Preliminary partial draft.
Not for distribution
John Bongaarts

DEMOGRAPHIC EXPLANATIONS FOR THE RECENT RISE IN EUROPE'S FERTILITY

Fertility as measured by the period total fertility rate (TFR) rose in the large majority of European countries over the past decade. This trend represents an unexpected reversal from the historically unprecedented low levels reached by most countries in the 1990s or early 2000s. Increases from these minima have reached as high as 0.51 births per woman in Denmark and eighteen countries experienced increases greater than 0.2 (Goldstein et al 2009). The turnaround has been especially rapid in populations with the lowest fertility: The number of countries with a TFR below 1.3 declined from 16 in 2002 to just one in 2008 (Goldstein et al 2009). These new trends are a very welcome development because the potential adverse consequences of population ageing and population decline will likely be substantially lower than feared in the 1990s.

Explanations for this new phenomenon can be provided at two levels, demographic or socioeconomic. Demographic explanations include the disappearance of period tempo effects that have distorted the TFR downward in the past as the age at childbearing rose (Bongaarts and Feeney 1998; Bongaarts 2002; Sobotka 2004), and a cohort driven process of recuperation at older ages of births that were postponed at younger ages (Lesthaeghe and Williams 1999; Frejka and Sardon 2009; Goldstein et al 2009). Further back in the chain of causation are social and economic determinants (e.g., economic growth rate, unemployment, gender equality) and pronatalist or family policies that affect the quantum and tempo of childbearing.

This study focuses on the demographic determinants of recent fertility increases in Europe. The availability of the new Human Fertility Database (HFD) makes it possible to analyze fertility trends in much greater detail than before. The HFD provides estimates of numbers of births, exposure to the risk of childbearing and fertility rates by age, period, cohort, birth order, parity and country. A full examination of these complex data sets for all available countries is beyond the scope of this exercise and the empirical analysis below will therefore focus on three countries: Czech Republic, Netherlands and Sweden which have experienced significant recent upturns in fertility.

After a brief overview of fertility trends, the paper focuses on two main topics. First, the potential roles of period and cohort influences as drivers of fertility fluctuations are discussed. The next section examines the role of tempo distortions as causes of low fertility and the recent upturn. Two variants of the Bongaarts-Feeney method for removing these distortions are presented. The discussion highlights the analytic difficulties in interpreting quantum and tempo trends that have led to differing interpretations. The aim is to contribute to a resolution of these debates and to move to a consensus on the demographic causes of recent fertility trends.

I. RECENT TRENDS IN THE QUANTUM AND TEMPO OF PERIOD FERTILITY

The dominant trend in fertility in Europe from the 1960s into the 1990s was a downward turn to below replacement. Europe's average TFR declined by more than one birth per woman, from 2.6 in 1960-1965 to 1.4 in 1995-2000 (United Nations 2009). Each major region within Europe experienced declines of a similar magnitude although patterns differed somewhat between regions (see Figure 1). A steep decline occurred first in the West and the North in the early 1970s, followed by the South in the late 1970s and 1980s and the East in the 1990s. By the end of the 1990s fertility levels converged around a TFR of 1.5, with a range from 1.7 in the North, to 1.4 in the West and 1.3 in the South and East. These are all record lows.

The recent upturn in fertility has been documented by Goldstein et al.(2009). Estimates of the increase in the TFR between the year of the minimum and 2008 for 29 European populations range from 0.03 in Portugal to 0.51 in Denmark. The following countries had increases of 0.2 or more:

Eastern Europe: Belarus, Bulgaria, Czech Rep., Estonia, Latvia, Lithuania, Moldova, Russia, Ukraine
Northern Europe: Denmark, Sweden, UK
Southern Europe: Greece, Italy, Slovenia, Spain
Western Europe: France, Netherlands

In absolute terms these fertility increases may seem modest, but they have nevertheless important demographic consequences because they close a substantial part of the gap between the minimum and the replacement level.

The second major trend since the 1960s has been a rise in the mean age at childbearing.

[Section and figure 2 to be added in full draft]

An examination of trends in the total fertility rate and the mean age birth is a first step in any analysis of fertility trends, but their aggregate nature can obscure important birth order specific changes. For example, Figure 3 plots the TFR by birth order for the Czech Republic, the Netherlands and Sweden. In all three countries increases in the overall TFR were mostly due to increases at birth orders one and two while TFRs at higher orders were flat or down. Fluctuations in fertility are largest in the Czech Republic and smallest in the Netherlands.

Trends in the order specific mean ages at birth plotted in Figure 4 demonstrate no major differences in patterns by birth order; they all trend upward over time. Nevertheless, it is desirable to undertake order specific analysis because it is possible for the trend in the aggregate mean age at childbearing to differ substantially from the trends in the order specific means. For these reasons any in-depth analysis of fertility trends should be conducted birth order by birth order, and the remainder of this paper will follow this approach.

II. PERIOD VERSUS COHORT CHANGES.

The driving forces of fertility change, in particulate of the new upward trend in the TFR, have been interpreted differently by various analysts. Goldstein et al (2009) summarize this debate as follows: "One area of research emphasizes the prominence of period factors in driving fertility change (Ni Bhrolchain 1992); this view is also explicitly adopted in the tempo adjustment of Bongaarts and Feeney (1998). A competing view stresses the prominence of a cohort driven process of fertility recuperation (e.g. Lesthaeghe and Williams 1999, Frejka and Sardon 2009)" The following comments aim to clarify the differences and agreements between these two perspectives.

Definitions

Definitions of cohort and period changes are essential before proceeding. Let $f(a,t,i)$ be the age-specific fertility rate at age a at birth order i and time t for the cohort born in year c ($c=t-a$). In the analysis that follows age-specific fertility rates will always be examined separately at different birth order, but for simplicity the subscript i will be dropped.

Four ideal type of changes in $f(a,t)$ can be identified:

1) A *period quantum* change in fertility is defined as an increase or decrease from one period to the next that is independent of age or cohort.

$$f(a,t)=(1+r(t))\, f(a,t-1)$$

where $r(t)$ is the proportional change in fertility between years $t-1$ and t. As shown in Figure 5 this change in quantum simply inflates or deflates the period fertility schedule proportionally at all ages.

2) A *period tempo* change is defined as an increase in the mean age at childbearing from one period to the next with the shift in schedule independent of age or cohort.

$$f(a,t)= f(a-s(t),t-1)$$

where $s(t)$ equals the amount of the shift between t and $t-1$. As shown in Figure 6 this tempo change involves a move up or down the age axis of the fertility schedule while its shape remains invariant.

3) A *cohort quantum* change in fertility is defined as an increase or decrease from one cohort to the next that is independent of age or period.

$$f(a,c)=(1+r(c))\, f(a,c-1)$$

where $r(c)$ is the proportional increase in fertility between c and $c-1$

4) A *cohort tempo* change in fertility is defined as an increase in the mean age at childbearing from one cohort to the next with the shift in schedule independent of age or period.

$$f(a,c)=f(a-s(c),c-1)$$

where $s(c)$ equals the amount of the shift in years between c and $c-1$

The real world is of course much more complex than any of these pure changes because period and cohort, and quantum and tempo changes often occur simultaneously to bring about observed year by year changes in fertility.

Are observed fertility fluctuations due to period or cohort changes?

The question of whether period or cohort changes dominate in determining fluctuations in fertility has been examined in a number of key studies in recent decades. Brass (1974) concluded that cohort completed fertility reveals no significant feature that distinguishes it from time averages of period indexes. Pullum (1980) concludes that "temporal variations that cut across cohorts, such as economic cycles, appear to be more important than changes in those variables that distinguish cohorts, such as shared socialising experiences". Foster's (1990) analysis of data for eight countries in Europe and North America arrives at a similar conclusion. In an authoritative review, Ní Bhrolcháin (1992) concludes that "of the two dimensions of calendar time—period and cohort—period is unambiguously the prime source of variation in fertility rates." These studies are essentially in agreement that period influences on fertility are much more important than cohort influences.

