Ultra-Low Fertility in East Asia: Quantum Effect or Tempo Effect?

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Abstract

Delayed childbearing is one of the main causes for ultra-low fertility in East Asia, but little is known about the extent of which the "postponement transition" depresses period total fertility rates in this region. To answer this question, I applied a new indicator suggested by Bongaarts and Sobotka, the so-called TFRp*, to the Korean case, one of the ultra-low-fertility countries. Results show that tempo effects have lowered the TFRs to a great extent since the early 1980s, and it was particularly pronounced in the early 2000s. The primary force that led to the ultra-low fertility was the ongoing shift of childbearing to later ages (tempo effect), but the ultra-low fertility was reinforced soon by a decline in period quantum, notably at lower-order births. The undistorted period fertility free from tempo distortions is forecast to further decline unless the current trends in both period quantum and tempo are immediately reversed.

Extended abstract

Tempo effects in fertility indicate that period total fertility rate (TFR) is over- or underestimated when women's timing of childbearing changes. In most European countries, for instance, many women tend to postpone their childbearing to later ages and this "postponement of transition" is still ongoing (Kohler et al. 2002; Bongaarts and Sobotka 2012). The delay of childbearing also involves a periodical decline in the number of births and thus lowers period TFRs although the total number birth women would have over the life course remain constant. Accordingly, disentangling tempo effects from period fertility is important to understand population dynamics because changes in the timing of childbearing mislead us about fertility changes.

Bongaarts and Feeney (1998) suggested a simple way to reflect such a distortion of TFR caused by the shift of childbearing to later ages. Since then, demographers have discussed and developed several ways to remove the tempo effects from the period fertility rates supplementing the shortcomings of the Bongaarts-Feeney method (e.g., Bongaarts and Feeney 1998, 2000; Kim and Schoen 2000; Zeng Yi and Land 2001). A few of them also began to consider variation of fertility timing or parity composition of female population as well (Bongaarts and Feeney 2008; Bongaarts and Sobotka 2012; Kohler and Ortega 2002; Kohler and Philipov 2001; Yamaguchi and Beppu 2004). These methods usually involve more complicated computation and also have own strengths and weaknesses so that demographers have yet come to any consensus regarding which method is most useful in terms of removing tempo effects. Although the debate is still ongoing, the idea and significance of tempo effect in fertility is widely accepted in demographic research.

The trend in period fertility rates can differ on whether the tempo effects are taken into account. Whether and to what extent the tempo effects affect period fertility rates is essential to understand a genuine change in period fertility and possible directions in the near future. For instance, in many European countries the downward trend in the period TFRs was reversed in the late 1990s and 2000s. According to Bongaarts and Sobotka (2012), the tempo effect is one of the important factors in explaining the recent reversal of fertility in many European countries. As the transition of childbearing to later ages comes to an end, the period TFRs that have been depressed in the past began to recover in some of European countries in recent years. From the demographic perspective, the fall and recovery in period fertility that happened in many European countries is mainly attributable to a change in tempo effects in fertility—the shift of childbearing to later ages—rather than a change in fertility quantum.

Despite vigorous research, however, the discussion on tempo effects in fertility has not yet expanded to countries outside Europe. East Asian countries, such as Hong Kong SAR, Japan, Singapore, Taiwan, and South Korea, have also experienced low fertility since the late 1970s and 1980s, and their period TFRs further declined below 1.3 between 2001 and 2005 (Jones et al. 2009). The TFR in China has also been well below the replacement level since the early 1990s (Morgan et al. 2009). The TFR below 1.3 is often described as "lowest-low fertility" (Kohler et al. 2002), but it is also called as "ultra-low fertility" in East Asia. The ultra-low fertility in East Asia is different from European one in that it does not rule out the potential for further declines (Jones et al. 2009). Many studies pointed out that the ultra-low fertility in East Asian countries is mainly attributable to delayed marriage and childbearing (Frejka, Jones, and Sardon 2010; Jones 2007). In many East Asian countries women's mean age at marriage has increased for the post several decades, which is followed by a rise in age at childbearing. As of yet universal marriage pattern remains although it is diminishing, and births out of wedlock are also not yet common in this region. A decline in nuptiality along with the solid link between marriage and childbearing resulted in ultra-low fertility in East Asia, which is in contrast with European experience characterized by prevalent non-marital births. The combination of late marriage and the remaining universal-marriage pattern implies that considerable births delayed at younger ages may be made up for later in these countries once women get married at later ages. However, it is obscure whether the ultra-low fertility in this region is attributable to the postponement of childbearing to later ages as in European countries or just reflects a pure decline in fertility. Despite its significance, it is hard to find research analyzing tempo effects in fertility in this region, perhaps due to lack of data that limit such an analysis. As a result, the role and contribution of tempo effects to the ultra-low fertility remains an open question.

In an effort to fill this gap, this study explores the tempo effect and its contribution to the period fertility rates in South Korea (hereafter just Korea). Korea is well known for its rapid fertility decline. The period TFR entered below-replacement level in 1983 and fell below 1.30 in 2001. Since then the TFR of Korea has remained below 1.30, which is one of the lowest levels in the world. Korean government also abolished the long-lasting anti-natalist policy in 1996 and converted it into pro-natalist policy in response to fertility decline and population ageing, but these policy efforts do not yet appear to have much effect (Lee 2009). A body of literature has studied socioeconomic factors that might lead to fertility decline (Anderson and Kohler 2013; Choe and Park 2006; Eun 2007; Jun 2005; C.-S. Kim 2007; D.-S. Kim 2005, 2013; Kwon 2007; Ma 2013, 2014; Park et al. 2013; Woo 2012; Yoo 2006, 2014), but the nature of ultra-low fertility has not yet been sufficiently explored. Especially little is known about the size and role of the tempo effects in ultra-low fertility. As far as the demographic transition is concerned, Korea is one of the forerunners in Asia. What is happening in Korea might be shared with other ultra-low-fertility countries and thus it is very indicative for coming changes in other developing countries.

