an irregular manner by the effects.

1. Introduction

The role of population projections is to provide information on various future changes in demographic structure (e.g., population size and age composition by sex) based on assumptions on the future course of vital events such as fertility, mortality and migration. However, since they offer a comprehensive demographic model, they can be broadly applied to analyzing population processes. In this paper, I describe the use of a fertility projection employed in the official population projection for analysis of the period effects in past and current fertility trends in Japan.

It is crucial to understand the relationships between the period and cohort observations of fertility in order to identify the essential trends and prospects. As adjustments and adaptation behavior in an individual's reproductive process take place along his/her life course, most of the large-scale regularities in fertility rates tend to emerge in cohort experiences. Demographic measures, however, usually trace fertility development annually, and try to provide a description of it with the "lifecycle" measures by means of the hypothetical cohort of the period. Hence two lifecycle measures with different values, i.e. those for true and hypothetical cohorts, describe the very same phenomena. There has been much effort to connect these measures, most notably by Bongaarts and Feeney (1998).

In addition to these formal issues, problems often arise in attempts to understand fertility changes in terms of period and cohort effects, which affect fertility trends via different mechanisms. In most cases, these efforts are unsuccessful due to the mixture of those effects in practice.

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In the present paper, therefore, the period effects are first sorted out according to their means of effect on the cohort fertility schedule. Then applying the cohort-based fertility projection model, we separate the period effect from fertility fluctuations observed in recent Japan in order to identify the driving forces of changes.

Accordingly, this paper has three objectives; (1) to demonstrate the utility of population projection models in analyzing demographic processes in the past and present as well as in the future, (2) to measure and understand the period effects in terms of modifiers of the cohort fertility schedule, and applying those new procedures (3) to identify factors and mechanisms of the recent peculiar fertility development in Japan, paying particular attention to the question of whether the small upturn in Japan is induced by the similar mechanisms as those behind the fertility upturns recently observed among most of the countries in Europe and North America.

2. Background

2.1 Historic population trends and the lowest low fertility in Japan

The year 2005 is a dividing line for population trends in Japan 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 steady rise since the closing period of the Tokugawa era except the turmoil during the Second World War, and second, the proportion of the population aged 65 and above exceeded one fifth (20.2 percent), attaining the highest in the world.

Though the combination of a low fertility rate and high longevity is the cause these striking changes in the population of Japan, the principal driver is the prolonged continuation of low fertility rates far below replacement level fertility, which Japan has been experiencing since the mid-1970s

In spite of a series of government measures and escalating public awareness, fertility continued to decline until it fell into the so called "lowest low" level for the first time in 2003, and finally reached the lowest ever 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.

Because of the population momentum, the broad course of these historic population changes is already inevitable at this point. However, the upcoming levels and pace of changes depend on the future fertility rates. As such, the impact on society of rise or further fall of the fertility rates could be of great significance.

As a matter of fact, fertility made an upturn immediately after achieving the lowest ever TFR. In 2006, the TFR rose by 0.06 to 1.32, which is the largest increase since the 1970s. Fertility kept rising to 1.34 in 2007, and 1.37 in 2008. The last three year period of rising TFR was during the period 1982-1984. Although the extent of the increase is relatively minor and the overall level still far below replacement, this recent upturn of fertility is a significant turnaround: such a rise is a unique development both in terms of magnitude and deviation from the downward trend. We now proceed to engage in a detailed examination of this phenomenon.