Additional support for this conclusion is provided by a brief examination of the shape of observed fertility schedules. A key feature of period changes is that all cohorts respond in the same way to period influences by either changing the level or the timing of fertility. As a result, in a period world (where only period effects occur) the shape of the schedule of period age-specific fertility rates remains invariant over time. The schedule can be inflated or deflated over time to reflect period quantum changes or it can shift to higher or lower ages to reflect period tempo changes but the shape remains constant. In contrast when pure cohort changes are present the shape of the period fertility schedule changes.

A first step in the empirical analysis of this issue is to examine trends in the standard deviation of the age schedule of period fertility. In the absence of cohort effects, the standard deviation should be constant. Figure 7 plots the standard deviations of the period age-specific fertility schedule (by birth order) for the Czech Republic, the Netherlands and Sweden. In these three populations the standard deviation shows no major trends up or down, although there are some fluctuations and there is a slight rise at birth order one in the Czech Republic. These pattern are consistent with the view that period effects are dominant.

Integrating period and cohort perspectives

The above definitions of pure period and cohort changes are straightforward, but there is one interesting and surprising implication that is worth emphasizing. As shown in Figure 6 a period tempo change shifts the age-specific fertility rates by an amount *s* between year *t-1* to and year *t*. This is a pure period effect, but this change can also be described as a decline in the fertility of younger cohorts ("postponement") combined with a rise in fertility of older cohorts ("recuperation") .

In fact any change in fertility at age *a* and time *t* in cohort *c* can always be described from either a cohort or a period perspective because what happens age *a* in period *t* is the same as what happens to cohort *c* at age *a* because, by definition, *c=t-a*. However, there is a difference between *describing* a change and *explaining* it. For example, the fertility change between *t-1* and *t* plotted in Figure 6 can be described as follows:

Cohort perspective: cohorts born before *t-20* had small (absolute) declines, cohorts born around *t-24* had substantial declines, cohort born in *t-26* had no change, cohorts born around *t-30* had substantial increases and cohorts born after *t-35* had a small increases etc.

Period perspective: The fertility schedule shifted by *s* years.

These statements are both factually correct, but the period *description* is more parsimonious and according to the principle of Occam's razor it is therefore preferable as an *explanation* of the change in fertility depicted in Figure 6. However, it is certainly not correct to state that if one perspective is right than the other has to be wrong.

Finally, it is import to note that neither a period shift nor cohort recuperation is sufficient to explain a rise in period fertility. Shifts and recuperations can occur for decades in countries with a constant total fertility rate and a rising mean age at childbearing. An adequate explanation of the recent rise in the TFR therefore requires an additional mechanism as discussed next.

III TEMPO DISTORTIONS AS CAUSE OF FLUCTUATIONS IN THE TFR

The terms "tempo effect" and "tempo distortion" were first introduced in the demographic literature by Norman Ryder, who made a series of fundamental contributions to the study of quantum and tempo measures in fertility (Ryder 1956, 1959, 1964, 1980). His most important finding was that a change in the timing of childbearing of cohorts results in a discrepancy between the period total fertility rate and the cohort completed fertility rate. He considered the period *TFR* to contain a tempo distortion when the timing of childbearing changed and he demonstrated that the size of this discrepancy depends directly on the pace of change in the mean age at childbearing. Ryder's work was highly influential and for most of the last half century the idea of tempo distortions in fertility has been widely accepted. The estimation of tempo distortions became simpler in 1998, when Bongaarts and Feeney (BF) defined a tempo distortion as an inflation or deflation of the period *TFR* when the period (instead of the cohort) mean age at childbearing changes. BF also provided a simple equation for estimating period tempo distortions, that requires only age order specific fertility rates and does not require cohort data (Bongaarts and Feeney 1998). In the BF framework the observed but distorted *TFR(t)* is related to the undistorted *TFR*(t)* as

$$TFR(t)=(1-r(t))\ TFR^*(t)$$

where *r(t)* denotes the annual rate of change in the period mean age at childbearing in year *t*. *TFR*(t)* is referred to as the *tempo-adjusted* total fertility rate*,* which equals the total fertility rate that would have been observed if the mean age at childbearing had been constant during year *t*. The absolute tempo distortion in the observed *TFR* equals *TFR(t)- TFR*(t)* which is negative when the mean age is rising i.e. when *r(t)*>0). For example, when the mean age is rising at a rate of 0.1 year per year then the *TFR* contains a downward distortion of 10%. The above equation is usually and preferably applied separately for each birth order. A later section will comment on the assumptions underlying this equation and describe a variant.

Note that the term *distortion* is distinct from the terms *effect* and *change*. Change is a purely descriptive term, while an effect implies that one variable influences another. For example, period and cohort changes in fertility rates are universal in recent decades, but the preceding discussion suggests that cohort changes are effects from period changes. A distortion is an undesirable effect that leads to misleading interpretations of the underlying process. The effect of a change in period tempo on the TFR is a distortion that should be removed to properly interpret fertility trends.

Simulation

The impact of tempo distortions on contemporary fertility trends is not always obvious in part because tempo and quantum changes often occur simultaneous. It is therefore useful to begin an examination of tempo distortions with a simulation of a hypothetical population in which conditions are simplified. Specifically, the simulation calculates the pattern of age-specific fertility over the period 1965-2015 in a hypothetical population in which 1) cohort quantum at birth order 1 is constant at 0.9 (i.e., 90% of women have a birth), and 2) the period mean age moves through a transition from an equilibrium at 25 years before 1965 to another equilibrium at 30 years after 2015 (i.e. a rise of five years). This pattern of change in the mean age at birth is plotted in Figure 8. The annual rate of increase in the mean age rises and falls during this transition and is most rapid around 1990 (see dashed line in Figure 8)

This hypothetical pattern of childbearing represents an obvious simplification of reality, but it nevertheless captures the broad pattern of change in tempo of first births observed in Europe over the past few decades and roughly follows the logistic pattern of the "postponement transition" observed by Goldstein et al (2009). Insights from this simulation can help interpret actual trends in fertility. In particular, it sheds light on the key changes in fertility that result from temp changes alone, as will be demonstrated next.

The impact of the pace of tempo change on the TFR

The essence of a tempo distortion is that its size depends on the rate of change (and not the absolute value) of the mean age at childbearing. As a result, the simulated trend in the TFR (a decline from 0.9 in 1965 to a minimum of 0.62 in 1990, before turning up to 0.9 again in 2015) follows the inverse pattern of the trend in the rate of change which rises and falls over the same period (compare Figures 8 and 9). The direct relationship between the $TFR(t)$ and $r(t)$ is plotted in Figure 10 with each data point representing one year between 1965 and 2015. The TFR equals 0.9 in 1965 and 2015 when the mean age is not changing (r=0) and it reaches its lowest point in 1990 when $r(t)$ is at its maximum. This relationship is described formally as $TFR(t)=0.9 *(1-r(t))$. Since $r(t)$ reaches a maximum of 0.31 in 1990, it follows that $TFR(t)$ reaches a minimum value of 0.9(1-0.31)=0.62 in the same year.

Broadly similar relationships between annual estimates of $TFR(t)$ and $r(t)$ are observed between 1970 to 2007 in the Czech Rep, the Netherlands and Sweden. As shown in Figure 11 the association between these variables (separately for birth order one and two) are roughly linear, inverse and statistically significant. The observations for individual years deviate somewhat from the expected linear relationship for the following reasons; 1) The observed *TFR* is affected by quantum changes as well as tempo distortions; 2) measurement errors; and 3) deviations from the period world assumptions in the BF framework. Nevertheless, it is encouraging that the empirical evidence clearly supports the theoretically expected relationship between the observed *TFR* and the rate of change in the mean age at childbearing.