Focusing on Korea, this study investigates the changes and roles of tempo effects over the post-transitional stages, from the replacement level in the early 1980s to the ultra-low fertility in the recent years. I apply a new indicator, *the tempo- and parity-adjusted total fertility rate* (TFRp*) developed by Bongaarts and Feeney (2003, 2008) and Bongaarts and Sobotka (2012), to the Korean case and estimate the size of tempo distortions in period fertility rates. I decompose changes in period fertility rates into period tempo and period quantum changes, and also further divide them into order-specific changes. Based on recent trends, I also make fertility projections that may be useful for understanding possible changes in the near future. Results show that, since the beginning of 1980s tempo effects have continued depressing period fertility rates to a great extent, and the tempo effects were most pronounced in the early 2000s. Unlike European countries, however, the TFR decline to far below-replacement level is more attributable to the decline in period quantum that happened gradually, first at higher-order births in the 1980s and later at lower-order births in and after the 2000s. Although the undistorted quantum of period fertility stands at around 1.48 in 2014, it is expected to decline further unless the current trends in both period quantum and tempo are immediately in the coming years. This study contributes to the literature by shedding lights on the commonalities and differences of the tempo effects in period fertility rates between Western countries and East Asian countries.

<Figure 1 is about here>

Data and Methods

Data for this study come from two different sources, Korean Population and Housing Census and vital statistics. Descriptive tables of both data are available online at Korean Statistical Information Service (KOSIS: kosis.kr). In Korea, population census is conducted every five years while birth registration data is available every year since 1981. To compute age- and order-specific fertility rates, I obtained the parity distribution of female population by age from 1985 census, and age- and order-specific number of births between 1981 and 2014 from birth registration data. Also, female population by age for each year was obtained from census-based population estimation provided Statistics Korea.

This study builds on the method protocol used for the Human Fertility Database (Jasilioniene et al. 2012). Basically I constructed period fertility tables by age and birth order for the entire period and used these tables for computing tempo-adjusted TFRs. Among available censuses I considered the 1985 census as a “golden” census because it is the first census between 1981 and 2004 in which age- and order-specific number of births are available. I first obtained age-specific parity distribution of female population from the 1985 census and then, updated it with age- and order-specific fertility rates for the following years until the latest year available (2014). The same procedure was also conducted backward, from 1985 to 1981, by reflecting responsible age- and order-specific fertility rates each year. In doing so, I assumed that women’s migration and mortality are not selected by their fertility. This assumption should not be problematic in Korea because women’s in- and out-migration rates stay below 1% until recent years, and women’s mortality is also very low at reproductive ages. Furthermore, the parity-specific information on migration and mortality is not available. It is also to be noted that all demographic data were converted, mostly from Lexis triangle which is common in Korea, into Lexis vertical parallelogram so that events are classified by a calendar year and age reached during the year (ARDY). In this study I also considered all reproductive ages, from less than age 15 (<15) for the first age interval to the age 50 or more (50+) for the open-ended interval, assuming that all births before age 15 occur on age 14 and all births after age 50 do so between age 50 and 54. Detailed adjustments for age-parity distribution of female population followed the HFD method protocol (see section 3 & 5. Jasilioniene et al. 2012).

Three period fertility measures

For this study I used three period fertility measures: the conventional TFR, tempo-adjusted TFR (Bongaarts-Feeney method), and tempo- and parity-adjusted TFR (Bongaarts-Sobotka method). The conventional TFR is measured as the sum of age-specific fertility rates in a given year. It indicates the average number of children women would have if current age-specific fertility rates continue until the end of their reproductive span. As the TFR is simple to compute and also easy for comparisons between multiple populations, it is widely used in demographic research. The TFR is defined as

$$TFR_{(t)} = \sum_{i} TFR_{(t,i)}$$

where *t* indicates year and *i* represents birth order. Because of its own nature, however, the conventional TFR is distorted when the period mean age at childbearing changes.

The tempo-adjusted TFR (just TFR* in this paper) suggested by Bongaarts and Feeney (1998) is to reflect such distortions of the TFR caused by changes in the timing of childbearing. In the Bongaarts-Feeney method, the tempo distortion is easily adjusted by taking the conventional TFR over (*1* - *r*). Here, *r* indicates the annual rate of change in the mean age at childbearing. In order to get a better adjustment, this procedure can be done separately for each birth order. As the adjustment procedure is simple and intuitive, the TFR* is popularly used in the literature among adjusted fertility measures. However, the TFR* also contains considerable year-to-year fluctuations and does not take account of the changing parity distribution of female population.

$$TFR^{*}{}_{(t)} = \sum_{i} TFR_{(t,i)}/(1 - r_{(t,i)})$$

With regard to this issue, several scholars have developed a few ways of measuring period fertility free from both tempo and parity-composition distortion (Bongaarts and Feeney 2008;

Bongaarts and Sobotka 2012; Kohler and Ortega 2002; Yamaguchi and Beppu 2004). Among these measures suggested, I used *the tempo- and parity-adjusted TFR*, also called as TFRp*, for this study because as far as the order-specific data is available, it is more stable and also closer to completed cohort fertility than other measures, as will be shown later. This method, which is originally developed by Bongaarts and Feeney (2004 and 2006) and also by Yamaguchi and Beppu (2004) in a similar manner, is computed from fertility rates of the first kind ("hazard rates"). Like other measures that take into accounts parity composition, this measure is also based on the life-table framework of order-specific fertility. The difference is that births with different birth order are considered as separate non-repeatable events in this method, and thus order-specific fertility tables are treated as independent from each other (Bongaarts and Sobotka 2012). This feature is distinguished from the increment-decrement life-table framework in the Kohler-Ortega method (Kohler and Ortega 2002). As a result, in computing fertility probability of *i*th birth, the 'exposure' population for a denominator becomes all women who have not yet reached *i*th birth, not all women at (*i - 1)*th birth. The way of adjusting tempo effect is also the same with that of the TFR* although the distortion index (*1 - r*) directly applies to order-specific fertility tables. Accordingly the TFRp* is defined as:

$$TFRp^*{}_{(t)} = \sum_i TFRp^*{}_{(t,i)} = \sum_i \left\{ 1 - \exp\left[-\sum_a \frac{p_{(a,t,i)}}{1 - r_{(t,i)}} \right] \right\}$$

where $p_{(a,t,i)}$ indicates the probability of having *i*th birth among all women who have not reached *i*th birth at age *a* during year *t.*

Measuring tempo distortions and decomposition analysis

The trends in tempo distortions and how that differs by birth order may be useful for understanding the recent development of the postponement–quantum interactions. As the TFRp* is designed to measure the period quantum of fertility that is free from any tempo and parity-composition distortion, the difference between the conventional TFR and the TFRp* should represent the extent of the distortions from both tempo and parity-composition effects. The tempo distortion is equal to the sum of the order-specific differences between the TFRp* and the conventional TFR, which can be defined as follows:

$$TFRp^{*}{}_{(t)} - TFR_{(t)} = \sum_{i} \left(TFRp^{*}{}_{(t,i)} - TFR_{(t,i)} \right)$$

where *i* indicates birth order and *t* indicates year of interest.