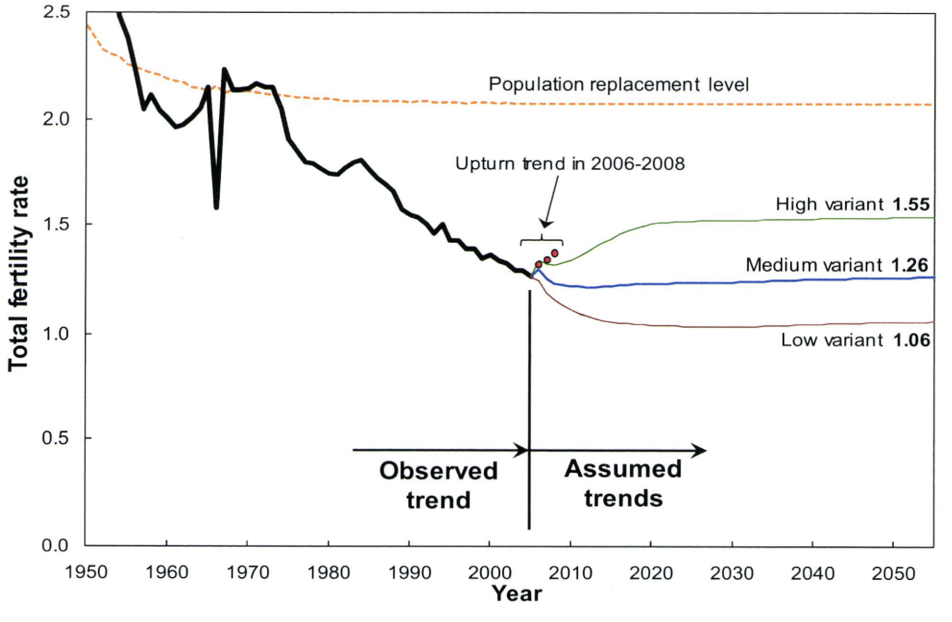
2.2 The upturn of the period fertility rate in 2006 and onward

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 thereafter, at least until 2008. Figure 1 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 2005 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.

Figure 1. Trends of Total Fertility Rate: Observed and Assumed.



Source: The Vital Statistics, NIPSSR(2007).

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 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 imply that these assumptions are inappropriate. Nonetheless, if the deviation occurs as a result of more basic changes in reproductive behaviors, the assumption must be reviewed for the future projections. Thus, this upturn is examined in more detail in the following discussion.

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 that 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 actual cohort fertility rates have not reached the level of 1.3, called the lowest low, in any of the countries but rather that this level in the period TFR is a transient phenomenon due to the aforementioned tempo effect.

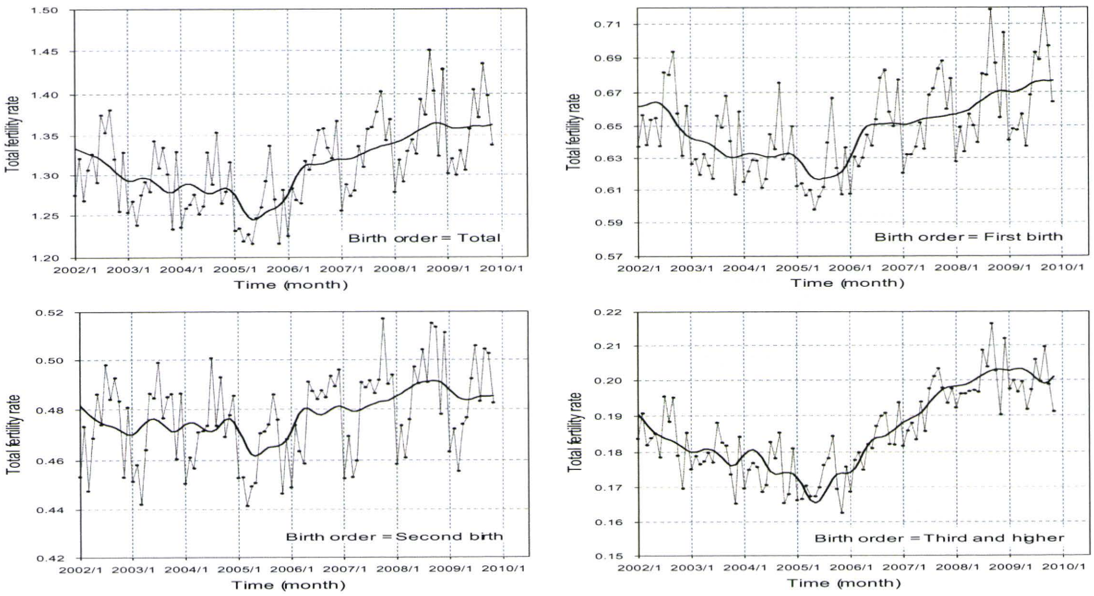
If this interpretation is correct and the fertility rate upturn in Japan observed since 2006 is caused by a mechanism similar to that of the trend observed in the US and countries in Europe, there is a possibility that the recovery may continue for a relatively long period of time. In this case it is 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.