The impact of tempo distortions on age-specific fertility rates

As shown in Figure 12 the surface of age-specific fertility rates in the simulated population changes substantially during the postponement transition. The schedules of age-specific fertility rates are constant before 1965 and after 2015. In the intervening years two forces operate: the five year shift of the schedule from a mean of 25 years before 1965 to 30 years after 2015 and the rise and fall of tempo distortions which affect each age proportionally the same. The surface is describes as $f(a,t)= (1-r(t))f(a-m(t)+m(1965),1965)$ where $m(t)$ is the mean age at birth and $r(t)=dm(t)/dt$. This rather complex pattern of change occurs solely because of a rise in the mean age at birth and the cohort completed fertility as well as the tempo adjusted *TFR** are held constant at 0.9.

The rise in the TFR between 1990 to 2010 is of particular interest because it can potentially shed light on the recent upturns in Europe. During this period the simulated schedule of age-specific fertility changes due to the continuing shift in the mean from 27.5 to 30 years combined with the disappearance of the tempo distortions (see Figure 13). The latter causes the schedules to inflate, resulting in large proportional increases at older ages (e.g. at age 40 the age specific fertility rates triple from 40 to 120). Note that it is correct to describe the changes in fertility as a recuperation for older cohorts and little or no change for younger cohorts. This is acceptable as a description, even though all change for the entire simulation is assumed to be driven only by period effects.

These patterns in the simulated population are broadly consistent with patterns observed in the Czech Rep, the Netherlands and Sweden in recent years. Figure 14 plots the observed patterns of age-specific fertility for birth order 1 beginning in the year of the most recent minimum TFR and ending with the year of the subsequent maximum (these years vary among countries). The changes are most extensive in the Czech Republic and smallest in the Netherlands which is as expected from the earlier discussion of aggregate trends in these countries. As in the simulation, the observed schedules shifts over time to higher ages and they rebound beginning around the year of the minimum in the TFR as the distortions decline over time. The most notable exception to this pattern are the years 1996-1998 in the Czech Republic which experienced extraordinary rapid changes in tempo and quantum during the 1990s. The empirical patterns don't confirm exactly to those of the simulated population because there are changes in childlessness (which was assumed constant in the simulation) as well as deviations from the BF assumption. Nevertheless the complex changes in the observed age pattern are broadly consistent with the changes expected from the simulated postponement transition.

Estimating tempo distortions

The tempo distortion $E(t)$ equals the difference between the observed and tempo adjusted TFR:

$$E(t)=TFR-TFR^*$$

Bongaarts and Feeney (1998) proposed to estimate TFR^* as

$$TFR^*(t)=TFR(t)/(1-r(t))$$

The tempo adjusted total fertility rate can therefore be estimated whenever estimates of the $TFR(t)$ and $r(t)$ are available. (These calculations have to be applied order by order). One of the main criticism of this simple BF procedure is that it does not take into account changes in the parity distributions of the female population (Kohler and Ortega ..). Fortunately, with the availability of parity specific data from the HFD, this issue can be addressed by using a variant of the BF basic method. As described in Bongaarts and Feeney 2005, a different tempo adjusted total fertility rate $(TFR^{**}(t))$ can be calculated from tempo adjusted hazard rates (see appendix for details).

The tempo adjusted total fertility rates obtained by these two BF adjustment procedures are plotted in Figure 15 for the Czech Republic, the Netherlands and Sweden for all years for which data are available from the HFD. Figure 16 plots the same variables for birth order one. A comparison of the two BF adjusted measures shows that they are on average relatively close but that TFR^* is more variable than TFR^{**}. Tempo distortions vary over time and between countries.

INCOMPLETE TEXT

****

The full version of the paper will include the following:

-Discussion of Figures 15 and 16

-Estimates of trends in tempo distortions by birth order and their contribution to TFR rise

-Expanded analysis of tempo distortions for additional countries that will become available in the HFD

-Comparison with other tempo adjustment methods (Kohler Ortega)

- Comparison of TFR** with cohort completed fertility rates

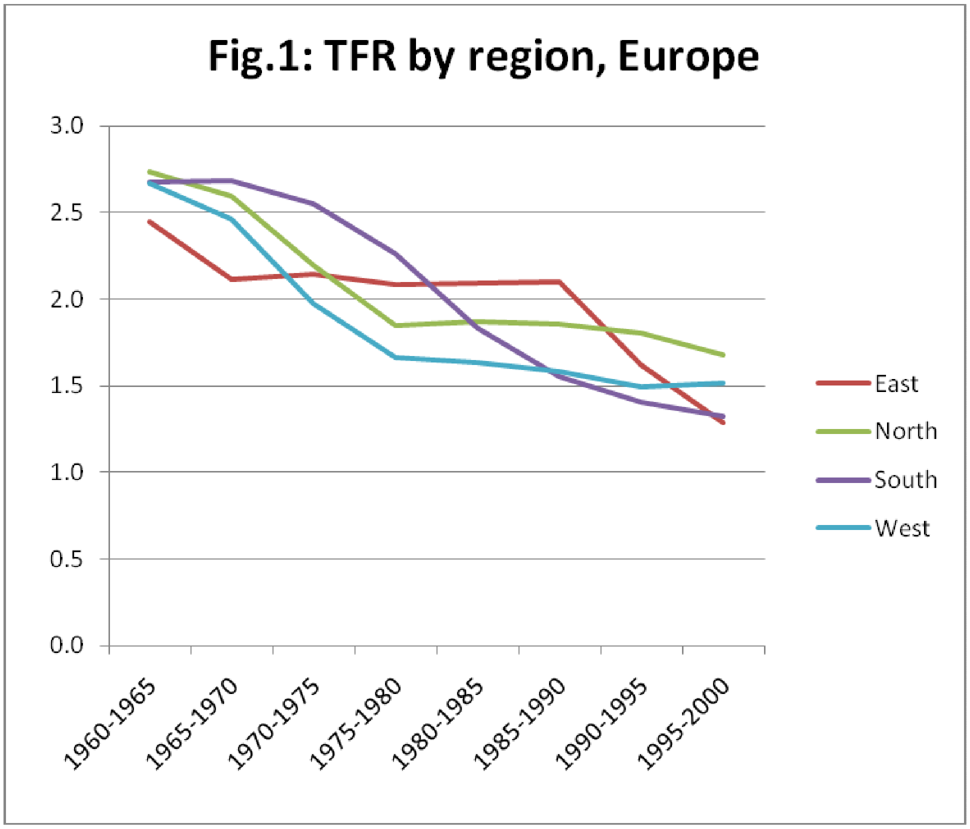


FIGURE 2 TO BE ADDED

Fig. 3a. Total fertility rate by birth order Czech Rep.