A change in period fertility consists of a *period quantum* change and a *period tempo* change. The period quantum change indicates the change in period fertility attributable to a genuine increase or decrease in fertility rates while the period tempo change suggest the change responsible for an advance or postponement of fertility schedules. As the TFRp* adjusts not only tempo effect but also parity-composition effect, its difference from the conventional TFR includes the distortions from both tempo effect and parity-composition effect. As the parity-composition effect is closely related to a change in sequencing of births, it is also be considered as part of tempo effect caused by the shift of childbearing. Thus, in this study I regarded the distortions from both tempo change and parity-composition change together as tempo effects in a broad sense (or just "tempo and parity-composition effects"). For the decomposition analysis, I separated a change in the TFR into a quantum change and a tempo change—tempo and parity composition together. Both quantum and tempo changes are further split by birth order as described below.

$$TFR_{(t+10)} - TFR_{(t)} = \sum_{i} \left(TFR_{(t+10,i)} - TFR_{(t,i)} \right)$$

$$= \sum_{i} \left\{ \left(TFRp^{*}{}_{(t+10,i)} - TFRp^{*}{}_{(t,i)} \right) + \left[\left(TFR_{(t+10,i)} - TFRp^{*}{}_{(t+10,i)} \right) - \left(TFR_{(t,i)} - TFRp^{*}{}_{(t,i)} \right) \right] \right\}$$

Analytic strategy

The analysis of this study consists of several subsections. First, I describe recent trends in completed cohort fertility, period mean age at childbearing, and period age-specific fertility rates, which may be helpful for understanding the demographic context of Korea. Then, I provide period fertility trends between 1981 and 2014 that include three period fertility measures: the TFR, TFR*, and TFRp*. The differences between the three measures will depict how much of the conventional TFR has been distorted by tempo effects over the past three decades.

With the decomposition analysis I assess the relative importance of tempo and quantum changes to changes in the TFR and also evaluate how that process differs by birth order. In particular, I separate the observed period into three decadal periods so that each of them represents a gradual phase of fertility decline in the post-transitional stages, from the entry to the below-replacement level in 1981-1991 through the low-fertility period in 1991-2001 to the ultra-low fertility period in 2001-2014. These periods also corresponds with the times when the TFR in Korea fell below the replacement level in 1983, rebounded in 1991, and fell again below lowest-low level in 2001 respectively. The decomposition results and the interdecadal comparisons will illustrate how postponement-quantum interactions have developed in Korea.

In the final section, based on recent trends I make fertility projections for the next sixteen years, until 2030. To accomplish this, I hypothesize three scenarios for *period quantum* changes—a) no change, b) the continuation of the current trend, and c) the reversal of the current trend, and also set two scenarios for *period tempo* changes—i) the continuation of the current trend and ii) the gradual disappearance of existing tempo effects. In the figure of age-specific fertility rates (ASFRs) which ages are on the X-axis against fertility rates on the Y-axis, a period quantum change is described as a vertical movement of the fertility schedule that proportionally inflates or deflates ASFRs at all ages. By contrast, a period tempo change makes a horizontal movement of the fertility schedule that moves to the left or right side on the X-axis without a change in its shape (Bongaarts and Sobotka 2012). In this sense, the three scenarios of period quantum changes represent the present state, move-up, and move-down of the ASFR curve while the two scenarios of period tempo changes hypothesize the move-to-the-left and the grinding halt of the move of the ASFR curve. The combination between these two components results in six different scenarios. These projections provide not only a range of fertility changes that might happen in the coming years, but also useful grounds for formulating realistic policy goals for Korea.

Preliminary results

Fertility trends in South Korea

Figure 2 depicts observed and estimated completed cohort fertility for female cohorts born between 1931 and 1980. The trend in completed cohort fertility shows a monotonic downward pattern: a steady decline until the 1955 cohort, a plateau among those born between 1956 and 1968, and then a moderate decline until the latest cohort available. The completed fertility rate is expected to decline further until 1.44 or 1.38, depending on whether we use the latest ASFRs available or the recent trends in ASFRs for projections. The overall trend is consistent with a previous study (Yoo 2014) although completed fertility rates for oldest cohorts are lower in this study (e.g., 4.70 vs. 4.97 for the 1931 cohort of women). The gap can be attributable to differences in methods and data sources. This study used a fertility table based on 1985 census and updated it with vital statistics while the previous study directly took the average number children among the women at the end of reproductive span from a set of census microdata samples. Accordingly, demographic factors like migration and mortality that were not considered in this study could make the difference in completed fertility rates although it remains marginal.

<Figure 2 is about here>

Figure 3 illustrates trends in women's mean age at childbearing between 1981 and 2014. The trend for all births shows a slacked *J*-shape over the period under consideration: a minor decline between 1981 and 1984 and then a steady rise until 2014. In the trend line for all births, the short decline in the early 1980s, which is much steeper than order-specific trends, suggests that the transition from high to small family size was more influential than the change in the timing of childbearing at the moment. The stable upward trend in the mean age at childbearing demonstrates that the shift of childbearing to later ages has continued since the early 1980s. A similar pattern is observed in order-specific trends although the increasing pace varied with birth order. For instance, the mean age at first birth increased at the fastest pace in tandem with that of second birth while the pace was more modest at higher-order births.

Changes in ASFRs also provide a glimpse of period quantum and period tempo changes (Figure 4). In the figure, the ASFRs in 1981 showed the highest fertility rates at all ages except for age 30 or higher, and women's primary ages for childbearing stayed in their mid-twenties. In 1991 the ASFRs declined at all ages, notably in their twenties. The decline in ASFRs continued in the 1990s, but this time the fertility schedule began to move toward the right side implying the postponement of childbearing. The shift of childbearing to later ages became clearer in comparison between 2001 and 2014. Fertility rates declined in their twenties but increased in their thirties. As a result, the vertex of the ASFR curve, which was around age 26 in 1981, also moved to age 32 in 2014. This figure displays how the "postponement transition" has changed the shape of ASFRs in the last three decades, but it is difficult to determine the exact size and impact of quantum and tempo effects.