3. Demographic analysis of the upturn

3.1 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 2 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 is the case here, where the population in the middle of a month is used.

Figure 2. Monthly Progress of Fertility Rates by Birth Order: 2002-2009.



Note: Dots with thin lines denote monthly time series of annualized TFR by birth order, and lines represent seasonally adjusted trends with the U.S. Census Bureau's X-11 method.

First, looking at the monthly changes of the overall TFR by birth order, we see that the TFR began to drop suddenly in December 2004, and remained low for six months until May 2005. Then, 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 starting 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 phases:

(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 TFR 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 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 further 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 are no obvious events that might have influenced childbearing to be found.

3.2 Examination of the 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 precisely.

One of the important aspects 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).

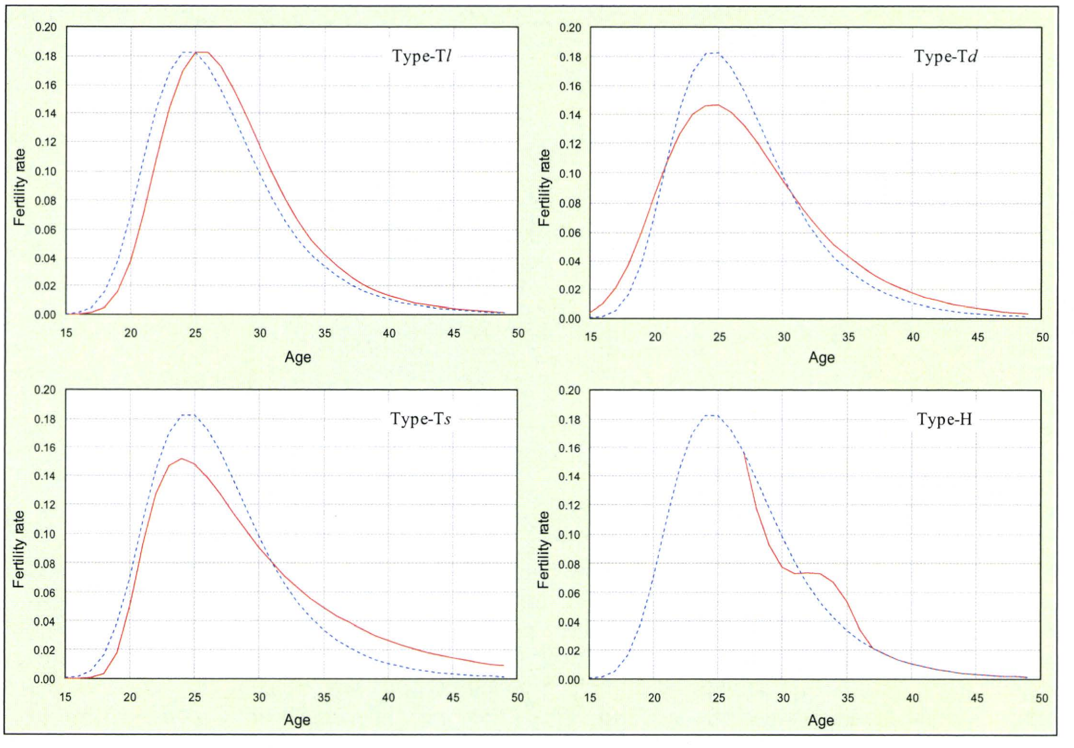
According to this definition, a period effect can be said to be a change in timing occurring in the childbearing schedule in terms of cohort fertility rates. A cohort is considered to have a unique childbearing schedule with a certain potential regularity, and a period effect is a change that causes 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 several different types of such changes in cohort childbearing schedules. The first group of changes 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, for example, a tempo effect causes the period TFR to go down. 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 3 for illustration).