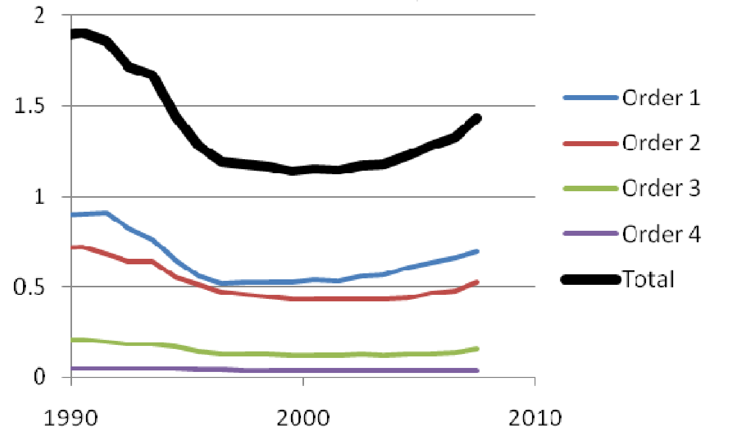


Fig. 3b. Total fertility rate by birth order Netherlands

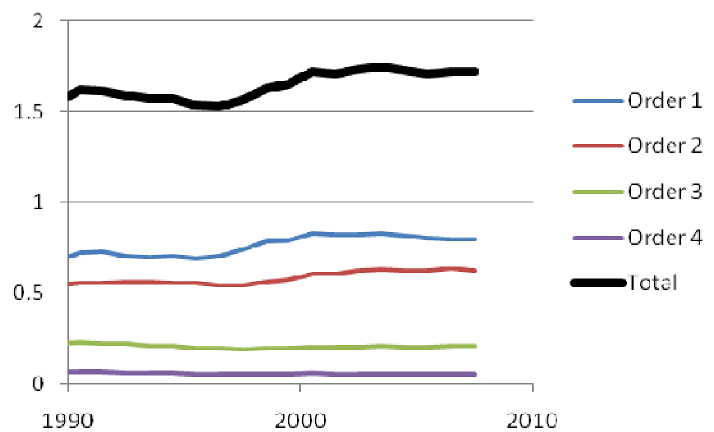


Fig.3c: Total fertility rate by birth order Sweden

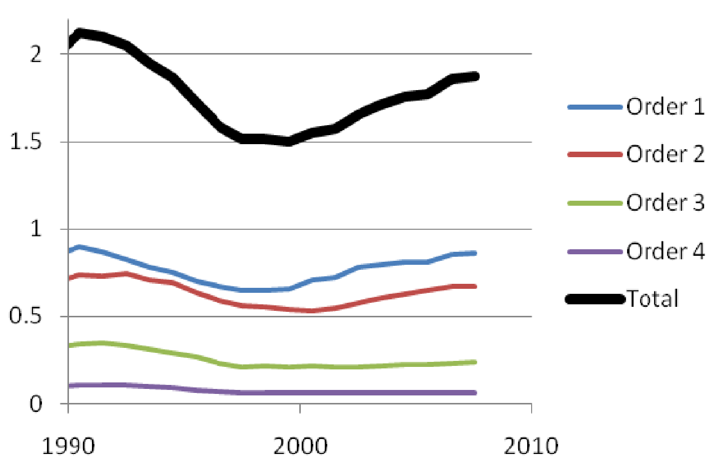


Fig. 4a: Mean age at childbearing Czech Rep.

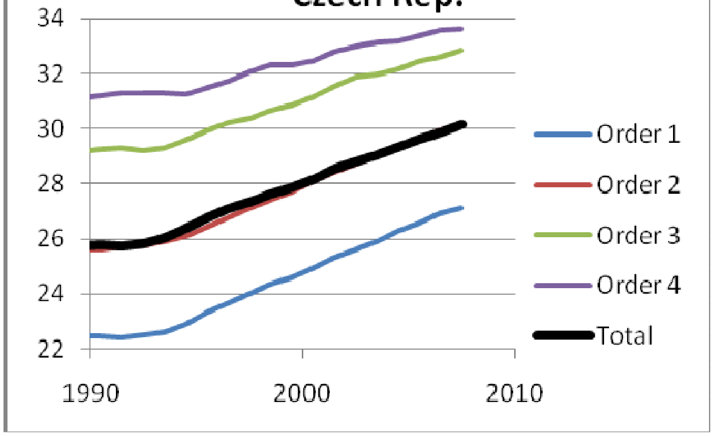


Fig. 4b: Mean age at childbearing Netherlands

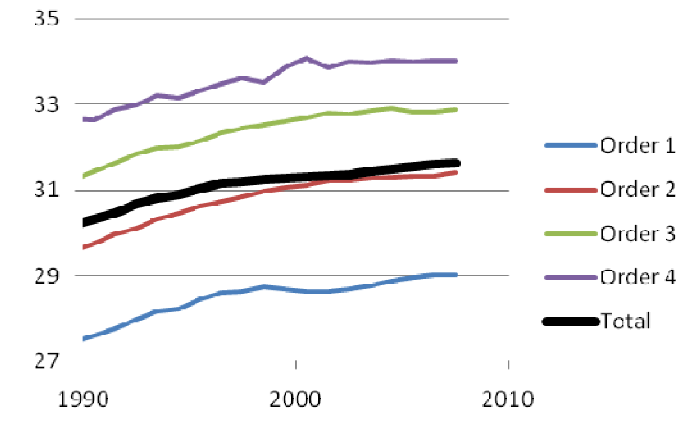


Fig.4c: Mean age at childbearing Sweden

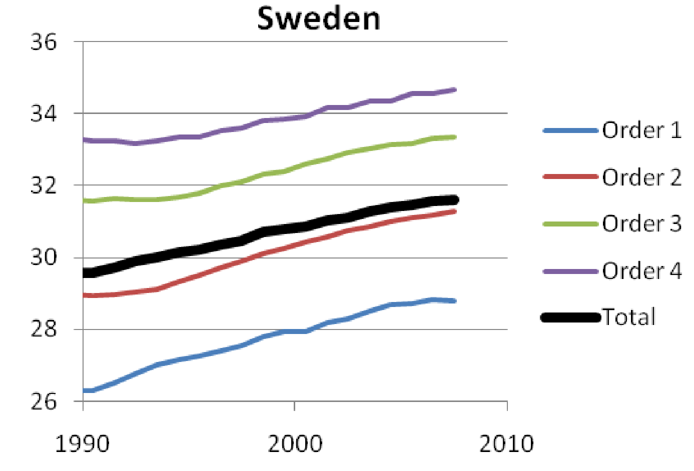


Fig.5: Period quantum change

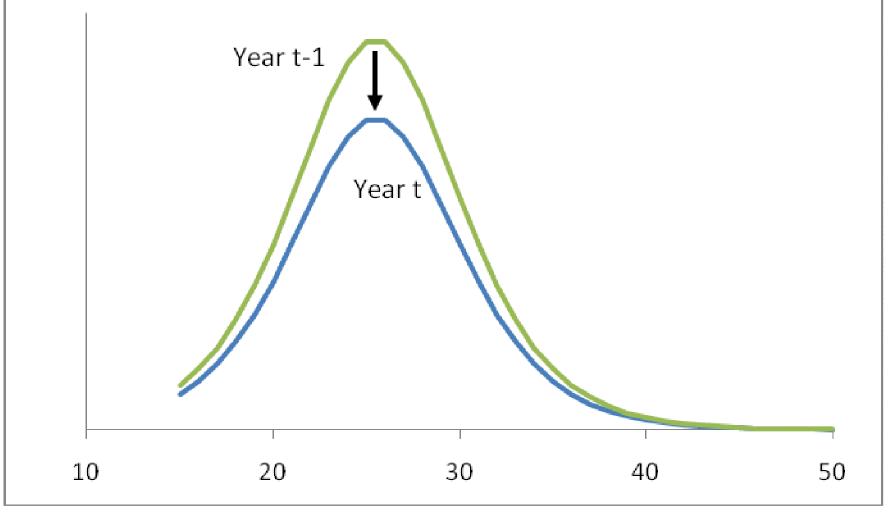


Fig.6: Period tempo change

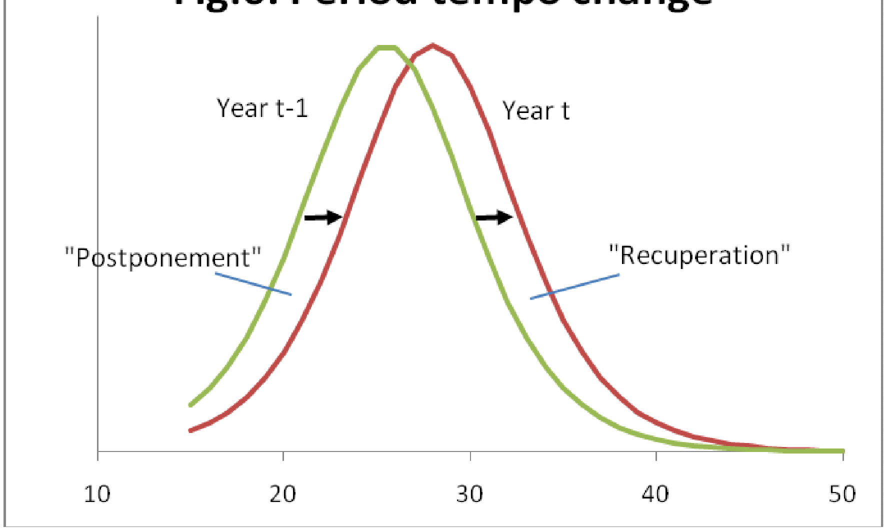


Fig. 7a: Standard deviation of age at childbearing, Czech Rep.

