Demographic explanation for the recent rise in European fertility:
Analysis based on the tempo and parity-adjusted total fertility

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Abstract

Between 1998 and 2008 European countries experienced the first continent-wide increase in the period total fertility rate (TFR) since the 1960s. This paper gives a demographic perspective on this increase. After a discussion of period and cohort influences on fertility trends the paper examines the role of tempo distortions of period fertility and different methods for removing them. We highlight the usefulness of a new indicator, called the 'tempo and parity-adjusted total fertility' (TFR_p*), which is a variant of the tempo-adjusted total fertility rate proposed by Bongaarts and Feeney (1998). Finally, we estimate levels and trends in tempo distortions in selected countries in Europe. Our analysis of period and cohort fertility indicators in the Czech Republic, the Netherlands, Spain and Sweden, shows that the new tempo adjusted measure gives a remarkable fit with the completed fertility of women in prime childbearing years in a given period, which suggests that it provides an accurate adjustment for tempo distortions. Using an expanded dataset for eight countries we demonstrate that the tempo adjusted fertility as measured by TFR_p* remained nearly stable since the late 1990s. This finding implies that the recent upturns in the period TFR in Europe are largely explained by a decline in the pace of fertility postponement and the resulting reduction in tempo distortions. The other currently used tempo-adjusted fertility indicators have not indicated such a large role for tempo effect in these TFR upturns.

1 INTRODUCTION

Fertility as measured by the period total fertility rate (TFR) rose in the large majority of European countries between 1998 and 2008. 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 children 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. These new trends are a very welcome development because the potential adverse consequences of population ageing and population decline will likely be substantially smaller 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; Philipov and Kohler 2001, Bongaarts 2002; Sobotka 2004, Goldstein et al 2009), and a cohort-driven process of recuperation at older ages of births that were postponed at younger ages (Lesthaeghe and Willems 1999; Frejka and Sardon 2009; Goldstein et al 2009, Neels and de Wachter 2010, Sobotka et al. 2011). Further back in the chain of causation are social and economic determinants (e.g., economic growth, 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 until 2008, i.e., until the onset of the severe economic recession that has affected fertility trends in many countries (Sobotka, Skirbekk, and Philipov 2011). The availability of the new *Human Fertility Database* (HFD) in combination with other sources 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 of the child, parity of the mother, and country. The detailed empirical analysis below will focus on three countries included at present in the HFD—the Czech Republic, the Netherlands and Sweden—as well as on Spain. In addition, selected data and indicators will also be presented for Austria, Denmark, Estonia, France, Italy, Russia, and the United Kingdom. The 'core' four analyzed countries have experienced significant recent upturns in fertility and they represent different regions of Europe as well as different socio-economic and institutional contexts. In two of them, the Czech Republic and Spain, the period TFR bottomed out at extreme low levels below 1.2.

After a brief overview of fertility trends, the paper focuses on three main topics. First, we provide conceptual and methodological discussion on the potential role of period and cohort influences as drivers of fertility fluctuations and relate it to the recent trends. Second, we examine the role of tempo distortions of period fertility and different methods for removing these distortions. Based on a comparison of different adjusted indicators with completed fertility of women born in 1961-67, we highlight the usefulness of a new tempo-adjusted indicator that is a variant of the Bongaarts-Feeney adjustment method, the so-called *tempo and parity-adjusted total fertility* (TFR_p*). Third, using this new indicator we estimate the role of decline in tempo distortions in the recent rise in the conventional total fertility rate in Europe.

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, to demonstrate the merits of the new tempo-adjusted fertility indicator, to stimulate more rigorous research and to move closer towards a consensus on the demographic causes of recent fertility trends in most developed countries.

2 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 child per woman, from 2.6 in 1960 to 2 in 1976 and to a low of 1.37 in 1999, before recovering somewhat to 1.56 in 2008 (Figure 1, VID 2010). Each major region within Europe experienced declines of a similar magnitude although patterns differed between regions (see Figure 1). A steep decline occurred first in the West and the North between 1965 and 1975, 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 1.4, with the Nordic countries and Western Europe (excluding three predominantly German-speaking countries, Austria, Germany, and Switzerland) forming a higher fertility group with the TFR of 1.6-1.7 and Eastern Europe falling slightly below 1.2. These were mostly record lows.

The recent upturn in fertility has been documented by Goldstein et al. (2009). It was recorded across the whole continent, both in the countries with extremely low TFR levels below 1.3 as well as in the countries that never experienced a TFR decline below 1.5. Estimates of the increase in the TFR between the year of the minimum and 2008 for European populations range from 0.03 in Portugal to 0.51 in Denmark (and 0.61 for East Germany, the former GDR). As many as 15 European countries recorded a TFR increase of 0.3 or more:

Central and Eastern Europe: Bulgaria, Czech Republic, Estonia, Latvia, Russia, Slovenia, and Ukraine;

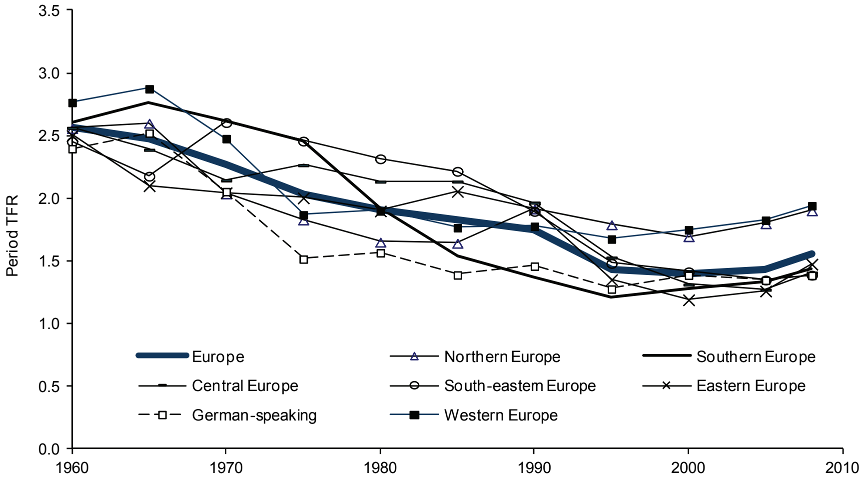
Northern Europe: Denmark, Finland, and Sweden;

Southern Europe: Spain;

Western Europe: Belgium, France, the Netherlands, and United Kingdom.

In absolute terms these fertility increases may still seem modest, but they usually represent a relative rise by more than 20% and have important demographic consequences because they close a substantial part of the gap between the minimum fertility and the replacement level.

Figure 1 Period TFR in European regions, 1960-2008



Notes: Regional data are weighted by population size of countries in a given region. Data for the whole Europe include all territory of Russia and exclude Turkey, and Caucasus countries.

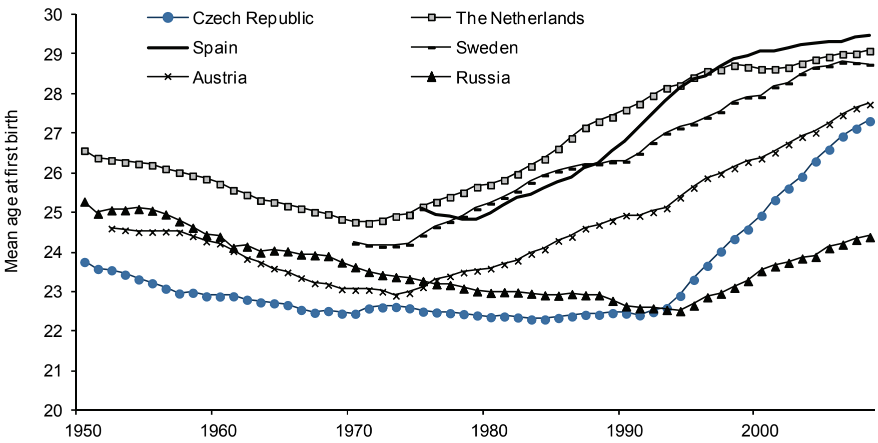
Countries are grouped into regions as follows:

Western Europe: Belgium, France, Ireland, Luxembourg, the Netherlands, United Kingdom;
German-speaking countries: Austria, Germany, Switzerland;
Northern Europe: Denmark, Finland, Iceland, Norway, Sweden;
Southern Europe: Cyprus, Greece, Italy, Malta, Portugal, Spain;
Central Europe: Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia;
South-eastern Europe: Bosnia-Herzegovina, Bulgaria, Macedonia, Montenegro, Romania, Serbia (recent data exclude Kosovo);
Eastern Europe: Belarus, Moldova, Russia, and Ukraine.

Sources: Own computations based on Eurostat (2010), VID (2010), Council of Europe (2006) and national statistical offices.

In part related to the fall in period fertility was a second major trend since the early 1970s, a continuous long-term rise in the mean age at childbearing, especially at first birth. This was labeled by some demographers as a "postponement transition" from an early to a late childbearing pattern (Kohler et al. 2002, Goldstein et al. 2009). Figure 2 illustrates this shift for six countries representing broader regional trends. Around 1970, when contraceptive pill just started spreading across Europe, the mean age at first birth stood between 22 and 25 years in most countries. By 2008, it increased to 27-29 years in most European countries, although in Eastern Europe, including Russia, it still remains younger. At the same time, the pace of increase in the mean age at first birth diminished markedly after 2000 in most countries reaching high values. This pattern is also observed in Figure 2 for the Netherlands, Spain, Sweden and the Czech Republic. As will be demonstrated below this reduction in the pace of increase in childbearing age is a crucial factor in explaining the recent rise in fertility.