As shown in the figure, there are three different types of effect identified as type-T period effects, i.e. shift in location of fertility schedule on age axis (type-T*l*), shift in dispersion (type-T*d*), and shift in shape (type-T*s*).

Another type of change encompasses disturbances occurring only for parts of a cohort childbearing schedule (the last graph in Figure 3). 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.

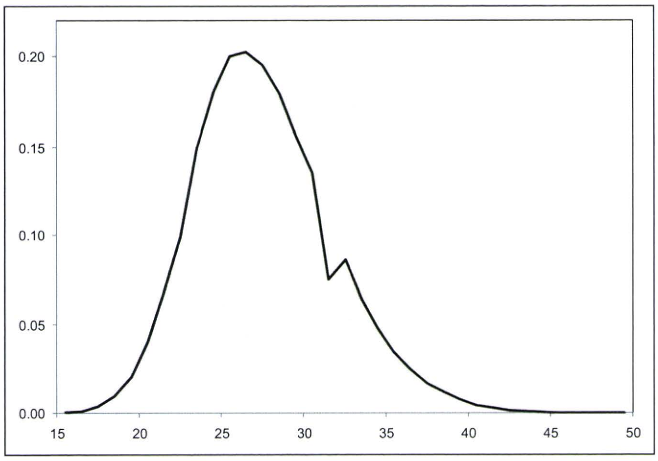
Figure 3. Types of Period Effect in Terms of Cohort Fertility Schedule.



Note: The period fertility exhibits similar changes due to different type of changes in the cohort fertility level and schedule. The period effect of type-T is caused by the shift of the cohort fertility schedule. The period effect of type-H is caused by the temporary fluctuation that is redeemed in another period, while the type-H' effect is a temporary fluctuation that continues to change the completed level of cohort fertility. Thus the type-H' effect is not a genuine period effect by our definition.

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, see changes of TFR in Figure 1). 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 (Figure 4). This type of fertility rate change is called type-H period effects here.

Figure 4. Age-specific Fertility Rate of Japanese Female Cohort Born in 1935.

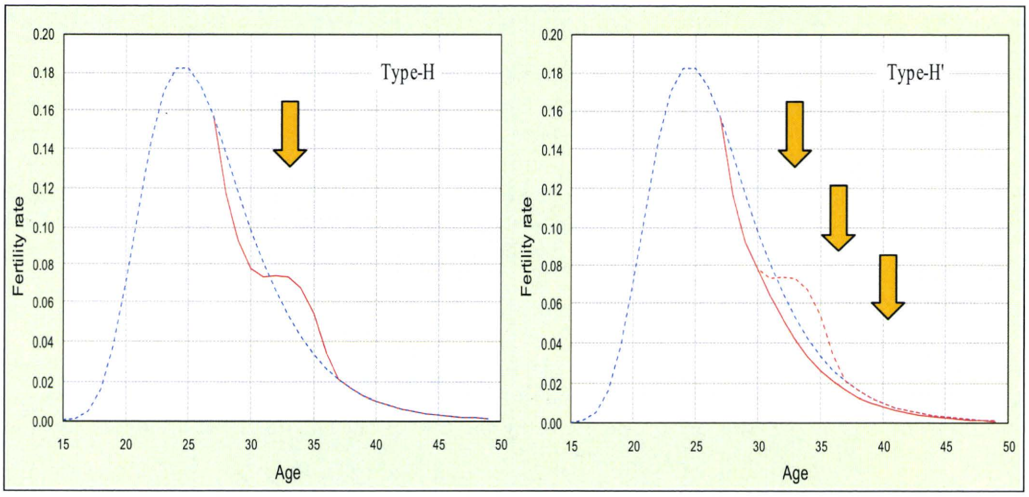


***Note*:** Female cohort born in1935 experienced the Hinoe-uma in1966 at age 31.

It should be noted, however, that some fertility rate changes that occur 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, considering them as a type of cohort effect induced by a certain period. However, whether this kind 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'), as illustrated in Figure 5.

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 transitions for 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 hypothesis can be ruled out by observing the monthly MAB development simultaneously. 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."

Figure 5. Types of Period Effect in Terms of Cohort Fertility Schedule.