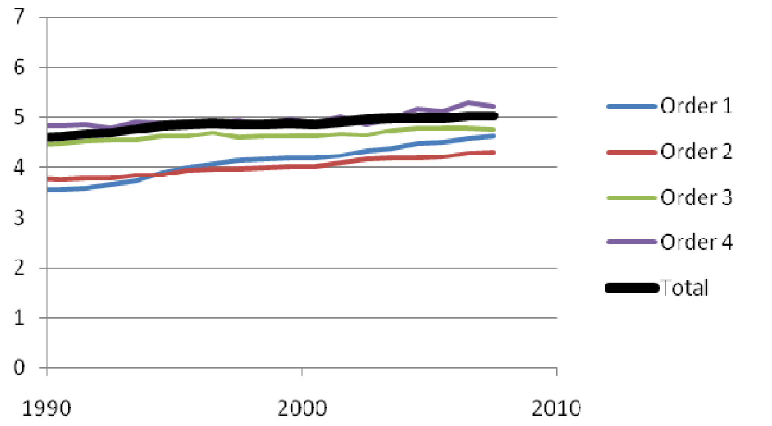


Fig.7b: Standard deviation of age at childbearing, Netherlands

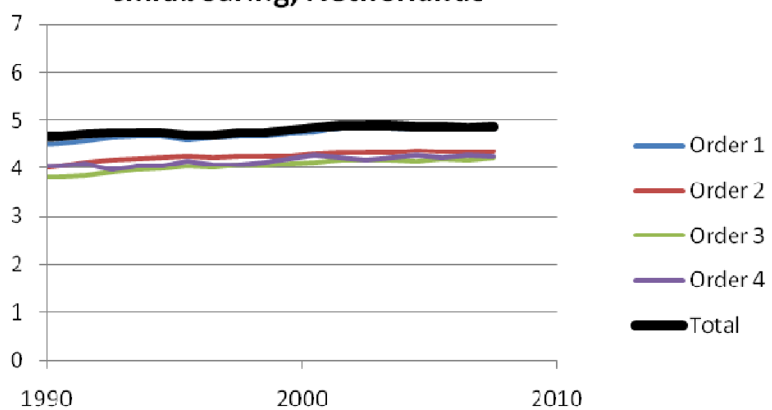


Fig.7c: Standard deviation of age at childbearing, Sweden

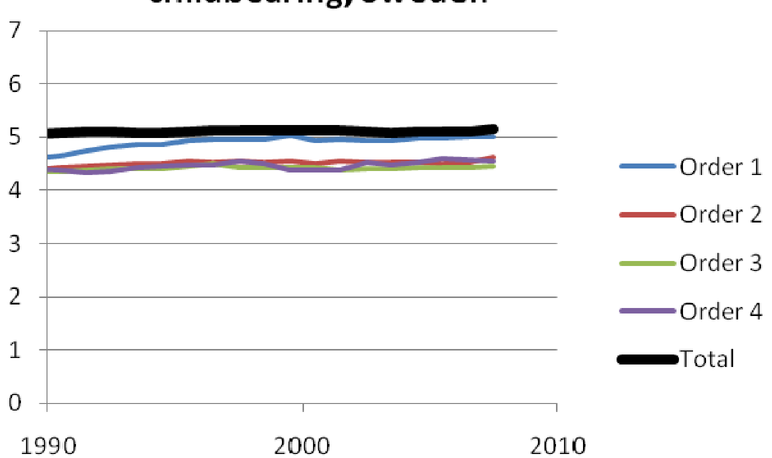


Fig. 8 Simulated mean age at childbearing and rate of change in mean

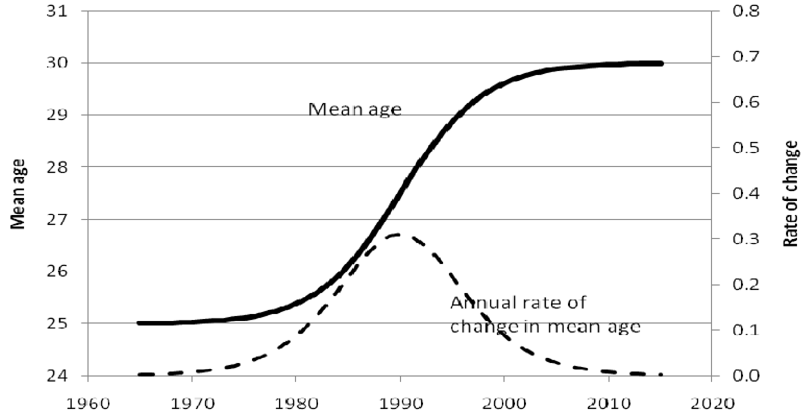


Fig. 9 Simulated total fertility rate and rate of change in mean age

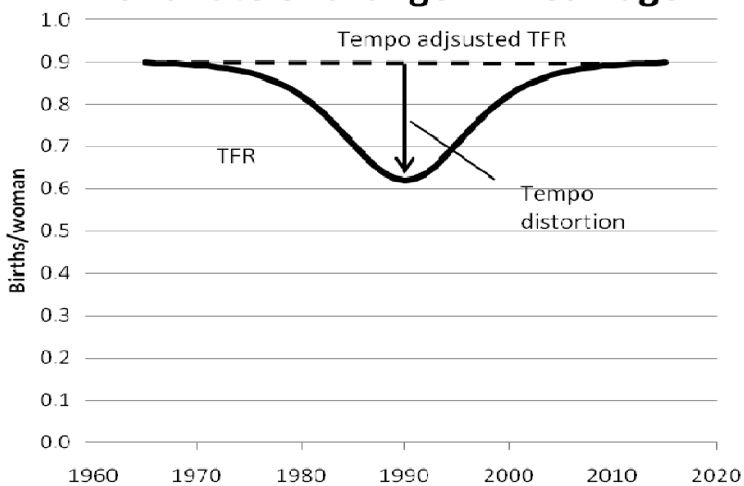
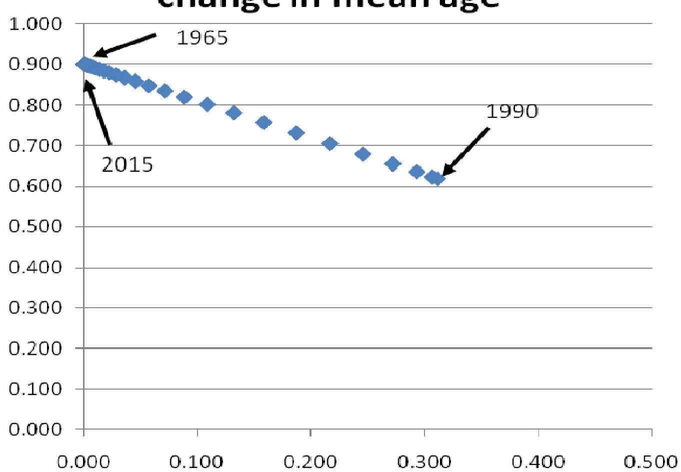