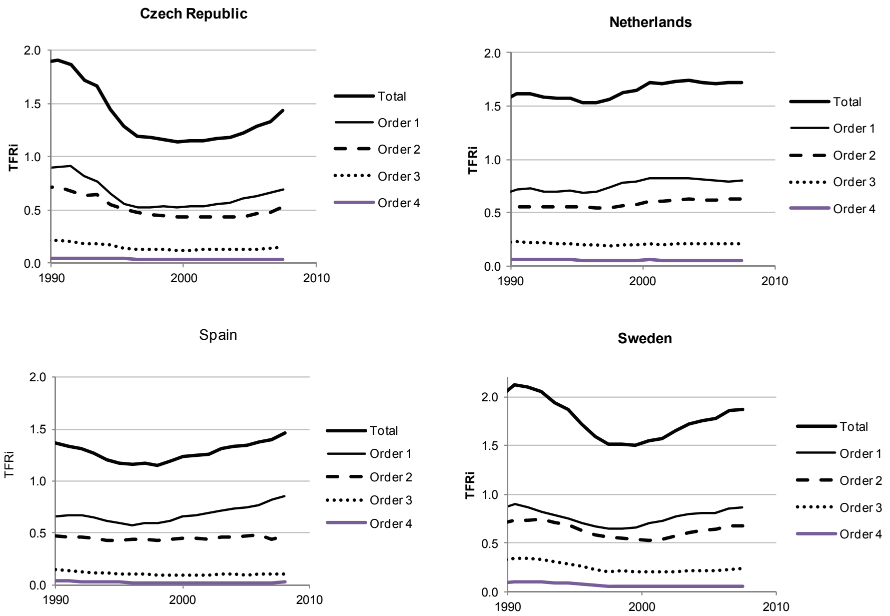
Figure 2 Period mean age at first birth in six European countries, 1950-2008



Sources: HFD (2010), Council of Europe (2006) and own computations based on Eurostat (2010) and national statistical offices.

An examination of trends in the total fertility rate and the mean age at childbearing is a first step in any analysis of fertility trends, but the aggregate nature of these indicators can obscure important birth order-specific changes. Figure 3 plots the TFR by birth order for the Czech Republic, the Netherlands, Spain, and Sweden for the period after 1990 which covers the recent trough and subsequent rise in period fertility. In all four 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. In Spain, practically all the increase in the TFR between 1998 (1.16) and 2008 (1.46) was concentrated into first-order TFR. Fluctuations in fertility were largest in the Czech Republic and smallest in the Netherlands.

Figure 3 Period TFR by birth order, Czech Republic, the Netherlands, Spain, and Sweden. 1990-2010



Source: Human Fertility Database (HFD 2010) for the Czech Republic, the Netherlands and Sweden and own computations from Eurostat (2003 and 2010) for Spain.

Since trends in quantum and tempo of fertility differ by birth order any in-depth analysis of fertility trends should be conducted by birth order, and the remainder of this paper will follow this approach.

3 PERIOD VERSUS COHORT CHANGES

The driving forces of fertility change, in particular 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 (Ní Bhrolcháin 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 Willems 1999, Frejka and Sardon 2009). We aim to clarify the differences and agreements between these two perspectives.

Definitions

Definitions of cohort and period changes in fertility are essential before proceeding. Four ideal types of changes in *age-specific fertility rates* by birth order 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. As shown in Figure 4a 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 the fertility schedule independent of age or cohort. As shown in Figure 4b 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,

resulting in an inflation or deflation the cohort fertility schedule proportionally at all ages.

4) A *cohort tempo* change in fertility is defined as an increase or decrease in the mean age at childbearing from one cohort to the next with the shift in schedule independent of age or period, resulting in a move up or down the age axis of the cohort fertility schedule while its shape remains invariant. This shift can also be referred to as postponement (at younger ages) and recuperation (at older ages), or simply as postponement.

Figure 4a Simulated *Quantum* change

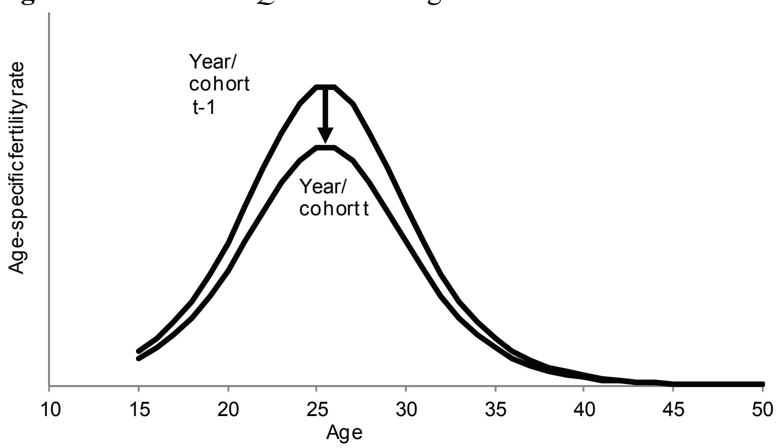
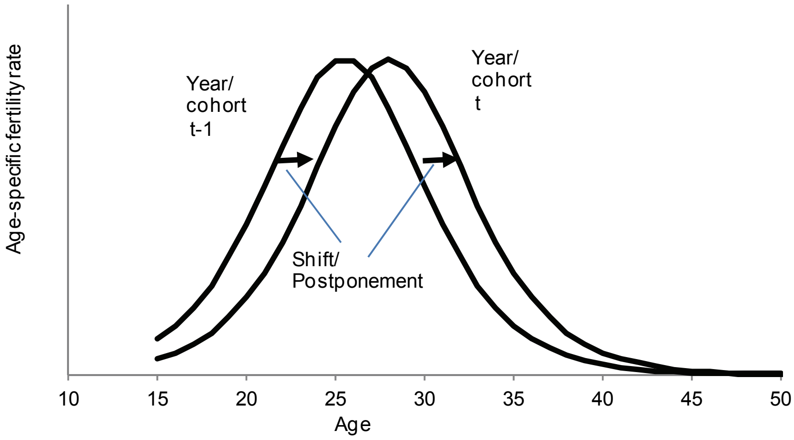


Figure 4b Simulated *Tempo* change



The real world is of course 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 effects?

The question of whether period or cohort effects 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". Ward and Butz (1980: 937) posited that completed family size is an outcome of a "sequence of period-specific decisions", where "couple's plans are revisable" and "the entire time path of births will not be precommitted but will change as new information accrues." 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 more important than cohort influences.

These findings contrast with the arguments about cohort-driven process of fertility change. Norman Ryder has asserted that "in the model of reproductive behavior, the driving force is change in cohort fertility. The actors are members of cohorts; their behavior is manifested in cross-section period summations in a distinctive manner because of ongoing change in the way these actors are distributing their reproductivity over time" (Ryder 1990: 444).

However, most recent proponents of the 'cohort view' on fertility behavior, including Ron Lesthaeghe (Lesthaeghe and Surkyn 1988, Lesthaeghe and Willems 1999, Lesthaeghe 2001), Tomas Frejka (Frejka

2010), and Joshua R. Goldstein (Goldstein and Kenney 2001, Goldstein 2010, Goldstein and Cassidy 2010) pursue a more nuanced picture, which, with some simplification, can be summarized as follows. They recognize strong period influences, especially at younger ages when period trends such as increased participation in higher education, are dominant. However, their description of fertility change emphasizes the presumably cohort-driven process of 'recuperation' at higher ages, which assumes that the cohorts of women that reduced fertility at younger ages will try to 'make up' for at least a part of this decline in order to realize their childbearing intentions. This does not mean, however, that these cohorts would be insensitive to period influences (see also Sobotka et al. 2011).

In our view the ongoing debate about the relative roles of period and cohorts would be clarified by emphasizing the following points:

First, the "period paramount" view of Brass, Ní Bhrolcháin and others can be perfectly consistent with the description of fertility change in the cohort postponement-recuperation perspective. The reason is that 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. A change at age a in period t is the same as the change to cohort c at age a because, by definition, $c=t-a$. As a result, a steady rise in the period mean age at childbearing produces changes in cohort fertility that can be described as postponement and recuperation.

Second, whether fertility is described from a period or cohort perspective is a separate question from whether period or cohort effects are the main underlying driving force of fertility change. We return to this issue in the next section.

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

4 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 (see also Ward and Butz 1980). 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) introduced a new approach to estimating tempo effects. 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 distortion that requires only age-specific fertility rates by birth order ('rates of the second kind') and does not require cohort data (Bongaarts and Feeney 1998). In the BF framework the observed but distorted TFR in any given year is related to the undistorted TFR* in the same year as

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

where r denotes the annual rate of change in the period mean age at childbearing in the year. TFR* 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-TFR* 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 years per calendar year 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 this and other methods for removing tempo effects and their strengths and weaknesses.

Simulation of period tempo distortions

The impact of tempo distortions on contemporary fertility trends is not always obvious in part because tempo and quantum changes often occur simultaneously. 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 of 50 years, 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 give birth to the first child), and 2) the period mean age increases by five years from an equilibrium at 25 years before 1965 to another equilibrium at 30 years after 2015. This pattern of change in the mean age at first birth is plotted in Figure 5a. 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 5a).

This hypothetical transformation 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" described 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 tempo 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 follows the inverse pattern of the trend in the rate of change of the period mean age which rises and falls over the same period (compare Figures 5a and 5b). The direct relationship between the TFR and r is plotted in Figure 5c 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 of 0.62 in 1990 when r is at its maximum. This relationship is described formally as TFR=0.9·(1-r). Since *r* reaches a maximum of 0.31 in 1990, it follows that TFR reaches a minimum value of 0.9·(1-0.31) = 0.62 in the same year.