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[3]. The index proposed by Bongaarts and Feeney is referred to as ATFRp in the following. Figure 6 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 the 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 only with 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 $f(t_c+a, a)$ experienced at a certain age (a) in a certain year ($t=t_c+a$) to fluctuate by age a (that is, for each year t) when focus is placed on a

[3] 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.

single cohort (birth year t_c) and, instead, assumes that all cohorts involved have a common timing change speed within a given year (period-shift framework). That is: 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).

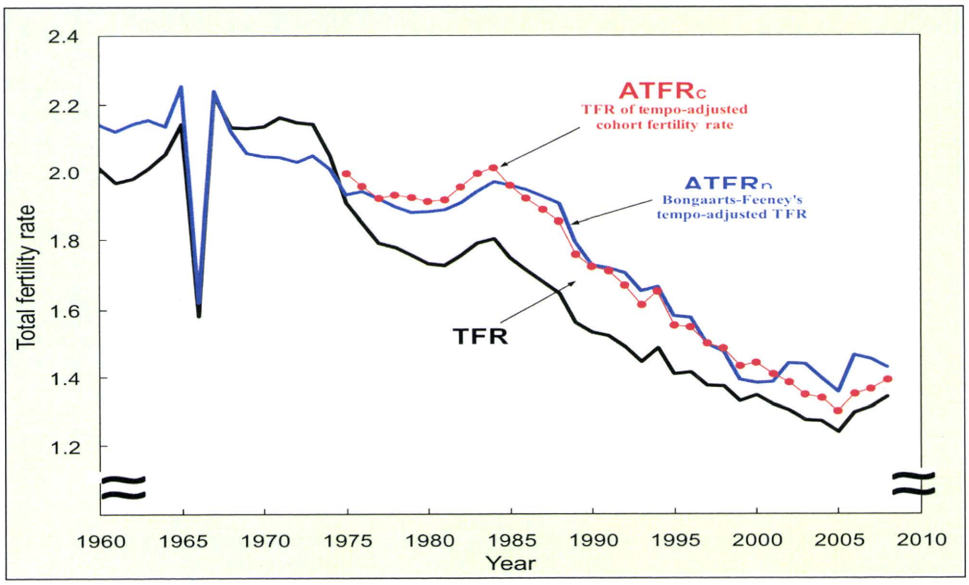
This view prioritizes harmonization among age-specific period fertility rates. However, in some cases it might be more appropriate to give precedence to harmonization of age-specific cohort fertility rates; that is, a framework in which r, the timing change speed of fertility rate, would be seen as a characteristic of a cohort and its tempo effect on the period total fertility is also a characteristic unique to the cohort (We refer to this as a cohort-shift framework). This can be achieved by expressing the timing change speed of a cohort as a function of the cohort born in year t_c, and the timing effect on the periods from this cohort as $\tau(t_c) = 1/(1 + r(t_c))$ (van Imhoff 2001), and the period TFR with adjusted timing effects as 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 the 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. However, we emphasize that it is only the timing changes in future fertility rates that are required - the fertility rates themselves are not used.

Figure 6 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 leveled out 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 an upturn in the same way as for the measured TFR, suggesting the increase in this period is not the recovery brought about by the elimination of type-T tempo effects, but rather a substantive rise of type-H effects.

Figure 6. Trends of the Total Fertility Rates with/without Tempo-adjustment



Note: The fertility rates are calculated based on births by Japanese women only.

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 over this period, which means that tempo effects that push down the period TFR exist. These tempo effects can also be seen from the development of the ATFRp and ATFRc indices for this period. The question now becomes, how can the scale of type-H period effects be measured while such tempo 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[4]. 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 (Kaneko et al. 2008).

The projection model is particularly good at describing the age-specific cohort fertility rate, and we believe it is fully capable of describing and expressing regularities latent at the base of the cohort childbearing schedule (see figure 7). Of course, there are cases where the achieved values deviate from the regularities for some ages. In fact, these deviations are precisely 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. The accuracy of the measurement result achieved by this method depends on the accuracy of the cohort model. For cohorts who have completed their childbearing process up to reasonably high ages, the applicability and accuracy of the cohort model has been established, as shown in the graphs above. For young cohorts with little experience in the childbearing process, however, there are various speculative factors involved in their remaining childbearing schedule and the accuracy of the model is less well understood. Therefore, the measurement values should be treated as provisional for the most recent years, where such cohorts contribute more.