<Figure 3 and 4 are about here>

Fertility trends and tempo distortions

Figure 5 shows fertility trends between 1981 and 2014 in Korea. Three period fertility measures—the conventional TFR, tempo-adjusted TFR (TFR*), and tempo- and parity-adjusted TFR (TFRp*)—are contrasted to the lagged completed cohort fertility. Following previous studies (e.g., Sobotka 2003), I also used the completed cohort fertility lagged as much as the period mean age at childbearing. For instance, if the period mean age at childbearing is 30 in 2000, I obtained the completed fertility rate for women born in 1970 and contrasted it with three period fertility measured in 2000. The conventional TFR declined from 2.57 in 1981 to 1.20 in 2014 with vigorous fluctuations. The trend displays a dramatic decline in the early 1980s, a minor bounce in the early 1990s, and a moderate decline between the 1990s and early 2000s followed by a wave pattern between 1.10 and 1.30 afterward.

The trends in two adjusted measures, the TFR* and TFRp*, similarly show a downward pattern but their paces and progresses differ from that of the conventional TFR. Compared to the TFR, the TFR* and TFRp* display consistently higher fertility rates over the observed period, except for the early 1980s. The substantial difference between the conventional TFR and two tempo-adjusted TFRs seems to have increased over time since the early 1980s, implying the rising tempo distortions. It is noteworthy that the TFRp* shows the most stable trend, which also contrasts to the TFR* showing considerable year-to-year variations. The TFRp* is also remarkably close to the lagged completed cohort fertility, proving excellence in estimating period quantum (Bongaarts and Sobotka 2012).

As the shift of childbearing to later ages differs by birth order, the relative importance of tempo effects can be different for each birth order. In addition to that, in a place like Korea where vigorous changes in fertility continue, the parity composition of female population also changes quickly. Figure 6 depicts the gap between the conventional TFR and TFRp* by birth order. In the figure of birth order 1, the trend in the TFR shows fluctuations in the downward pattern while the TFRp* has a very flat line until 2002 and then began to decline slowly. The difference between the TFR and TFRp* was small in the 1980s, but gradually increased between the 1990s and 2000s reaching 0.35 in 2002. For birth order 2, both the TFR and TFRp* have a clear declining pattern which is also more dynamic. The distance between the TFR and TFRp* peaked in the mid-1980s, but became stabilized for the rest of the period. By contrast, in the figures of birth order 3 and birth order 4+, the marginal difference between the TFR and TFRp* observed in the 1980s gradually diminished over time, and the lines of TFR and TFRp* eventually converged in the 1990s.

In Figure 7, the difference between the TFR and TFRp* is stacked by birth order, one by one. A positive or negative value represents the extent of which the TFR is over- or underestimated, respectively, by tempo and parity-composition effect for each birth order. With some variations, tempo effects—both tempo and parity-composition changes together—have consistently depressed the TFR over the past three decades. The size of tempo distortion that includes all births together varied from a low of 0.08 in 1983 to a high of 0.58 in 2002. The trend in tempo distortions, measured by the gap between the TFR and TFRp* for all births, shows two different waves. The TFR-TFRp* difference first fell and rose between 1983 and 1992 reaching -0.43 at trough in 1986. The difference levelled off at around 0.19 for 4-5 years, but it began to fall again in 1995. The TFR-TFRp* difference reached the lowest point of -0.58 in 2002, which suggest that the tempo effect depressed the TFR as much as 0.58. Since then, the gap between TFR and TFRp* has gradually reduced, but still stays around -0.27 in 2014. While the first wave took just a decade, the second wave is still ongoing spending more than two decades. The latter is also much greater in size compared to the former. As a result, the changes in tempo and parity composition have lowered the conventional TFR of Korea to a great extent over the past three decades, and the impact of tempo distortions was most pronounced when the TFR reached lowest-low fertility level in the early 2000s.

Decomposition analysis

A change in period fertility consists of a *period quantum* change and a *period tempo* change. Decomposition analysis breaks down a change in period fertility into a change in period quantum and a change in period tempo so that we can determine the relative significance between the two. In this study, I further divided it by birth order. Figure 8 represents the decomposition results for the three interdecadal periods. A blue colored bar represents a change in period quantum in absolute terms while an orange colored bar indicates a change in period quantum that includes both tempo and parity-composition effects. A gray dot represents a net effect between the two. In the period of 1981-1991 in which the TFR slid into the below-replacement level, the TFR decline reached as much as 0.86 and about 99% of the decline was attributable to a quantum change. The decline in period quantum is more salient among higher-order births, birth order 3 and 4+, which also proves that the transition from three or more children to two or less was still under way at the moment. At the same time, minor tempo effects at birth order 1 and 2 that lowered the TFR, were largely offset by the similar levels of tempo effects at birth order 3 and 4+ that worked in the opposite way. Accordingly the TFR decline attributable to the change in tempo effects was negligible in this period.

During the period of 1991-2001 in which the TFR further declined from 1.71 to 1.34, both quantum and quantum effects switched their roles in fertility decline. While the share of quantum changes to the TFR change dramatically declined, tempo changes became a dominant source that makes changes to the TFR. To be specific, a change in period quantum was trivial at all birth orders except a minor decline at birth order 2. By contrast a significant change in period tempo appeared at lower-order births, notably at first birth. Consequently around 88% of the TFR decline is attributable to the changes in period tempo, and four-fifths of the tempo changes were from first-order birth. The increasing tempo effects indicates that the trend toward late childbearing was intensified particularly in this period. In the meantime, the TFR decline owing to quantum change was just 12%, 0.05 children per woman.

In the last period of the ultra-low fertility between 2001 and 2014, both period quantum and tempo changes worked in opposite ways. The drop in period quantum contributed to the TFR decline to a great extent while the relaxed period tempo in part rather alleviated the declining trend in TFR. It should be noted that the positive values of tempo changes do not indicate the reversal of postponement transition, but instead suggest relative reduction in its size between 2001 and 2014. As was seen above, the tempo effect measured by the TFR-TFRp* remains substantial until 2014, which suggest the ongoing postponement transition. It is also noteworthy that both period quantum and tempo changes were concentrated at lower-order births, birth order 1 and 2. Those at higher-order births did not have much impacts on fertility changes.