Figure 5a Simulated mean age at childbearing and rate of change in the mean age

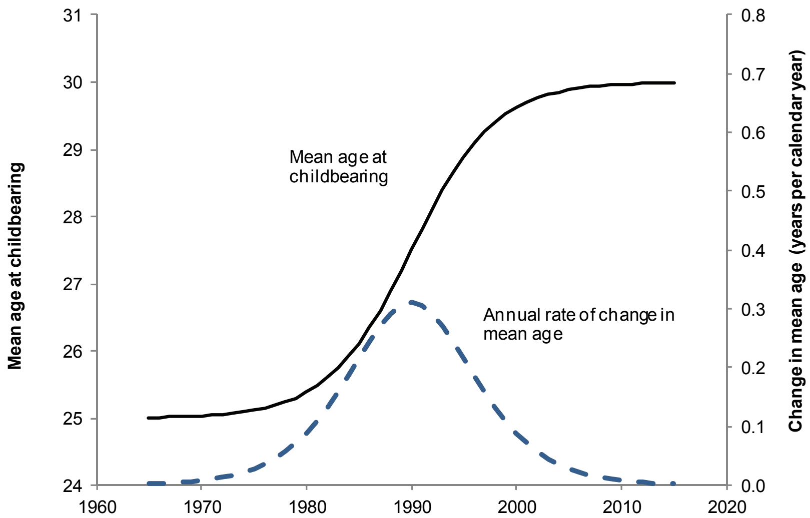


Figure 5b Simulated total fertility rate and tempo distortion

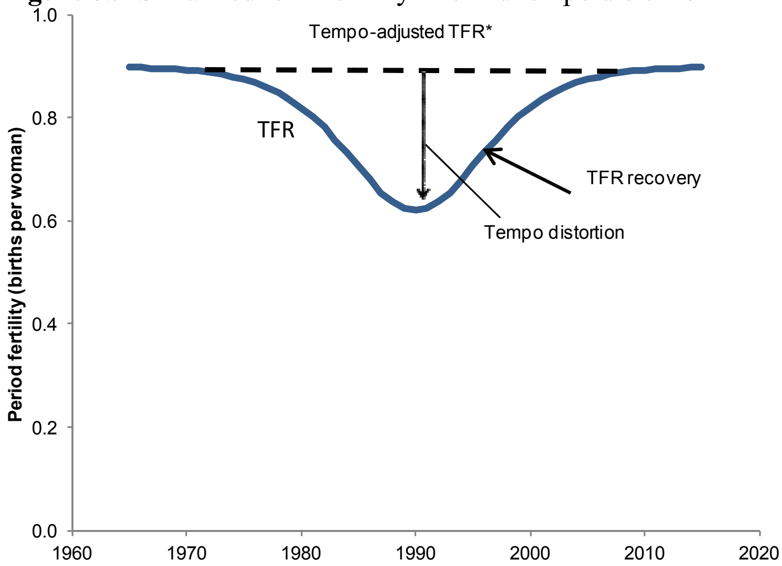
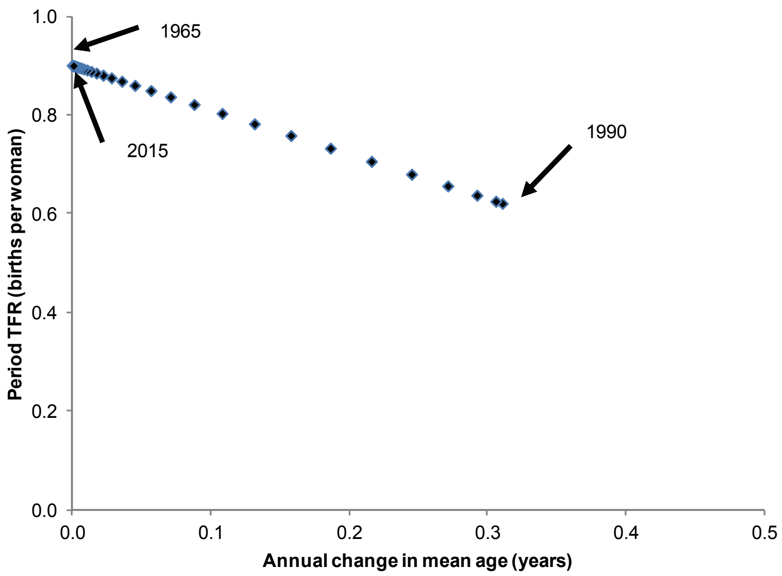
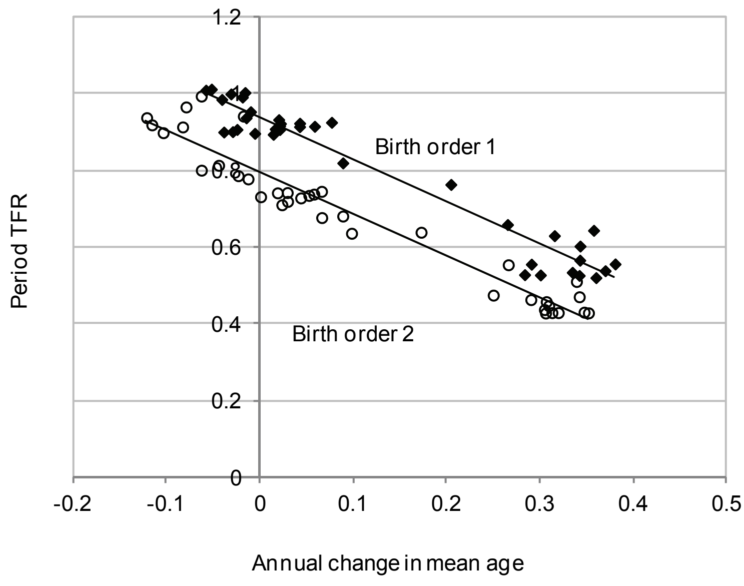


Figure 5c Simulated TFR by rate of change in mean age, 1965-2015



A broadly similar relationship between annual estimates of TFR and r is observed in 1970-2008 in the four analyzed countries. As shown in Figure 6 the association between these variables in the Czech Republic (separately for birth orders one and two) are roughly linear, inverse and statistically significant (data for the Netherlands, Spain, and Sweden not shown, but are available from the authors upon request). 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 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.

Figure 6 TFR by rate of change in the mean age at childbearing (r(t)); Czech Republic



Source: Computations based on Human Fertility Database (HFD 2010).

The impact of tempo distortions on age-specific fertility rates

We first inspect the simulated fertility changes based on the assumption that these changes are entirely period-driven. As shown in Figure 7 ('period world') 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 related forces operate: the shift of the age 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[1]. This rather complex pattern of change occurs solely because of a rise in the period mean age at first birth since the cohort completed fertility is held constant at 0.9.

The rise in the simulated TFR between 1990 and 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 age from 27.5 to 30 years combined with the disappearance of the tempo distortions (see Figure 8, 'period world'). The latter causes the elevation of fertility curves, resulting in large proportional increases at older ages (e.g., at age 40 the age-specific fertility rate triples from 40 to 120). Note that it is correct to describe the simulated changes in fertility as a 'recuperation' for older cohorts and little or no change for younger cohorts. This is correct as a description, even though all change for the entire simulation is assumed to be driven only by period effects.

[1] The surface is described as $f(a,t) = (1-r(t))\ f(a-(MAB(t) - MAB(1965)))$ where $MAB(t)$ is the mean age at birth and $r(t) = dMAB(t) / dt$.

Figure 7 Simulated age-specific fertility rates by year during postponement transition

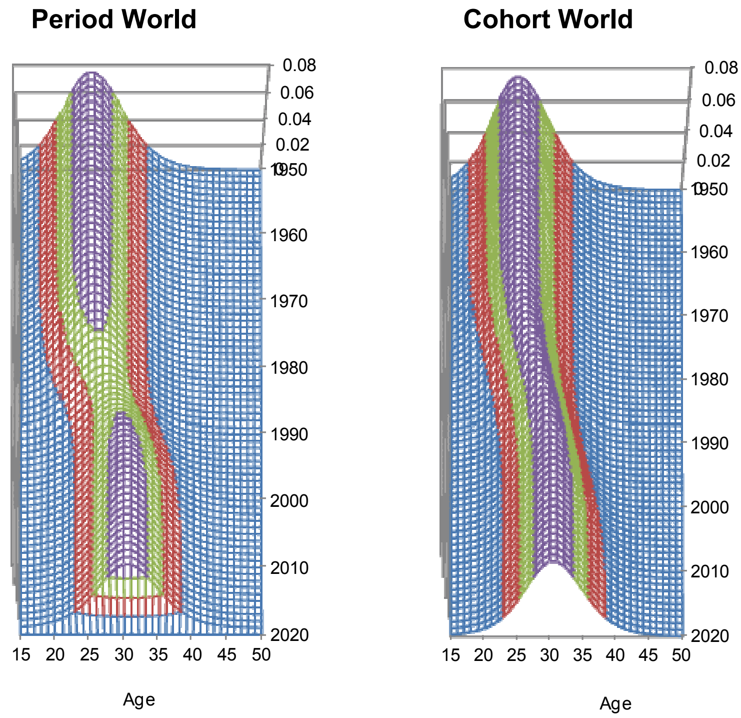
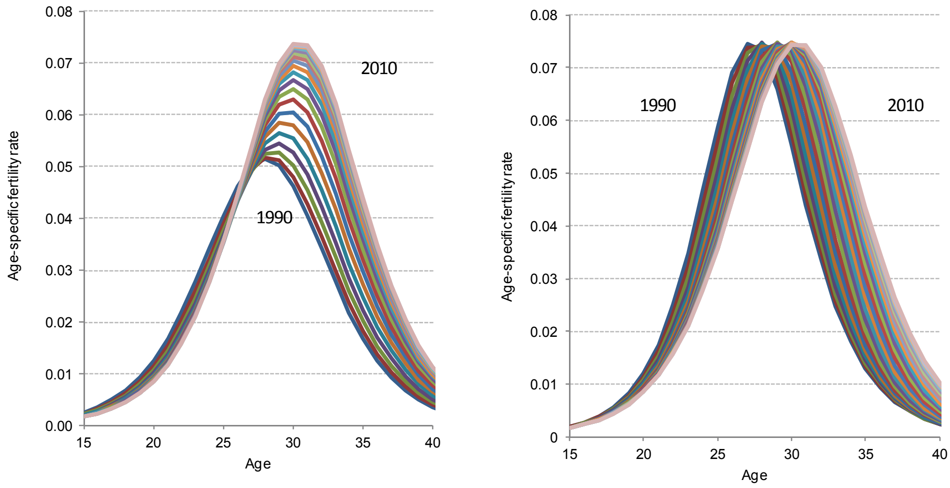


Figure 8 Simulated age-specific fertility rates, 1990-2010



Comparison of simulations of period and cohort driven fertility change with observed trends

The preceding simulation assumed a 'period world' in which only period effects occur and 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 as all cohorts respond in the same way to period influences.