Figure 8 illustrates the result of measuring type-H period effects using the method proposed above. Figure 8-a and Figure 8-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.

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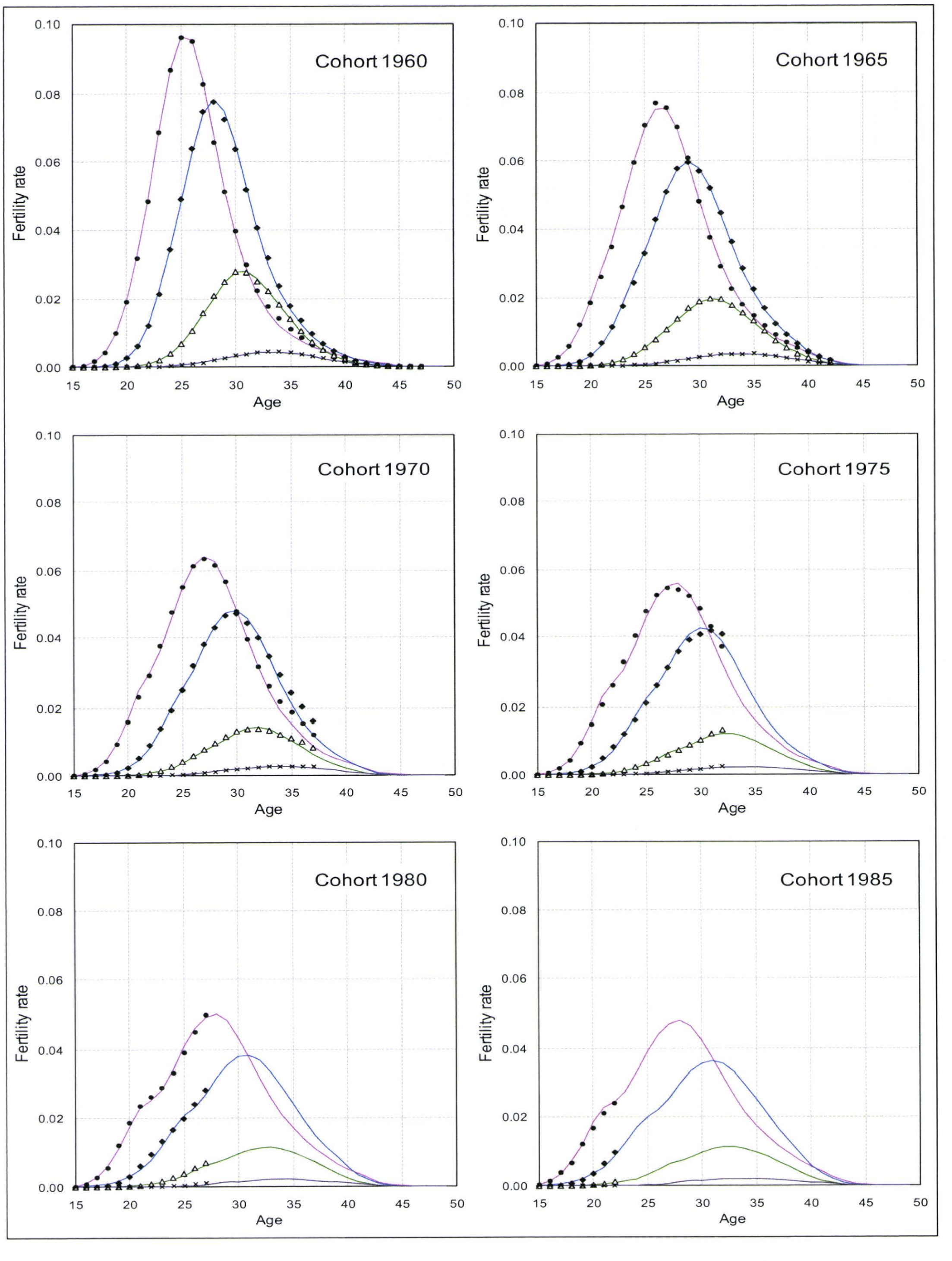
4) The model is based on the probability density function of the generalized log-gamma distribution, which is one of standard distributions in statistics. The fertility rate at age x for n-th birth is $f_n(x): f_n(x) = C_n \cdot \gamma(x; u_n, b_n, \lambda_n)$

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 the distribution will 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 and used 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.