Fertility projections until 2030

Based on recent trends in period quantum and tempo, I tested six different scenarios of fertility projections until 2030. I set three scenarios for *period quantum* changes and two scenarios for *period tempo* changes respectively, and combined them with each other. For *period quantum* changes, I hypothesized a) no change in quantum, b) the continuation of the current trend, and c) the reversal of the trend. The no-change scenario assumes that without a change in period quantum the latest ASFRs observed in 2014 continues until 2030. For the scenario of the current trend, I applied the recent trend of quantum changes, an annual 2% decline in the ASFRs at all ages, to the fertility tables. The last scenario, the reversal of the trend, set up a gradual rise (an annual 2% rise) in the ASFRs which is against the current trend. For *period tempo* changes, I considered two scenarios, i) the continuation of the current trend and ii) the gradual decline of the tempo effect. Between 1981 and 2014 the mean age at childbearing increased around 0.17 year-old every year on average. In the first scenario, I applied the annual delay of 0.17 year to the fertility schedules for the following years assuming that this trend lasts to 2030. By contrast, the second scenario assumes that the annual delay of 0.17 year declines by 20% every year so that the postponement of childbearing gradually disappears. Although the 20% decline in the annual delay is somewhat arbitrary, this scenario well describes the ending phase of 'postponement transition' that is not far from European experience (Bongaarts and Sobotka 2012).

Figure 9 depicts the projection results that reflect well the interplay between period quantum and tempo changes. In the three scenarios with a constant tempo effect in the upper part of the figure, the TFR-TFRp* difference maintained until 2030 without convergence. However, the TFR and TFRp* get close to each other in other three scenarios that set up a declining tempo effect, and even cross each other in scenarios 6. The contrast between a constant tempo effect and a declining tempo effect confirms that the TFR is consistently distorted by tempo effects unless the shift of childbearing to later ages stop in the coming years.

Figure 10 just summarized the trajectories of the TFRp* for six different scenarios. Depending on hypothesized scenarios, the estimated TFRp* differed to a greater extent. For example, scenario 4 (a declining quantum + a declining tempo) revealed the lowest estimates of

TFRp* while scenario 6 (a rising quantum + a current tempo) showed the highest figures, reaching 0.91 and 1.91 respectively in 2030. However, these scenarios (4 and 6) are based on the assumption that both quantum and tempo changes work in opposite ways. A delay in the fertility schedule is usually associated with a decline in period fertility while an advance in the fertility schedule is accompanied with a rise in period fertility. The mix of a rising quantum and a persisting tempo effect is unnatural and thus less likely to happen; the opposite is the same as well. If we exclude these scenarios from consideration, the possible direction of period fertility changes become much narrower and clearer.

Except for the two extreme scenarios, all of the estimated TFRp* fell into a range of 1.10-1.60 in 2030. Among four scenarios under consideration, none of them passed 1.50 until scenario 6 reached it in 2025. Whether a period quantum increases or decreases, the undistorted period fertility is expected to decline for more than a decade. Even in scenario 6, the most desirable scenario that set up with a rising quantum and a diminishing tempo effect, it took a decade to recover the current level of the TFRp*. In the scenario the delayed upturn in the TFRp*can be attributable to the interplay between existing parity composition and the pace of declining tempo effect. The projection results clearly suggest that the TFRp*, along with the conventional TFR, will continue to decline for the next couple of decades unless the current trends in both period quantum and period tempo are immediately reversed in the coming years.

Discussion and conclusion

The preliminary results already demonstrate that the ultra-low fertility in Korea was first led by a strong tempo effect, which is still ongoing, and then reinforced later by a decline in quantum, notably at first and second births. The decline in quantum at lower-order births is unique and particularly important because of its potential for further declines in the undistorted period fertility. It is also interesting to see whether the undistorted period fertility free from tempo distortions actually could reach below the “lowest-low” level (1.3) in Korea in the near future because that implies a complete divergence from European patterns. Among advanced economies in East Asia, Singapore is a city-state while Japan is rather exceptional for its long period of fertility decline compared to neighboring countries. Therefore many developing countries in East and Southeast Asia where fertility decline is underway, are more likely to follow the trend happened in Korea. In this sense, findings of this paper have more theoretical importance and policy implications.

* **The final version** will include backgrounds on the ultra-low fertility, fine-tuned analysis, and detailed discussion on the results. I will also discuss the commonalities and differences in the tempo effects between East Asian and European countries.

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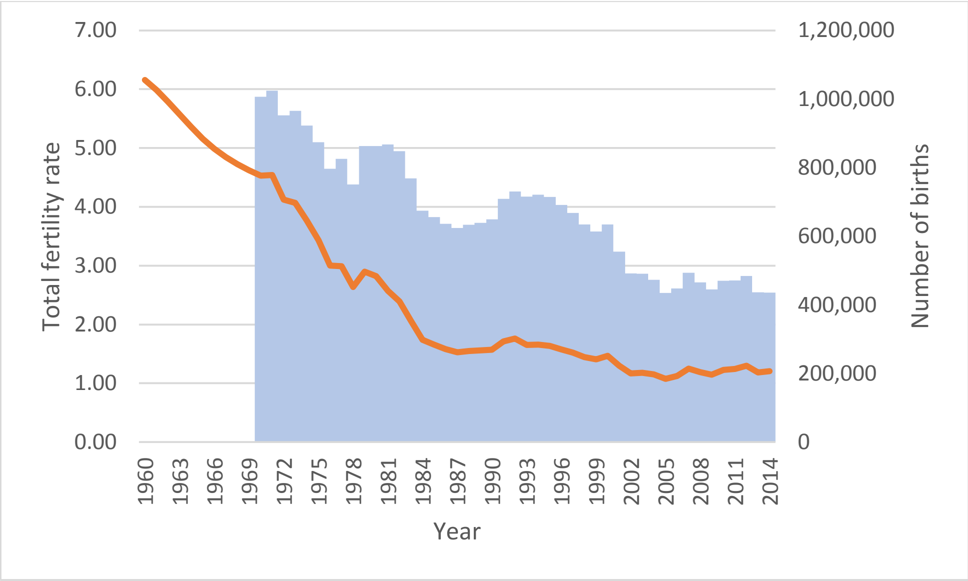
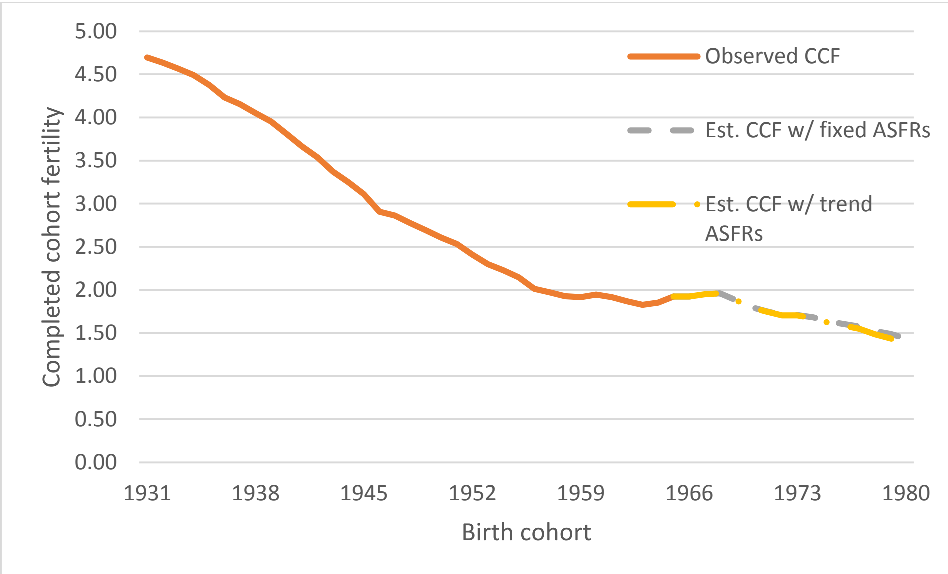
Figure 1. Period total fertility rates and total number of births in South Korea, 1960-2014