We have also undertaken a simulation of a 'cohort world' in which only cohort effects occur and the shape of the schedule of cohort age-specific fertility rates remains invariant over time. In this simulation the quantum is also fixed at 0.9 births per woman for all cohorts. The only change being simulated is a postponement transition which moves the mean age at childbearing of cohorts from 25 to 30 years. When these cohort shifts are 'translated' into period fertility trends, spanning over a comparable period as the simulated changes in the `period world' above, the annual rate of increase in the mean age rises and falls during this transition and is most rapid around 1990. The surface of period age-specific fertility rates for this cohort simulation is presented in Figure 7 ('cohort world'). It shows the expected shifting of fertility to higher ages but it does not show any changes in the mode (i.e., peak value) of the fertility schedule. The resulting trend in the TFR is similar to the one plotted in Figure 5b with values of 0.9 before the transition, a minimum in 1990 and then a rebound to 0.9 after the transition is completed. The changes in the period age-specific fertility during the TFR rebound after 1990 are plotted in Figure 8 ('cohort world'). A notable feature is that the variance of the period fertility schedule (which was constant in the 'period world') changes during the cohort-driven transition. Variance first falls (alongside the TFR decline) in the first stage of the transition and then it increases (alongside the TFR recovery) in the later stage of the transition, reaching back the initial values. The rise in the TFR is due to this increase in the variance of the period fertility schedule; no change in the mode is evident.

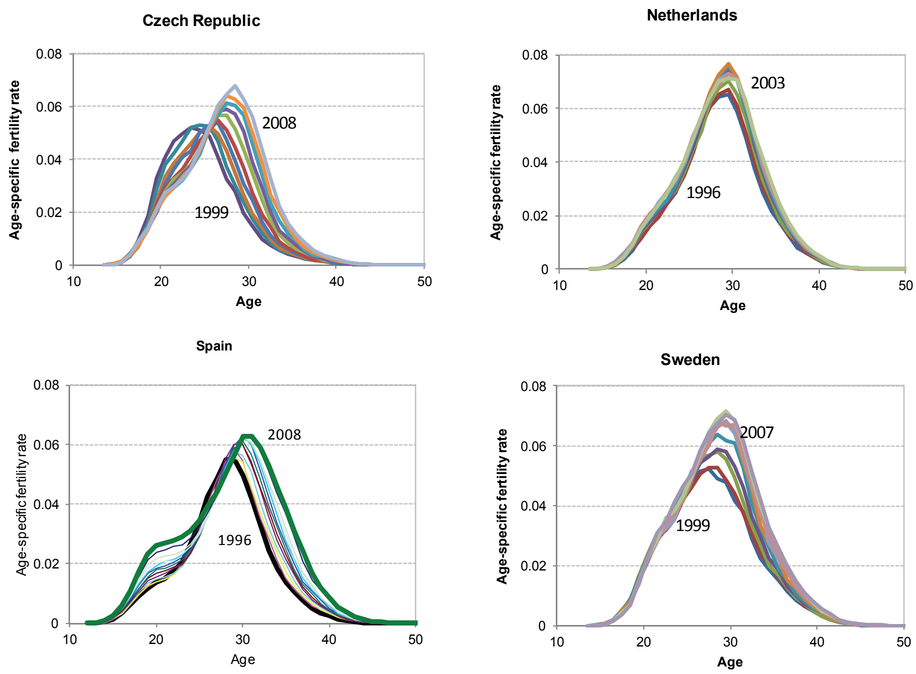
In sum the overall TFR trends are similar in the simulated period and cohort worlds, but these trends in overall fertility are brought about by different patterns of change in age-specific fertility rates. The key differences are as follows.

Period world: Mode of period age-specific fertility schedule falls and rises over the course of the transition, but the shape of this schedule (and hence its standard deviation) remains constant.

Cohort world: Mode of period age-specific fertility schedule is constant but shape changes with the variance, which first falls and then rises over the course of the transition.

These simulation results can now be compared with observed trends to assess the roles of period and cohort effects in actual populations. Figure 9 plots the observed patterns of age-specific fertility for birth order 1 in the Czech Republic, the Netherlands Spain and Sweden, beginning in the year of the most recent minimum TFR (after 1990) and ending between 2003 and 2008, when considerably higher TFR was reached. The changes are most extensive in the Czech Republic and Sweden and smallest in the Netherlands which is in line with the expectations based on the earlier discussion of aggregate trends in these countries. As in the 'period world' simulation, the observed schedules shift over time to higher ages and they rebound beginning around the year of the minimum in the TFR. The mode clearly rises in all four countries. Spain shows an unusual early childbearing 'bulge' in its fertility schedules after 2000; this is largely due to a rapidly rising population of immigrant women with a young schedule of childbearing (Goldstein et al. 2009).

Figure 9 Age-specific fertility rates for birth order 1 (rates of the second kind, incidence rates) between a TFR minimum after 1990 and a subsequent TFR high between 2003 and 2008



Sources: Human Fertility Database (HFD 2010) and Eurostat (2010).

These empirical patterns are not exactly equal to the simulated period-driven fertility changes because there are changes in childlessness (which was assumed constant in the simulation) as well as deviations from the BF assumption, including the assumptions of a ‘pure’ period-based shift[2]. Nevertheless the complex changes in the observed age pattern are broadly consistent with the changes expected from the simulated postponement transition in a ‘period world’. This conclusion is generally

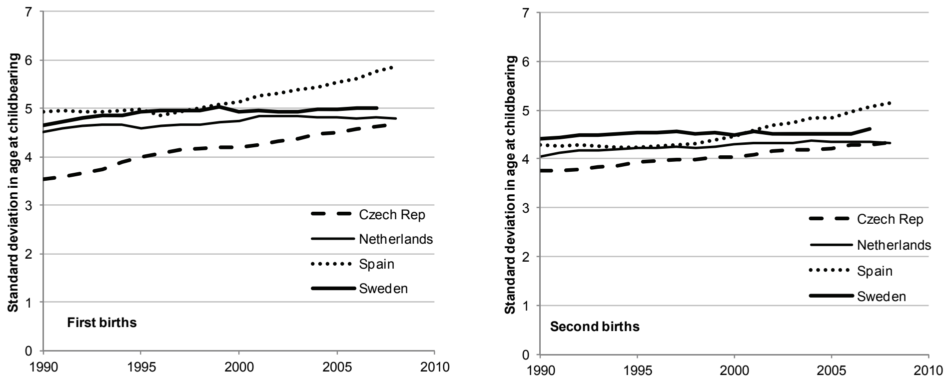
[2] It is possible that any cohort-driven change in fertility does not violate much the assumptions contained in this and other tempo-adjusted period indicators of fertility.

supported by an examination of trends in the standard deviation of the age schedule of period fertility. In the ‘period world’, the standard deviation should be constant. The observed variance, as measured by standard deviations of the period age-specific fertility schedule for the four analyzed countries, is plotted in Figure 10 for first and second births. These standard deviations show very little change in the Netherlands and Sweden and significant change in the Czech Republic, mostly at order one and in Spain. As noted above the increase in standard deviation in Spain is partly driven by the rise in immigrant fertility at young ages which complicates the interpretation of this trend.

These results are largely consistent with the view that period effects are dominant in the Netherlands and Sweden. Period effects are also important in the Czech Republic and possibly Spain, but significant cohort effects appear to be present as well, especially at order one.

The preceding analysis of empirical evidence was limited to countries for which fertility rates are available by birth order, because quantum and tempo trends differ by birth order. However, when these order specific trends are similar, an examination of overall age patterns of fertility can be informative. Appendix 2 presents overall fertility schedules for Denmark, France, Italy, and the United Kingdom. The changes in these countries since the mid 1990s also suggest a dominance of period effects.

Figure 10 Standard deviations in age at childbearing, first and second births



Source: Computations based on Human Fertility Database (HFD 2010) and Eurostat (2003 and 2010) for Spain

***Estimating tempo distortions: past indicators and the new tempo and parity-adjusted total fertility* (TFR_p*)**

A substantial literature discusses methods for removing tempo distortions in period fertility indicators. These methods estimate tempo-adjusted total fertility (denoted here by an asterisk). When subtracted from the observed TFR, the tempo-adjusted total fertility yields an estimate of the tempo distortion. We focus on three tempo-adjusted indicators[3]:

1) *TFR**. The oldest and most widely used tempo-adjusted TFR was proposed by Bongaarts and Feeney (1998). By rearranging the equation presented above they estimate the tempo adjusted TFR* in a given year as

TFR* = TFR / (1-r)

A key advantage of this equation is that it requires only data on TFR and r by birth order which are available for many developed countries.

[3] For further discussion of the underlying assumptions for these indicators and their interpretation see Appendix and Bongaarts and Feeney (2006), Yamaguchi and Beppu (2004), Kohler-Ortega (2002, 2004), van Imhoff (2001), and Sobotka (2003).

2) *PATFR**. One of the main criticisms of this simple BF procedure is that it does not take into account changes in the parity distribution of the female population (Kohler and Ortega 2002; van Imhoff and Keilman 2000). To address this issue, Kohler and Ortega (2002) proposed a tempo adjusted period fertility indicator (we will call it PATFR*) which differs in two ways from the Bongaarts Feeney approach. First, it uses fertility tables which convert age and parity-specific fertility rates or probabilities into period quantum measures[4]. Second, the tempo adjustment to these probabilities is derived from the rate of change in the mean age of the probabilities rather than from the change in the mean age of the conventional age-specific birth rates (i.e., it is based on rates of the first rather than the second kind). The PATFR* represents a tempo-adjusted version of an index of period fertility introduced by Rallu and Toulemon (1994) and earlier elaborated by Park (1976).