Fig.10: Simulated TFR by rate of change in mean age



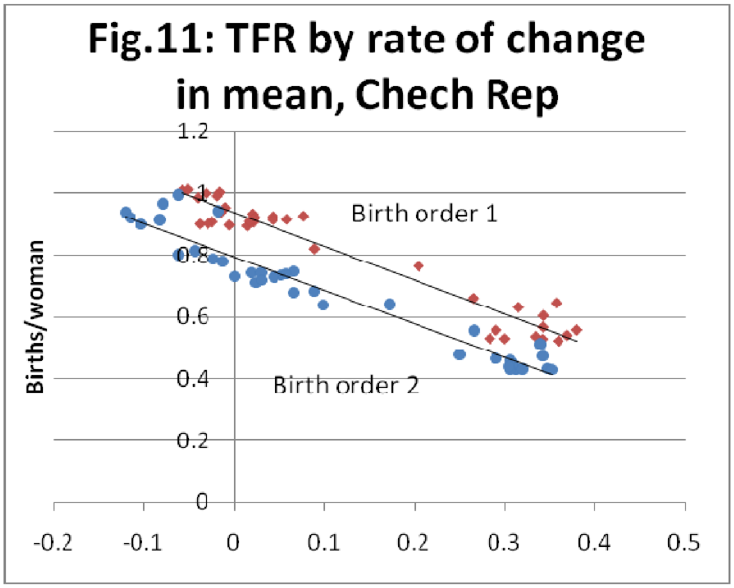


Fig.11: TFR by rate of change in mean, Chech Rep
Births/woman
Birth order 1
Birth order 2
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5

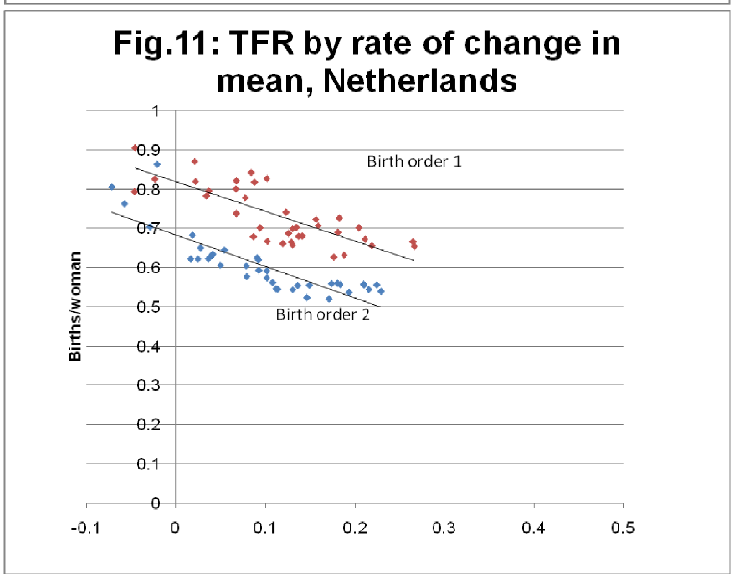


Fig.11: TFR by rate of change in mean, Netherlands
Births/woman
Birth order 1
Birth order 2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
0.1
0.2
0.3
0.4
0.5

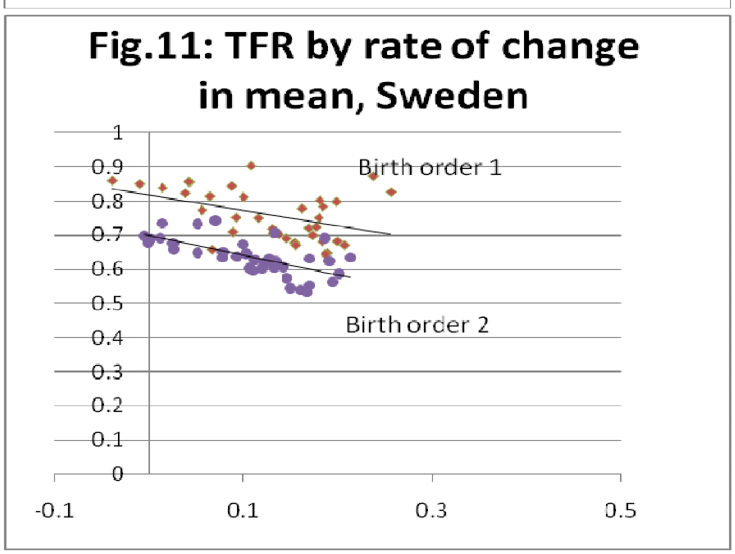


Fig.11: TFR by rate of change in mean, Sweden
Birth order 1
Birth order 2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0.1
0.3
0.5

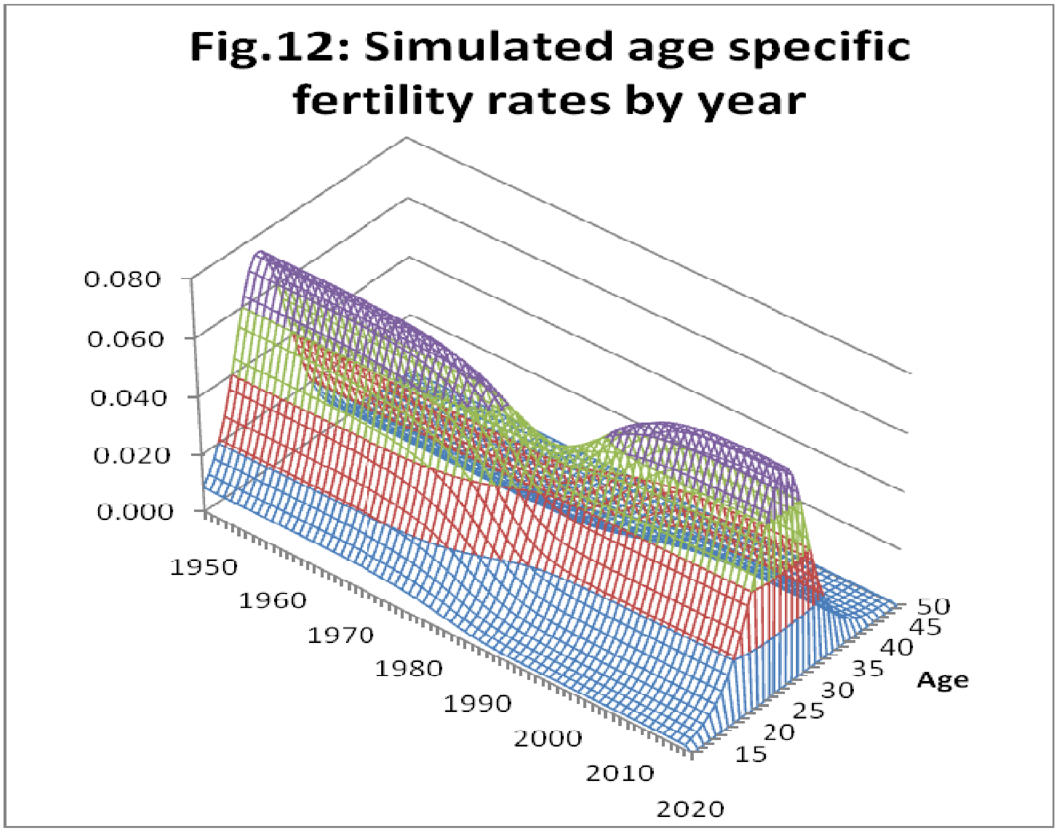


Fig.12: Simulated age specific fertility rates by year
0.080
0.060
0.040
0.020
0.000
1950
1960
1970
1980
1990
2000
2010
2020
50
45
40
35
30
25
20
15
Age