Source: KOSIS (2015) and the World Bank (2015)

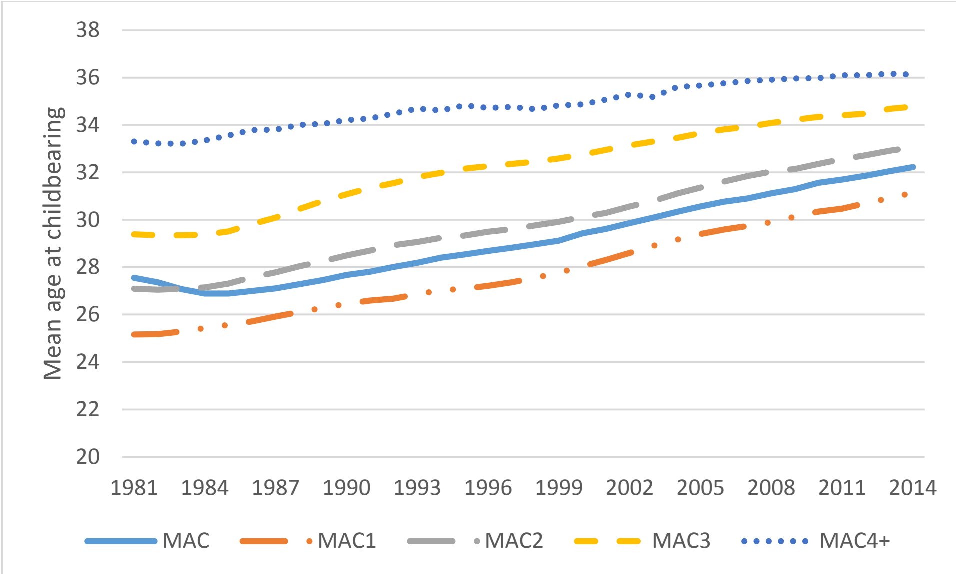
Figure 2. Observed and estimated completed cohort fertility of female birth cohorts born between 1931 and 1980



Note: For women born from 1966 to 1980, who have passed age 35 but not yet reached age 50, completed cohort fertility was estimated in two different ways: i) the fixed ASFRs observed in 2014 and ii) the trend ASFRs.

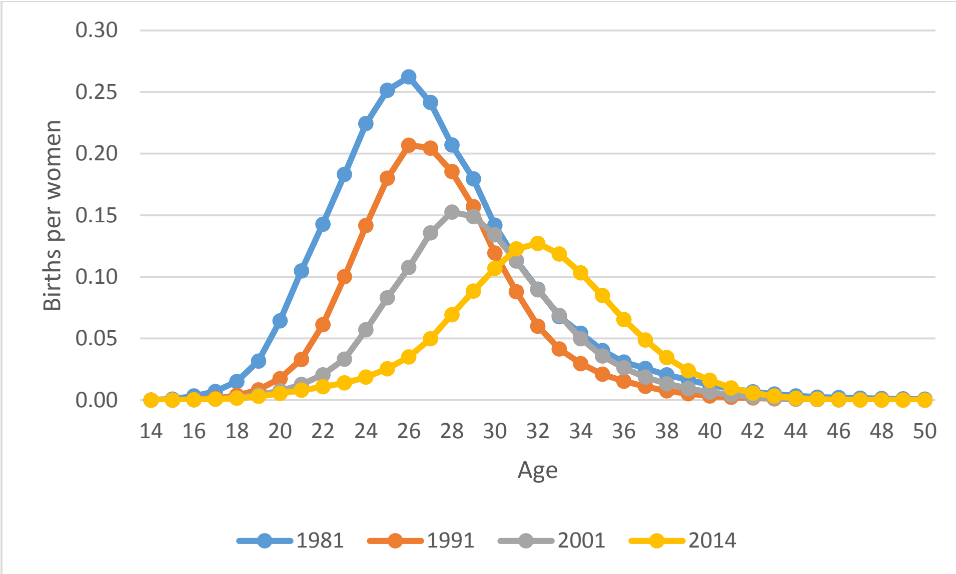
Source: own calculations based on vital statistics and census data.

Figure 3. Women's period mean age at childbearing by birth order, 1981-2014



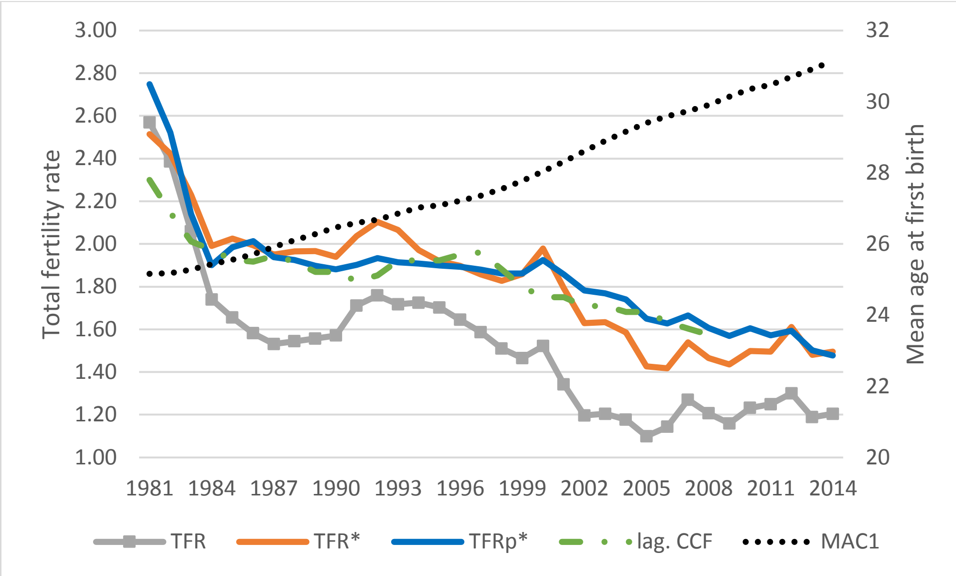
Source: own calculations based on vital statistics and census data.