3) TFR_P*. More recently Bongaarts and Feeney (2004, 2006) proposed a variant of the BF basic method. This approach has been used to estimate mortality tempo effects by Bongaarts and Feeney (2003), but has thus far been neglected in fertility literature. The tempo- and parity-adjusted total fertility, TFR_P*, differs in three ways from the original method. First, fertility tables are used to convert age and parity-specific fertility rates ('hazard rates') into period quantum measures. Second, the fertility tables for different birth orders are entirely independent of each other rather than linked as in the Kohler-Ortega method[5]. Third, the tempo adjustment of probabilities is made with the original Bongaarts-Feeney method, based on

[4] In estimating these probabilities only women at parity i-1 are at risk of having a birth of order i (i.e., births are assumed to be repeatable events: giving an i-th birth exposes one to have an i+1th birth, and so on).

[5] In this method age-specific birth hazard rates are estimated assuming that all women who have not reached parity i—and not only those with i-1 births as in the case of the PATFR computation—are exposed to the risk of having an i-th birth (i.e., births are assumed to be separate non-repeatable events).

the changes in the mean age of age-specific fertility rates by birth order. Yamaguchi and Beppu (2004) proposed a very similar approach.

These three tempo adjusted fertility indexes are plotted in Figure 11 for the four compared countries for all years for which data are available after 1980 from the HFD or national statistical sources. Figure 12 plots the same variables for birth order one. Generally, all the adjusted indicators are higher than the observed TFR, indicating fertility depressing tempo effect due to postponement of childbearing especially after 1990. Measures can differ substantially, especially during the times of rapid fertility changes and trend reversals. This is well illustrated by the fertility fluctuations in Sweden around 1991, when rapid changes in birth interval, stimulated by an extension of parental leave, caused a sudden upturn in the conventional TFR, and an even more sudden shift in the TFR* and PATFR*. In contrast, the TFR_P* is much more stable [6].

The different adjusted indicators shed a very different light on the recent upturn in the period TFR. The TFR_P* suggests a stagnation in the fertility quantum since the year of the minimum TFR while the other adjusted measures indicate a slight increase in fertility quantum. For reasons presented below, the TFR_P* is our preferred indicator for estimating tempo effects.

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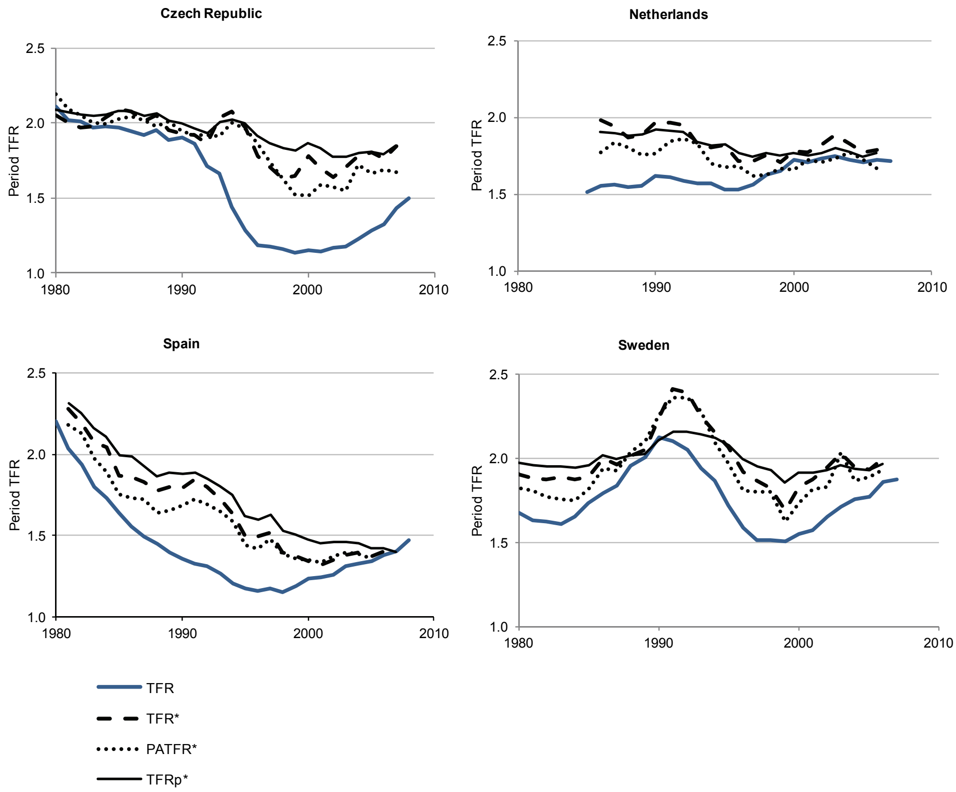
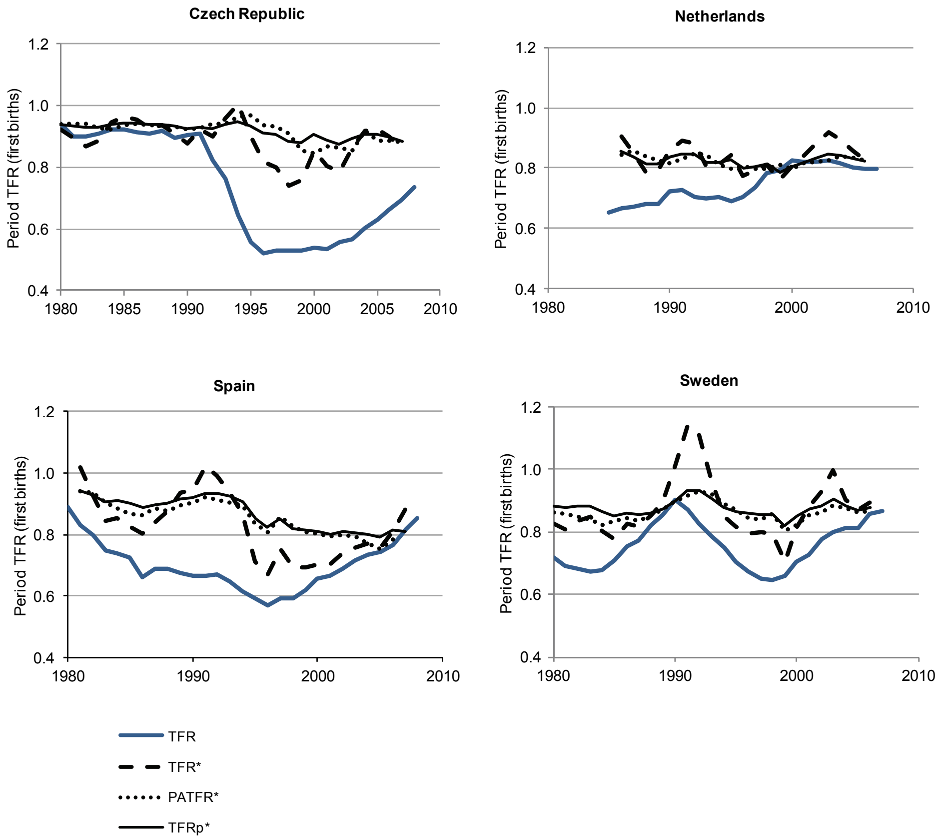
[6] The TFR* is considerably more variable than TFR_P*. This instability is most visible in the case of birth-order specific data, where TFR* may show large year-to-year changes and implausible values, as in the case of the first order TFR* above 1 (see graphs for Spain and Sweden in Figure 12). These fluctuations are in part due to fact that TFR* is sensitive to errors or slight changes in the registration of birth order in the official vital statistics data. Problems in birth order reporting in some provinces in Spain and in the birth order allocation to multiple births, especially around 1996 and in 2007-2008 (Devolder and Ortiz, unpublished document) may lie behind some first-order TFR* fluctuations there.

Figure 11 Observed and tempo-adjusted total fertility indexes for all birth orders



Source: Computations based on Human Fertility Database (HFD 2010) and Eurostat (2003 and 2010) for Spain.

Figure 12 Observed and tempo-adjusted total fertility indexes for birth order 1



Source: Computations based on Human Fertility Database (HFD 2010) and Eurostat (2003 and 2010) for Spain.

5 COMPARISON OF PERIOD AND COHORT FERTILITY

Tempo-adjusted period fertility indicators (TFR*, PATFR* and TFR_P*) can be considered variants of the conventional period TFR, which aim to remove tempo distortions caused by the changes in the timing of childbearing and in the case of PATFR* and TFR_P* also control for the parity composition of the female population. With the tempo component of the TFR removed, these adjusted indicators are estimates of the period fertility quantum. It is important to emphasize that these pure period measures do not predict or aim to predict the completed fertility of any cohort or to forecast future period fertility. The reason is clear: the completed fertility of a cohort is accumulated over decades of childbearing while a period measure only reflects childbearing in a single year.