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

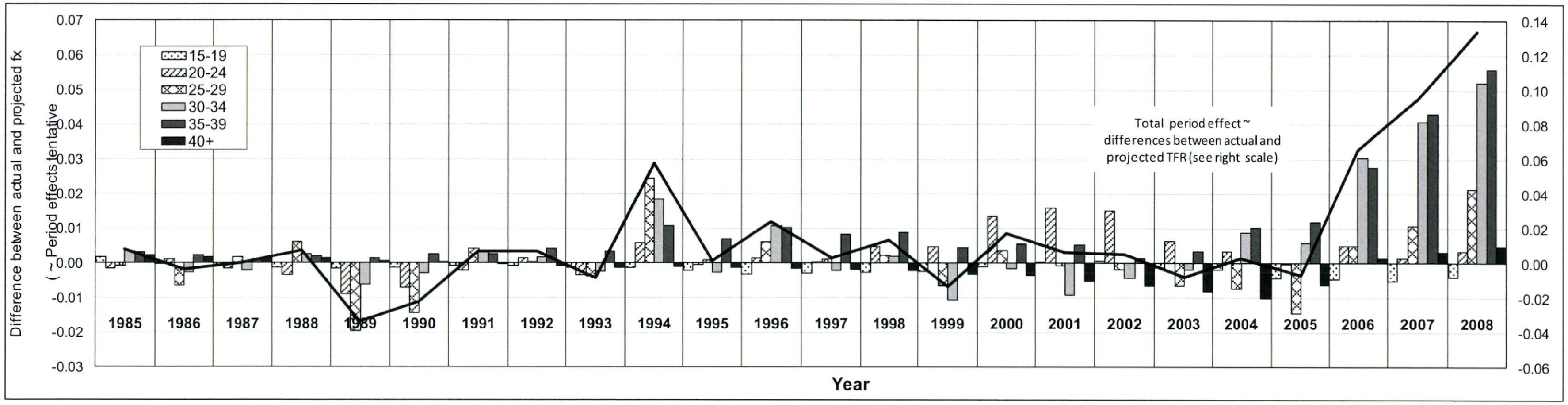
Figure 7. Actual and Modelled Fertility Rates of Japanese Female Cohorts by Birth Order



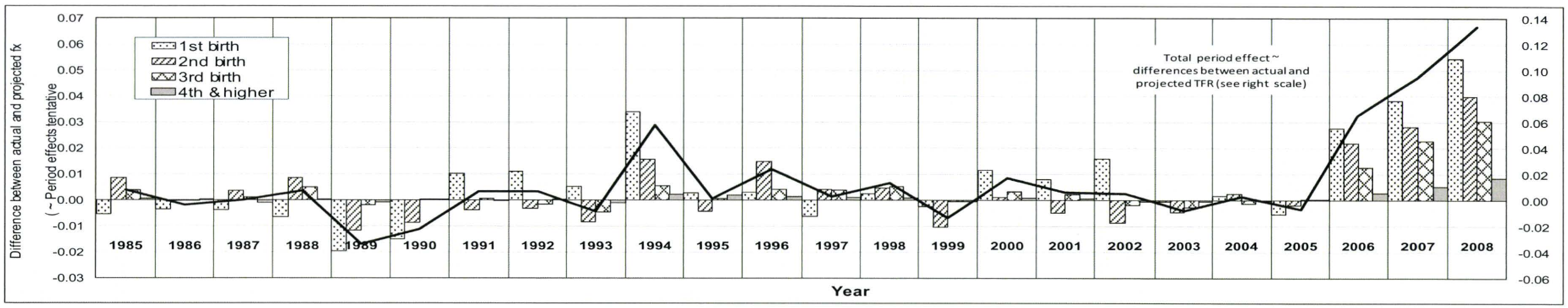
Note: Actual age specific fertility rates by birth order for female cohorts are plotted by dots, while modeled rates are plotted by lines. The actual rates are calculated only for female with Japanese nationality. The model rates are those employed in the official population projection conducted in 2006 as the medium assumption.