Figure 4. Changes in age-specific fertility rates between 1981 and 2014



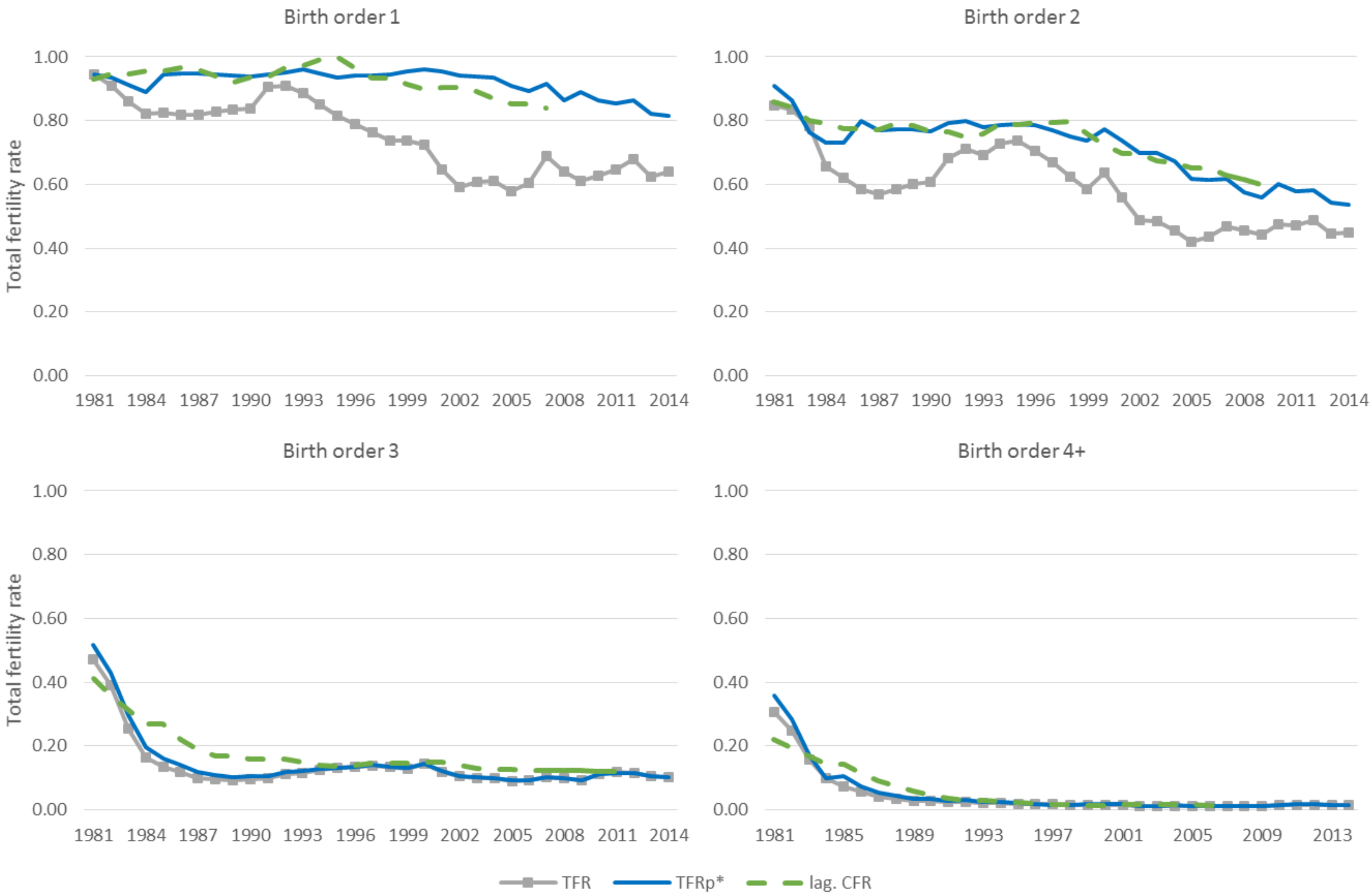
Source: own calculations based on vital statistics and census data.

Figure 5. Fertility trends in South Korea, 1981-2014



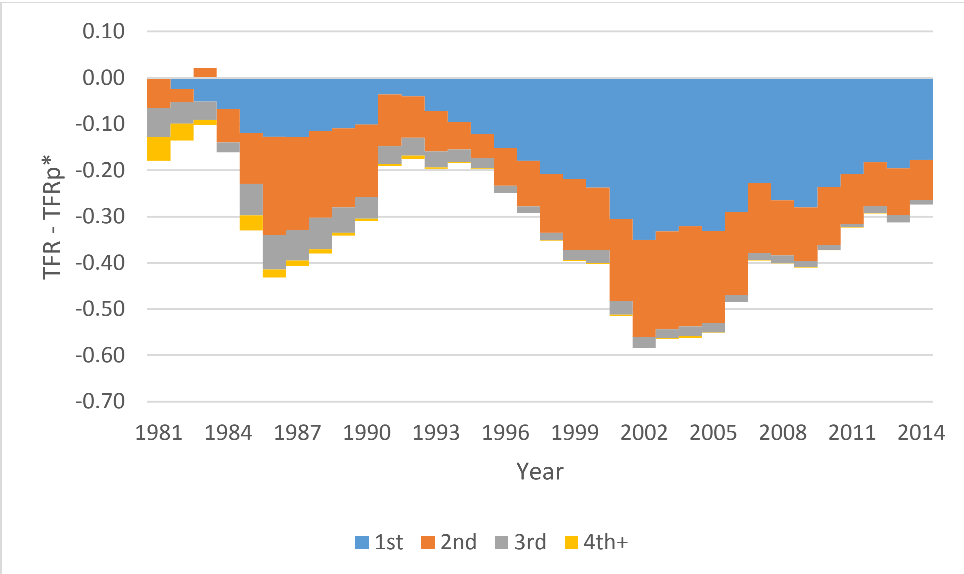
Source: own calculations based on vital statistics and census data.