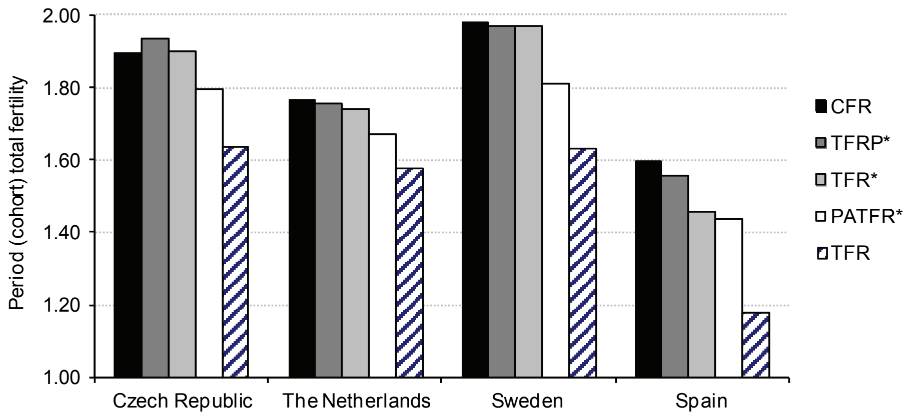
Nevertheless, there are conditions in which a comparison of cohort fertility with the tempo-adjusted period fertility is appropriate. The simplest situation is one in which completed fertility is constant for successive cohorts (as was the case in the above simulations). In such a hypothetical population the TFR can fluctuate from year to year due to tempo changes, but the tempo adjusted TFR is constant and equal to the cohort CFR (provided that the assumption about the constant shape of the period fertility schedule holds and the parity composition of women shifts along with the fertility schedule). In the real world cohort fertility is not constant and the constant shape assumption is only an approximation. Fortunately, in contemporary European populations cohort fertility tends to change relatively slowly and without significant fluctuations, and the shape of the period fertility schedule changes relatively little from year to year. Under these conditions, the tempo effect is the main factor responsible for the observed differences between period and cohort fertility rates. If it is correctly accounted for, period fertility indicators should get on average close to the completed cohort fertility—not in individual years, but in a longer-term perspective—and a comparison of cohort and adjusted period measures can be helpful in assessing which of the available tempo adjusted measures is preferable.

Several past studies have compared cohort and tempo-adjusted period fertility. Typically, adjusted period indicators for a particular period are compared with the value of completed cohort fertility of women who reached the mean age at childbearing in that period. For example, Bongaarts and Feeney (1998, 2006) compared lagged completed cohort fertility with the adjusted TFR* averaged over the period during which these cohorts were in their prime childbearing years and found good agreement. Sobotka (2003) compared lagged cohort fertility with the tempo adjusted TFR* for a single year (rather than the average over a number of years); he found somewhat less correspondence because the adjusted TFR* contains seemingly random year-to-year fluctuations. A few other contributions also used annual TFR* data, noting the instability of this indicator (e.g., Schoen 2004 for the United States in the late 1970s). The confounding effect of these annual fluctuations can be minimized by smoothing time series of the adjusted TFR*.

Our analysis of this issue follows these procedures and compares the completed fertility of the cohort born in year C with the smoothed tempo-adjusted measures in year t, where t –C equals the mean age at childbearing in year t. All estimates are made separately for different birth orders (1 to 5+) and the period measures are smoothed using a simple 5-year moving average. Only cohorts whose fertility up to age 40 has been observed by the last available year are included and their fertility after age 40 is assumed to equal the observed schedule above age 40 in that year.

Figure 13 presents data for the most recent cohort analyzed (1967 for the Netherlands, Spain, and Sweden and 1968 for the Czech Republic) and compares them with the three adjusted period indicators as well as the conventional period TFR. In addition, Table A1 in the Appendix provides a comparison of the cohort CFR with all these indicators analyzed for each birth order up to 4+. The main finding is that the TFR_P* and CFR are in striking agreement in all four countries. This indicator is therefore our preferred one for the analysis of tempo distortions. Figure 13 also shows that one of the critiques against the use of tempo adjusted measures, namely that they may give an inflated impression of tempo-free fertility in a period, is not warranted.

Figure 13 A comparison of the completed fertility rate (CFR) among women born in 1967 (1968 in the Czech Republic) with three adjusted fertility indicators and with the conventional period TFR in the year this cohort reached the mean age at childbearing



Source: Computations based on Human Fertility Database (HFD 2010) and Eurostat (2003 and 2010) for Spain

To summarize the analysis on the proximity of the cohort and the corresponding adjusted period fertility, Table 1 displays the average absolute difference between them in the cohorts of 1961-67. This difference is our main measure for assessing the accuracy of the tempo adjustment achieved by different indicators. As expected from the results in Figure 13 the adjusted indicators largely close the substantial gap between observed period and cohort fertility. This is especially in the case of the two indicators derived using the BF method: TFR*, and TFR_P*. In particular, the TFR_P* shows a remarkably good approximation of the CFR in all the four countries analyzed, often removing 80-90% of the initial difference between TFR and CFR. For instance, it reduces the gap between the TFR and the corresponding CFR in the Netherlands from 13.8% to just 0.8% and in Spain it narrows the gap of 25% to below 3%.

An examination of the birth order dimension in Table 1 shows that all adjusted indexes show a remarkable correspondence with the CFR in the case of first births. Fertility rates at later births, however, show a major weakness of the adjusted PATFR* index. In contrast, TFR* and TFR_P* depict fairly good correspondence with the completed fertility at higher birth orders. As in the case of all birth orders combined, TFR_P* performs best of all indicators for third births (Table 1) and its performance has exceeded our expectations. The similarly good performance of the TFR* is in part attributable to the 5-year smoothing of period fertility series used here, which took away most of its annual variation.

There are also theoretical grounds for preferring the TFR_P*. In a 'classic' fertility table framework, the interconnectedness of fertility tables of different birth orders is a disadvantage in periods with rapidly changing timing of childbearing because a tempo effect at one birth order may then magnify a similar distortion at the subsequent birth orders. This appears to be a key factor in the relatively poor performance of the PATFR* for higher birth orders[7]. The TFR_P* avoids this problem by treating each birth as a separate event, disconnected from the previous and subsequent births.

[7] Another problem is the instability of age and parity-specific birth probabilities at younger ages in conventional fertility tables.

Table 1 Percent absolute differences between completed cohort CFR and period fertility indicators, average of cohorts 1960-1967

	Czech Republic[1]	Netherlands	Spain	Sweden	Average for four countries
Total births					
TFR_P*	1.9	**0.8**	**2.7**	**1.8**	**1.8**
TFR*	**0.3**	1.4	3.3	5.3	2.6
PATFR*	4.6	5.0	7.3	3.4	5.1
TFR	9.9	13.8	25.0	8.5	14.3
First births					
TFR_P*	1.1	**1.2**	3.4	**2.0**	1.9
TFR*	**0.5**	2.6	5.5	8.6	4.3
PATFR*	0.9	1.3	**1.7**	2.5	**1.6**
TFR	1.7	13.9	25.5	7.5	12.2
Third births					
TFR_P*	**4.7**	**1.0**	**4.7**	**3.7**	**3.5**
TFR*	4.9	1.8	9.4	4.7	5.2
PATFR*	38.5	18.3	38.5	15.3	27.7
TFR	29.3	12.1	20.6	13.6	18.9

Notes: The indicator that is closest to the completed CFR is shown in bold. Indicators sorted from those which come closest to the completed fertility rates to those that are most distant from them in the case of total births.
1 Data for the Czech Republic pertain to the 1966-67 cohorts only, as the older cohorts experienced only a very minor shift in their childbearing ages.

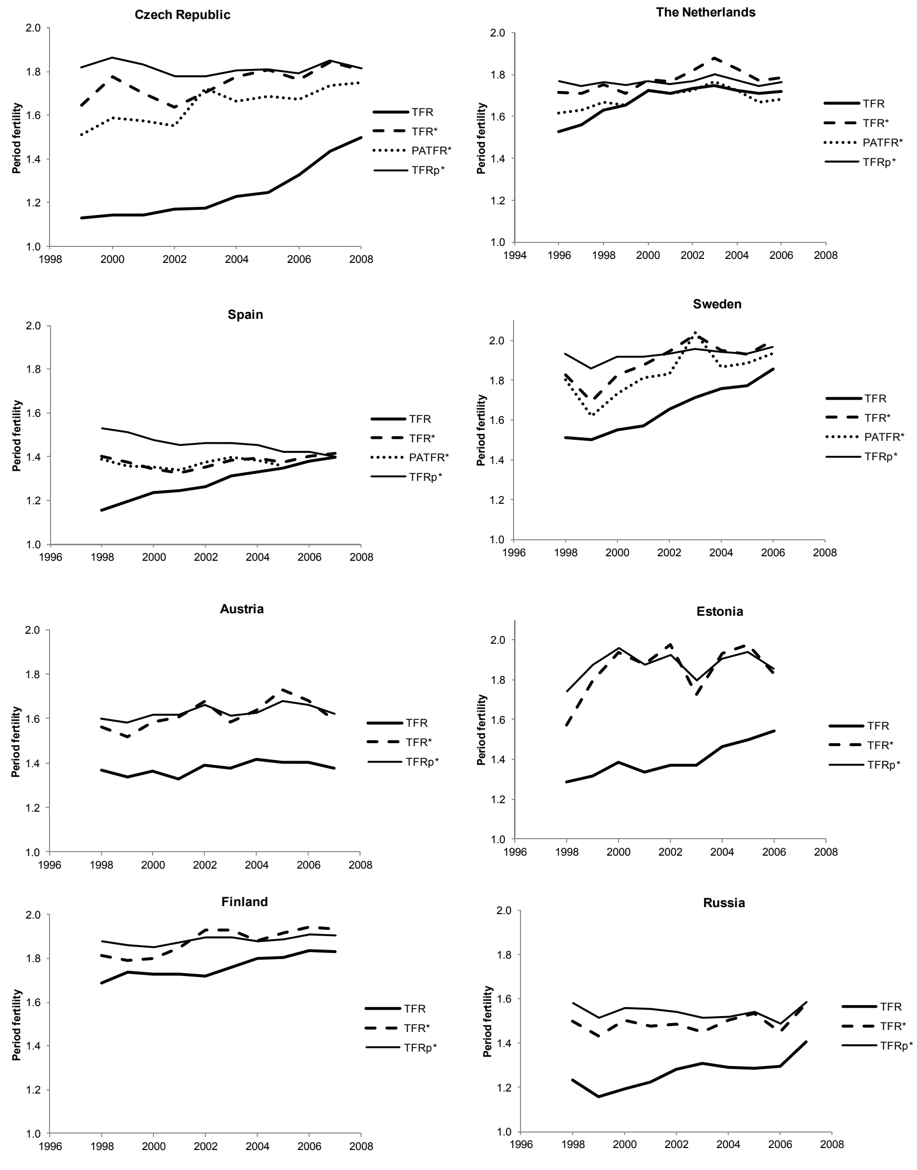
Source: Computations based on Human Fertility Database (HFD 2010) and Eurostat (2003 and 2010) for Spain

6 CONTRIBUTION OF DECLINING TEMPO DISTORTIONS TO RECENT TFR RISE

One of the main purposes of the tempo-adjusted indicators is to analyse whether the observed changes in conventional TFR could be attributed to a ‘genuine’ change in fertility *quantum* or whether they are mostly due to a changing *tempo effect*. The recent increase in the period TFR across most developed countries provides a particularly suitable opportunity for such analysis (see Goldstein et al. 2009). Unfortunately, the widely used tempo adjusted indicator TFR* is subject to year-to-year instability which necessitates smoothing the annual data and thus losing the most recent year(s) of observation. As Figure 11 showed, the new tempo and parity-adjusted total fertility, TFR_P*, displays more stable values and is therefore more suitable for examining the role of trends in tempo effects. This is yet more clearly illustrated in the graphs focusing at the recent period of increasing period TFR between 1998 and 2008, displayed in Figure 14.