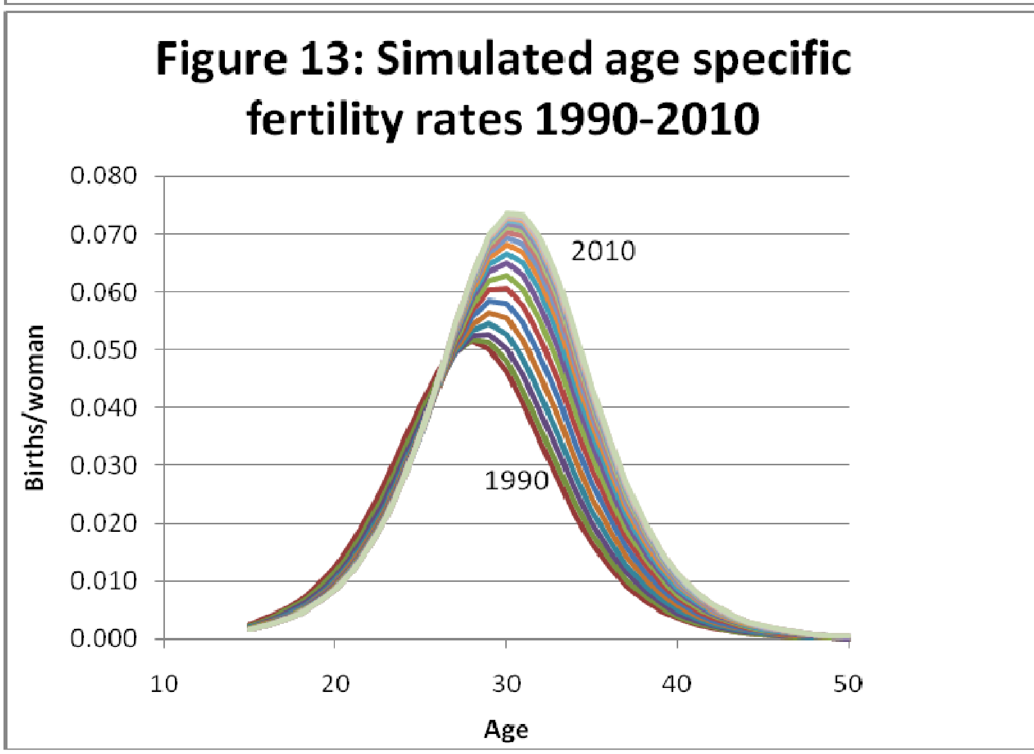


Figure 13: Simulated age specific fertility rates 1990-2010
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
Births/woman
2010
1990
10
20
30
40
50
Age