Figure 6. Order-specific fertility trends, 1981-2014



Source: own calculations based on vital statistics and census data.

Figure 7. Tempo distortions from tempo and parity composition by birth order, 1981-2014

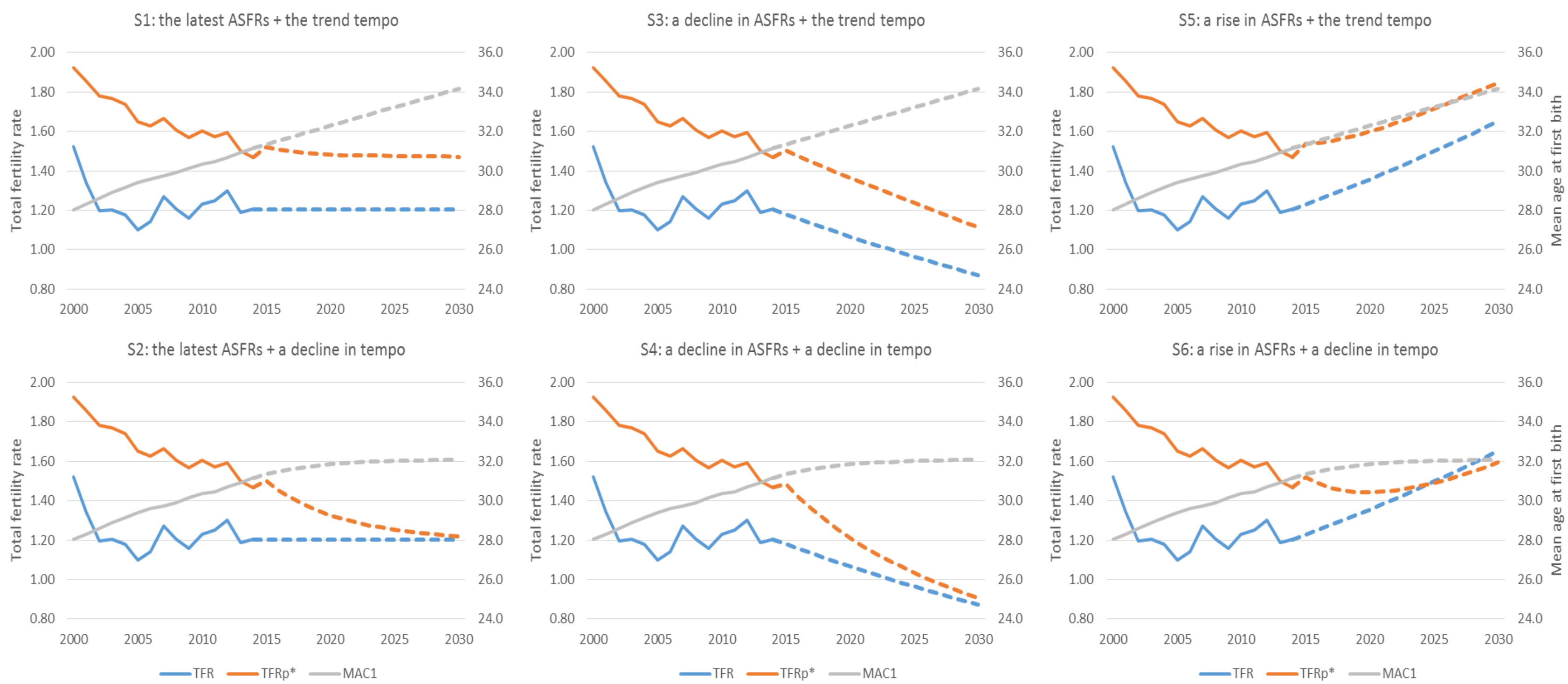


Source: own calculations based on vital statistics and census data.

Figure 8. Decomposition analysis of changes in period total fertility for three different periods

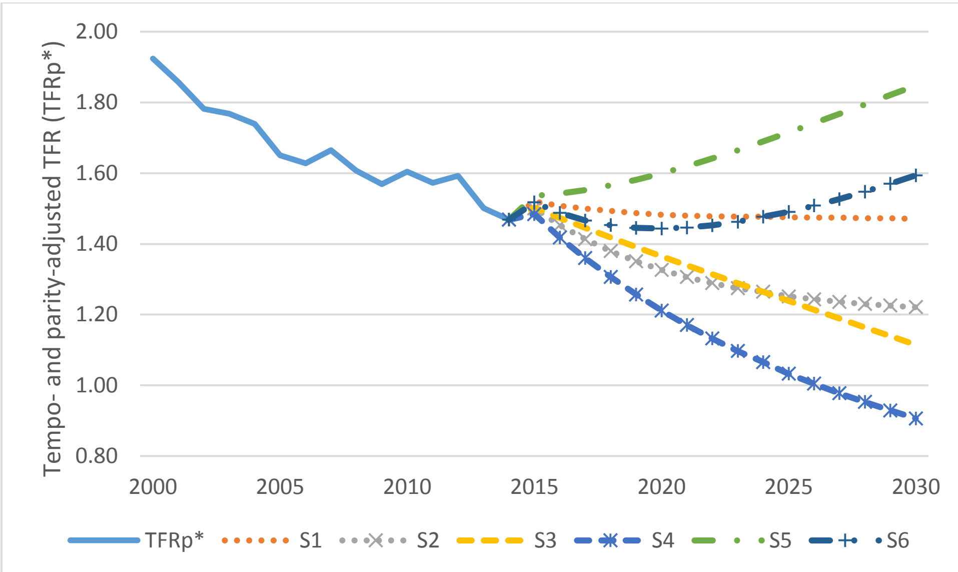
Source: own calculations based on vital statistics and census data.

Figure 9. Six scenarios of fertility projections until 2030, South Korea



Source: own calculations based on vital statistics and census data.

Figure 10. Comparison of tempo- and parity-adjusted TFRs (TFRp*) among six scenarios



Source: own calculations based on vital statistics and census data.