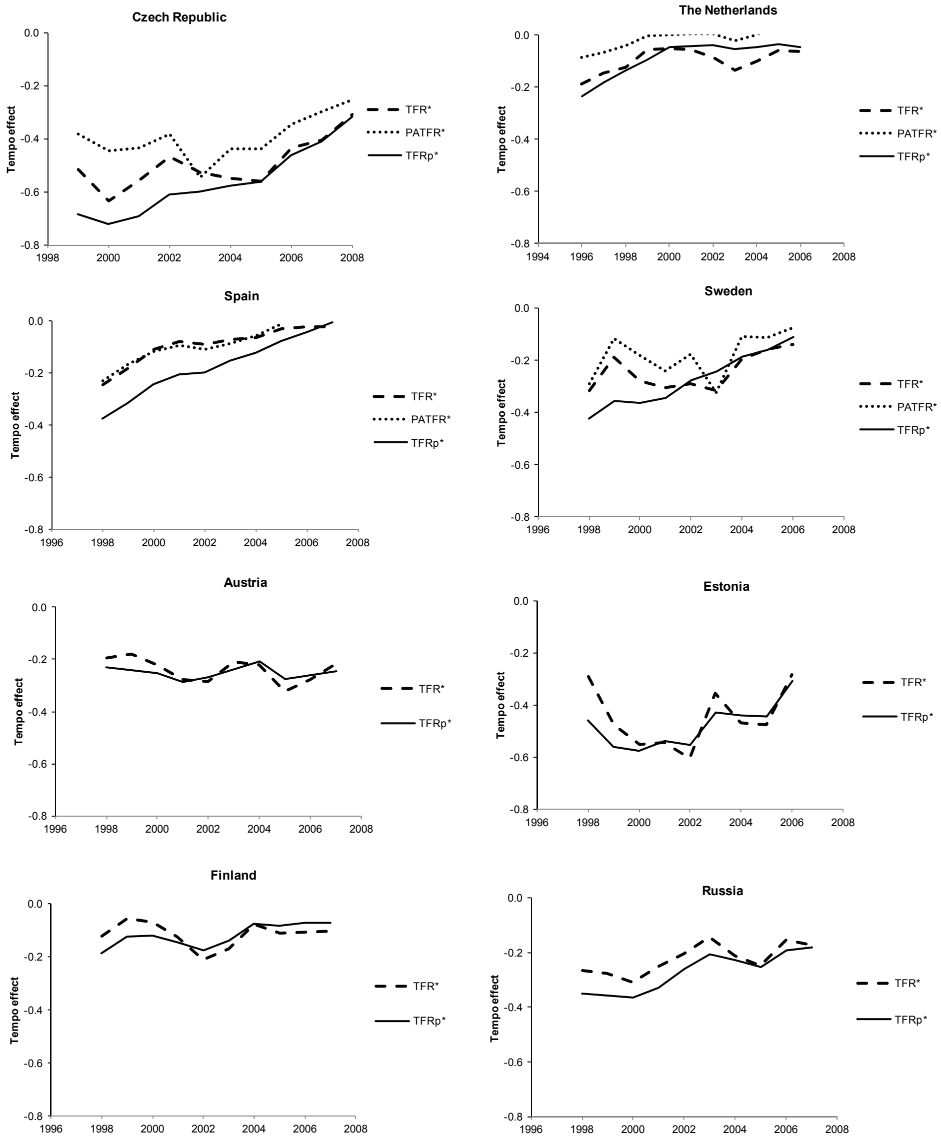
We use data for eight countries (in addition to our 'core' set of four countries, we included data for Austria, Estonia, Finland, and Russia) to assess whether using different adjusted indicators leads to different conclusions about the role of tempo effect in the TFR increase in the four countries analysed in this paper. Figure 15 presents the tempo effect (i.e., the gap between the adjusted and unadjusted TFR) implied by each adjustment method since the year of the fertility trough in the late 1990s. The main finding is a decline in the tempo effect over time in all countries except Austria, where no perceptible trend can be observed: the tempo effect becomes less negative and it entirely vanishes in Spain. This trend is broadly depicted by all three adjusted measures, but the TFR_P* stands out in several aspects: First, as noted earlier, it gives smoother trends over time, relatively little interrupted by year-to-year ups and downs typical of the TFR* and PATFR*. This is potentially a great advantage as it provides more stable estimates of tempo effect and its changes over time. Second, the tempo effect derived from the TFR_P* is considerably larger than the tempo effect derived from the other indicators during the period when the conventional TFR reaches a trough. This suggests that the negative tempo effect in many low-fertility countries in the late 1990s was actually higher than previously estimated with the TFR*.

Figure 14: Period TFR during its recent increase as compared with three tempo-adjusted indicators in eight European countries



Source: Computations based on Human Fertility Database (HFD 2010).
Note: The Kohler-Ortega's adjusted index of fertility, PATFR*, has been computed only for four 'core' countries.

Figure 15 Estimated *tempo effect* in the period TFR during the its recent increase in eight European countries



Source: Computations based on Human Fertility Database (2010).
Note: PATFR* has been computed only for four ‘core’ countries.

Table 2 Percent TFR increase attributable to diminishing tempo effects since the year the lowest TFR was reached

Country	Period	Abs. TFR increase	Percent TFR increase due to tempo effect		
			TFR*	PATFR*	TFRp*
Czech Republic	1999-2008	0.37	56	35	100
Estonia	1998-2006	0.26	3	..	57
Finland	1998-2007	0.14	13	..	82
The Netherlands	1996-2003	0.22	24	30	85
Russian Federation	1999-2007	0.25	41	..	71
Spain	1998-2005	0.19	100	100	100
Spain	1998-2007	0.24	93	..	100
Sweden	1999-2006	0.35	14	12	69

Source: Computations based on Human Fertility Database (HFD 2010) and Eurostat (2003 and 2010) for Spain.

Note: The Kohler-Ortega's adjusted index of fertility, PATFR*, has been computed only for four 'core' countries.

The main implication of these findings is that the assessment of the importance of changes in the *tempo effect* during the recent TFR rise depends widely on the indicator used. This issue is examined in Table 2 which presents the percentage of the TFR increase that is attributable to the diminishing tempo effect since the lowest TFR in the 1990s. Our preferred indicator, the TFR_P* shows a paramount role of diminishing *tempo effect* in explaining the recent TFR upturns. The proportion of the recent TFR increase due to the decline in the *tempo effect* ranges from 57 % in Estonia up to 100 % in the Czech Republic and Spain (Table 2). Except for Spain, these estimates are substantially larger than those obtained by Goldstein et al (2009) using the TFR* or from the PATFR*. In three countries—Estonia, Finland, and Sweden—the 'traditional' adjusted TFR* indicated a negligible role of declining *tempo effect* in the observed TFR increases since the late 1990s, ranging between 3 % in Estonia and 14 % in Sweden.

7 CONCLUSIONS AND DISCUSSION

Our analysis pertained to a unique period of a European-wide increase in total fertility rates, which occurred on such a scale for the first time since the baby boom of the mid-1960s. We began our analysis of the recent rise in European fertility by reviewing the ongoing debate about the relative roles of period and cohort effects. To shed light on this issue we compared observed trends in age-specific fertility rates in four countries with hypothetical trends from simulations of pure period and cohort 'worlds'. This comparison demonstrated that the complex changes in the observed age pattern are broadly consistent with the changes expected from the simulated postponement transition in a 'period world'. Important period effects were present in all four countries. In addition, cohort effects were present especially in the Czech Republic and perhaps Spain (where high immigrant fertility has yielded unusual age patterns of fertility that are difficult to interpret).

These findings can be reconciled with previous studies by noting that

- the "period paramount" perspective can be perfectly consistent with the description of fertility change in the cohort postponement-recuperation perspective. The reason is that 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. As a result, a period-driven rise in the mean age at childbearing can produce changes in cohort fertility that can be described in terms of postponement and recuperation;
- whether fertility is described from a period or cohort perspective is a separate question from whether period or cohort effects are the main underlying driving force of fertility change;

- neither a period shift nor cohort postponement and recuperation is sufficient to explain a rise in period fertility. Shifts and postponements can occur for decades in countries with a constant total fertility rate and a rising period mean age at childbearing.