Figure 8. Estimates of Period Effects as Differences between Actual and Projected Fertility Rates by Five Year Age Groups: 1985-2008.

a. Age groups



b. Birth orders



***Note*:** The total period effects (solid line – right scale) is drawn in half the scale of the effects by age group (bar graph – left scale). Fertility rates are calculated based on births by Japanese women only here as well.

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 in the figures showing the annual TFR development (figures 1). 1989 is the year the TFR dropped below the value in the year of Hinoe-uma and achieved the lowest value in recorded history and is also the year of "Merkmal" that triggered widespread societal awareness in Japan of the 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 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 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 show actual values higher than expected from the cohort model for first children.

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 8-a), the upward effects in the 30s age group are notable 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 8-b), the period effect seems to contribute to all orders roughly equally.

Table 1 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.

Table 1. 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	4 6.5	43 .1	39 .0
35-39	- 4.0	18.8	4 2.5	45 .5	41 .8
40+	- 2.2	- 1.7	2.2	3 .4	3 .5
Total (values)	100.0 1 (-0.034)	00.0 (0.058)	100.0 10 (0.065)	0.0 10 (0.095)	0.0 (0.134)

b. Birth orders (%)

Birth order	Years whose "period effect" exceeds 0.03				
	1989	1994	2006	2007	2008
1st birth	5 7.9	58.9	42 .5	4 0.4	4 0.8
2nd birth	34. 3	27.3	3 3.6	29 .8	30 .0
3rd birth	5.6	9.7	1 9.4	24 .0	22 .8
4th & higher	.12	.14	4.5	.75	.46
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.

In general, the rise of fertility in this period is known as "last-minute birth" and similar terms. These descriptions generally imply that women who delayed 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 is their last chance. If only period effect patterns are examined, however, women in this age range not only tended to give birth to the first and second children they felt compelled to have in order to avoid childlessness and having an only-child, but also exhibited an increasing number of births to 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 interpretation will be examined in the subsequent discussion.

6. Discussion

In this paper, I utilized fertility projection prepared for the official population projection to analyze the period effects that are latent within the past and current fertility trends. Before applying the framework, I operationally defined a period effect as a fertility rate change observed in a certain period of time, which does not influence the cohort completed fertility (cohort TFR). Then I sorted out several types of period effect according to its effect on cohort fertility schedule, i.e. three different types of type-T period effect (T*l*, T*d*, and T*s*), and type-H. Type-T period effect is equivalent to a so called tempo effect.

Using this decomposition, period fertility rates synthesized from projected cohort fertility schedules are compared with observed rates. The former includes cohort changes and type-T period effects, but is free from the type-H period effects. Therefore difference between the projected and observed period fertility rate identifies the type-H (or type-H') period effects which should be induced by some period specific events.

Three temporal aspects of driving factors, i.e. period, cohort and age effects, are recognized in trends of demographic measures in general. In our framework, the age effects are expressed with a function of age as the regularity approximated by a mathematical function, while the cohort effects (variation by cohort) is represented by the different parameter values of the function. The period effects are disturbances to the age schedules shaped by the function with the certain parameter values affecting simultaneously many cohorts at different ages.

The fertility rates dropped continuously until 2005 in Japan, and the so-called lowest low fertility was attained for a three-year period from 2003 to 2005. However, from 2006 to 2008, an upward trend has been observed in the fertility rates, and the breadth of this upsurge is quite extraordinary as compared to past fluctuations seen since the fertility decline below replacement level started in 1974. Considering how important the fertility trends are for a society already in a phase of depopulation and rapid aging, it is extremely 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, we 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