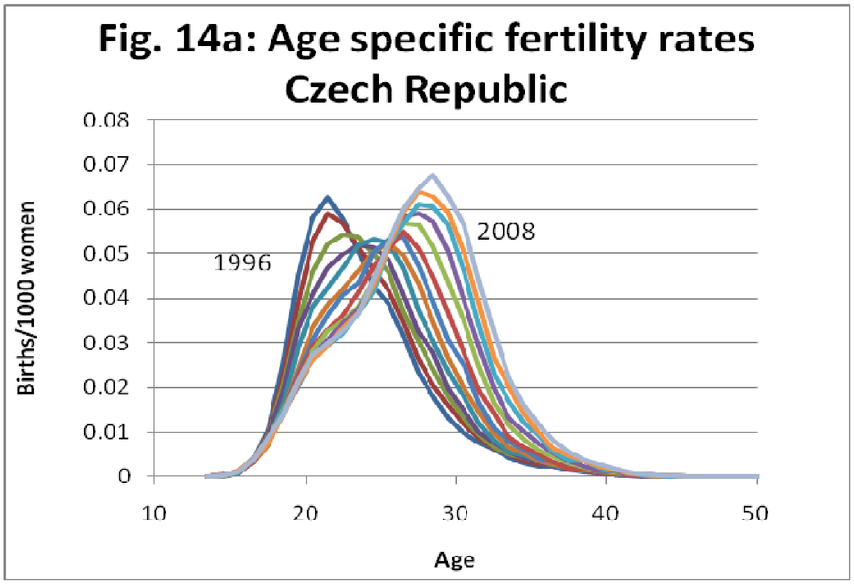


Fig. 14a: Age specific fertility rates Czech Republic

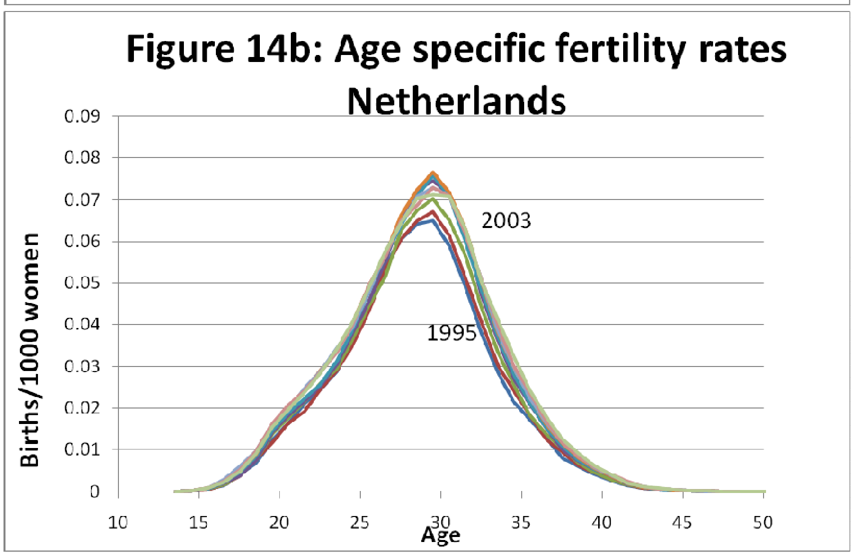


Figure 14b: Age specific fertility rates Netherlands

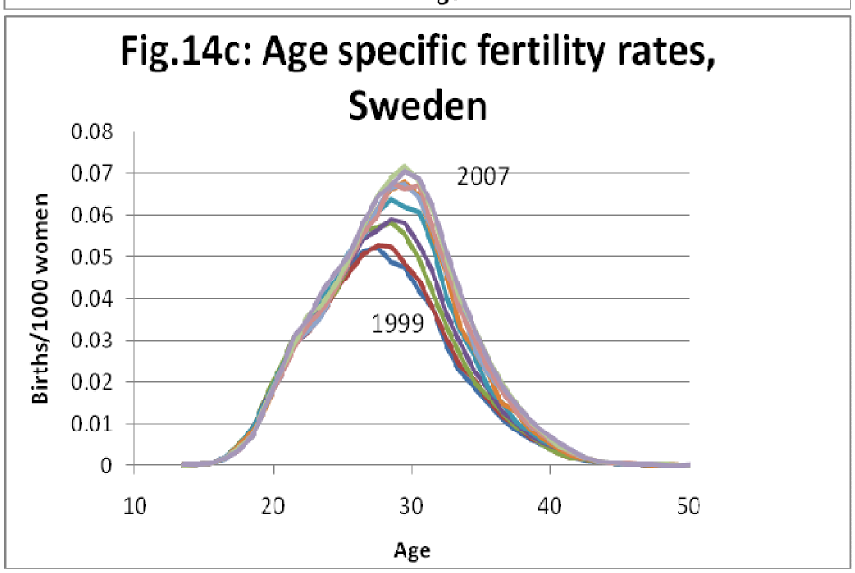


Fig.14c: Age specific fertility rates, Sweden

Fig.15a: Observed and tempo adjusted TFRs, Czech Republic

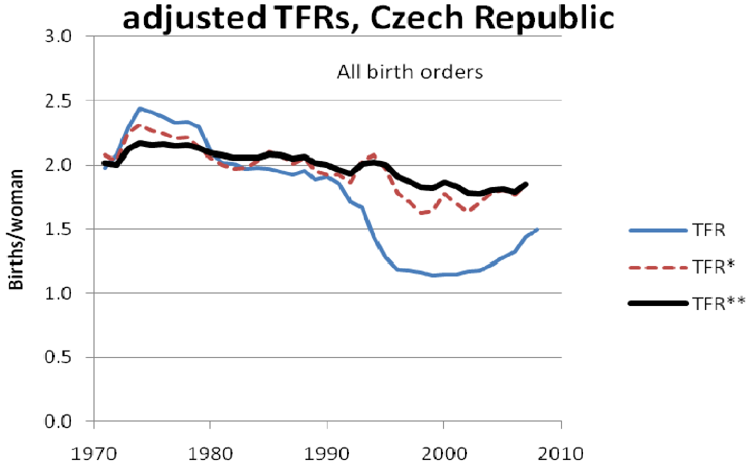


Fig.15b: Observed and tempo adjusted TFRs, Netherlands

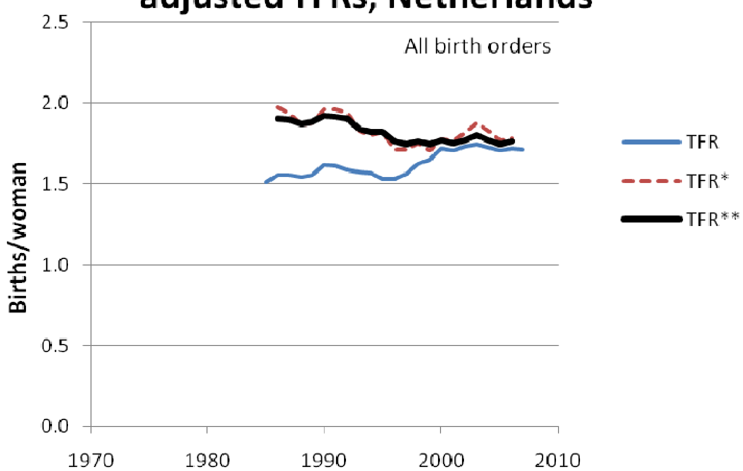
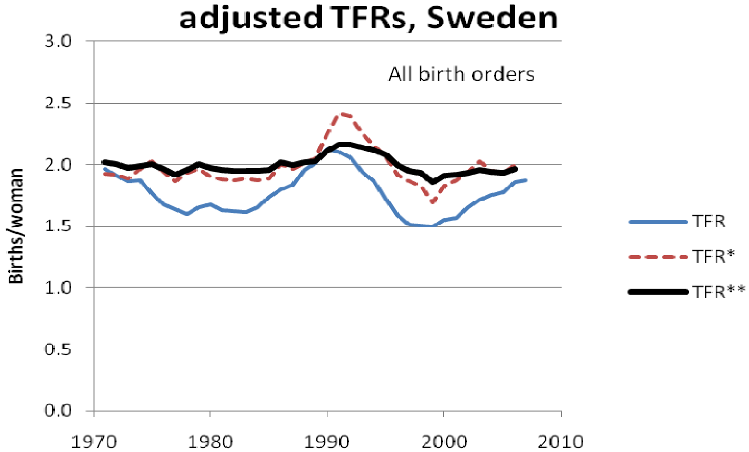


Fig.15c: Observed and tempo adjusted TFRs, Sweden



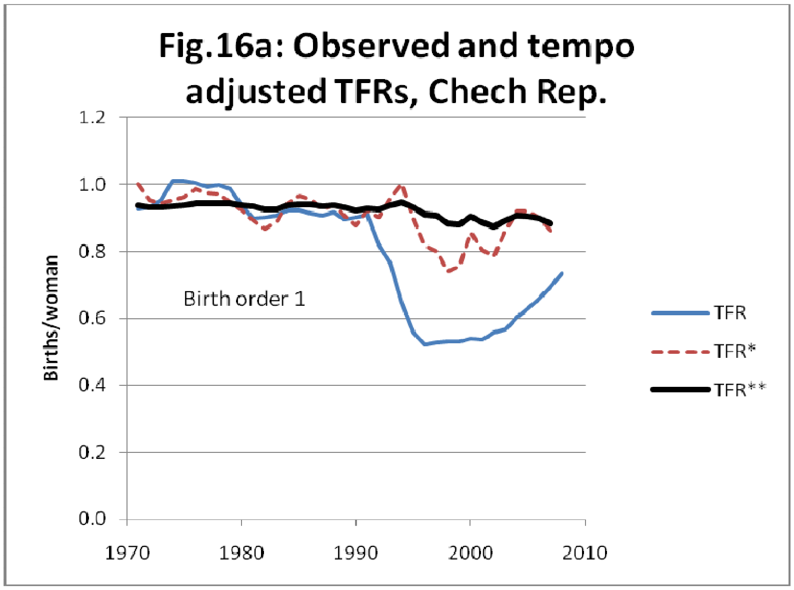


Fig.16a: Observed and tempo adjusted TFRs, Chech Rep.
Births/woman
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1970
1980
1990
2000
2010
Birth order 1
TFR
TFR*
TFR**

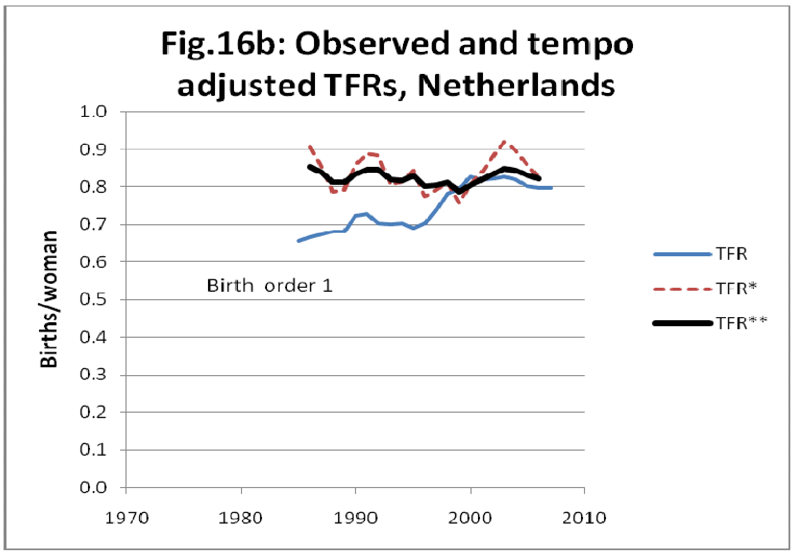


Fig.16b: Observed and tempo adjusted TFRs, Netherlands
Births/woman
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1970
1980
1990
2000
2010
Birth order 1
TFR
TFR*
TFR**

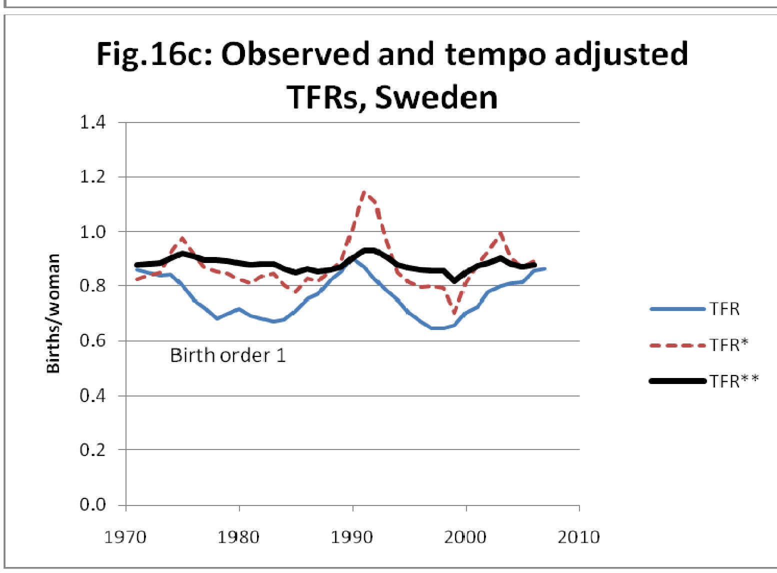


Fig.16c: Observed and tempo adjusted TFRs, Sweden
Births/woman
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1970
1980
1990
2000
2010
Birth order 1
TFR
TFR*
TFR**