We then examine the hypothesis that the rise in fertility in Europe is caused by the end of the postponenment transition. During the peak of this transition in the 1990s, substantial tempo distortions were present in most countries. However, as the postponement transition nears its end and annual increases in the mean age at birth decline, these tempo distortions are now becoming smaller, thus leading to a rise in period fertility. To asses the importance of diminishing tempo effect for explaining the recent rise in period total fertility rates across Europe we made extensive use of a new indicator of period fertility, termed *tempo and parity-adjusted total fertility* (TFR_P*). This indiator, which was first proposed by Bongaarts and Feeney and developed independently in a similar form by Yamaguchi and Beppu (2004), is based on a table computation using hazard rates with births of different birth order treated as separate (disconnected) events.

Our analysis gives a positive preliminary assessment of the new TFR_P* indicator. Why should anyone choose this indicator over the growing and at times bewildering set of adjusted and nonadjusted period fertility rates? First of all, for its empirical 'performance', especially its relative stability from one year to the next. Second, because of its unexpected and remarkably close approximation of the completed cohort fertility among women of prime childbearing age in a given period. This proximity is also aparent in order-specific analysis, especially at higher-order births, where other perod indicators often fail to get significantly closer to the completed fertility. Finally, there are theoritical reasons why classical table measures perform poorly at higher birth orders when the timing of childbearing changes. This problem is avoided in the new indicator. The use of the TFR_P* still needs to be more extensively tested with data for more countries and different situations with regard to the changes in fertility timing. Also, the theoretical underpinning of this and other fertility indicators need to be studied more thoroughly.

When parity-specific data are unavailable and the TFR_P* cannot be computed the ‘traditional’ adjusted TFR* remains an acceptable alternative to estimate period fertility *quantum*. It should, however, be computed as a smoothed average for several years (as it is done in the *European Demographic Datasheet* (VID 2010)) rather than for individual years when it may suffer high year-to-year fluctuations. It may also underestimate fertility levels around the time when tempo effect reaches maximum.

Our main conclusion, based on on an analysis of trends in TFR_P* is that tempo effect had a considerably more prominent role in the recent increase in the conventional TFR than previously estimated with other tempo-adjusted fertility indicators. In other words, the TFR_P* provides a straightforward demographic explanation of recent fertility trends: there was little or no increase in the level (*quantum*) of fertility between the late 1990s and 2008, while most of the observed TFR rise (and the entire TFR rise in the Czech Republic and Spain) can be attributed to a diminishing pace of the postponement of childbearing. This finding also sheds light on the previous period of declining total fertility rates. The TFR_P* signals that, net of *tempo effect*, European fertility rates declined less in the 1980s and 1990s and fertility *quantum* remained higher when the TFR lows were reached in the late 1990s than previous analyses showed. Highlighting the key role of *tempo effect* in driving period fertility changes in Europe in the last two decades does not mean that socioeconomic and policy factors are irrelevant for explaining the TFR upturns. Rather than explaining the *quantum* change in period fertility, they might have had an impact on the trends in fertility *timing* (see Örsal and Goldstein 2010).

In a majority of European countries the recent economic recession has temporarily reversed the trend of increasing period total fertility or put a break to its previous increase (Sobotka et al. 2011). The impact of economic recession was partly filtered by family-related policies, which were expanding in many countries during the last decade (e.g., in Bulgaria, Estonia, Germany, Russia, Ukraine and the United Kingdom), but, more recently, have began contracting in some instances as governments faced increasing budget constraints (e.g., in the Czech Republic and Spain). Beyond these factors, two of our findings shed light on the likely future fertility trends. First, the quantum of fertility has been roughly constant in the last two decades, therefore it seems reasonable to assume that it will remain close to recent levels for some time in the future (except for the distorting influences of economic recession). Second, the tempo effect has declined in the past decade and we believe that it is likely to continue to do so until it eventually disappears as the postponement transition comes to an end. The average tempo effect in the EU was 0.12 births per woman as measured by TFR* around 2006 (VID 2010). As we have demonstrated this estimate may have some downward bias, so the actual tempo effect was probably somewhat larger. For the EU the recent (2008) TFR stood at 1.60, while the adjusted TFR* equaled 1.72 around 2006. The actual period quantum is perhaps slightly higher and close to the cohort fertility estimate of 1.74 for the women born in 1968 (VID 2010). In the absence of quantum effects we expect period TFR to rise at a slow pace to this level once the recession-induced economic uncertainty diminishes. We also expect that the TFR_P* will contribute to our understanding of such fertility reversals.

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APPENDIX 1: Fertility indicators used in this study

The unadjusted and adjusted period fertility indicators used in this study are estimated from three distinct unadjusted age- and order-specific birth rates defined as follows:

f(a,t,i): age specific fertility rate of the second kind in year t, at age a and order i . Denominators of these rates equal all women aged a at time t, regardless of their parity;

h(a,t,i): conditional fertility rates of the first kind (i.e., hazards) with births of each order treated as repeatable events. Denominators of the exposure-specific rates for order i and age a are equal to women of parity i-1;

p(a,t,i): conditional fertility rates of the first kind with births of each order treated as separate non-repeatable events. Denominators of the hazard for order i equal all women who have not yet reached parity i.

Indicators are estimated as follows:

TFR(t), the conventional period total fertility rate is calculted from rates of the 2nd kind

$$TFR(t) = \sum_i TFR(t,i) = \sum_i \sum_a f(a,t,i) \quad (1)$$

$TFR_P(t)$, the total fertility rate derived from rates of the first kind (births nonrenewable; Bongaarts and Feeney (2004 and 2006), Yamaguchi and Beppu (2004))

$$TFR_P(t) = \sum_i TFR_P(t,i) = \sum_i 1 - \exp[-\sum_a p(a,t,i)] \quad (2)$$

PATFR(t), the total fertility rate derived from rates of the first kind h(a,t,i) with births treated as renewable events; see Rallu and Toulemon (2004) for details. PATFR(t) can be computed from increment-decrement fertility tables, where the computation of the indicator for any parity above 1 depends partly on the output (i.e., table births) from the lower-parity tables. This interconnectedness across parities may be the main source of hugely magnified tempo distortion at higher parities. For birth order one the PATFR(t) equals the $TFR_p(t)$, but at higher orders they differ because the computation of the $TFR_p(t)$ resembles 'traditional' survival curves: all women are supposed to be exposed to having a birth of any parity at the beginning of their reproductive age and the computation of 'births' and 'survivorship' is provided for each parity independent on the other parities.

TFR(t)*, the tempo-adjusted version of TFR(t) (Bongaarts and Feeney 1998, 2006)

$$TFR^*(t) = \sum_i TFR^*(t,i) = \sum_i \sum_a \frac{f(a,t,i)}{1-r(t,i)} = \sum_i \frac{TFR(t,i)}{1-r(t,i)} \tag{3}$$

with

$$r(t,i) = (MAB(t+1,i) - MAB(t-1,i))/2 \tag{4}$$

$$MAB(t,i) = \sum_a a\, f(a,t,i)/TFR(t,i) \tag{5}$$

TFR_P(t)*, the tempo adjusted version of $TFR_P(t)$ (Bongaarts and Feeney 2004, 2006)

$$TFR_P{}^*(t) = \sum_i TFR_P{}^*(t,i) = \sum_i 1 - \exp[-\sum_a \frac{p(a,t,i)}{1-r(t,i)}] \tag{6}$$

Yamaguchi and Beppu (2004) proposed a very similar approach. Their equation for estimating the tempo adjusted period fertility is

$$adjTFR(t) = \sum_i adjTFR(t,i) = \sum_i 1 - (1 - TFRP(t,i))^{\frac{1}{1-r(t,i)}} \tag{7}$$

Substitution of (2) in (7) and simplifying shows that *adjTFR=TFR_P**

PATFR(t)*, the tempo adjusted version of PATFR(t) calculated from occurrence-exposure rates h(a,t,i). For details see Kohler and Ortega (2002). In this approach the tempo adjustment is based on the rate of change in the mean age of the schedule of hazards (instead of the BF approach based on the mean age of the schedule of rates of the second kind). We employ a simplified version of this adjustment without iterative corrections to the observed mean age and the inferred tempo of fertility (corrected for distortions caused by the variance effects).

It should be noted that we examined a fourth tempo adjusted indictor in which the Bongaarts-Feeney tempo adjustment is applied to remove the tempo effect from hazard rates h(a,t,i). This indictor's ability to match cohort fertility is approximately the same as for the TFR*.

APPENDIX 2: Age patterns of fertility in Denmark, France, Italy and the United Kingdom

The comparison of simulated period and cohort fertility schedules with empirical ones has been limited to countries for which fertility rates are available by birth order. This unfortunately implies that some of the largest countries in Europe, including France, Italy and the United Kingdom, had to be excluded from our earlier analysis, because order-specific information is lacking for them.

There are, however, conditions under which an examination of the changing shape of the overall fertility schedule is instructive. Specifically, if the fertility quantum at each birth order is constant over time and if changes in the tempo effect are the same for all birth orders then the characteristic changes in the age patterns of fertility will hold for the overall fertility schedule and not just for each order separately. We believe that these conditions are approximately valid in many countries in Europe since the late 1990s (see discussion in the last section of the text).

Figure A1 plots recent trends in age-specific fertility rates for Denmark, France, Italy and the United Kingdom. In all four countries the

TFR rose since reaching its lowest point between 1993 (France) and 2001 (UK). As of 2008, the absolute TFR increase amounted to +0.17 in Denmark, +0.33 in France, +0.22 in Italy and +0.33 in the UK and the figures cover the years between the most recent minimum and maximum. Each of these countries shows an increase and a shift in the mode which are the key characteristics of a period-driven pattern of change (termed "period world" in Figures 7 and 8). The standard deviation of the fertility schedules shows little change. These results therefore suggest a dominance of period effects in recent fertility upturns in these four countries. This conclusion must be tentative as the assumptions made about the quantum and tempo changes may not hold exactly and order-specific patterns of change may differ to some extent.

Figure A1 Changes in age-specific fertility schedule between the year of reaching a minimum TFR in the 1990s and the recent (2008 or 2009) maximum, France, Italy, Denmark and the United Kingdom

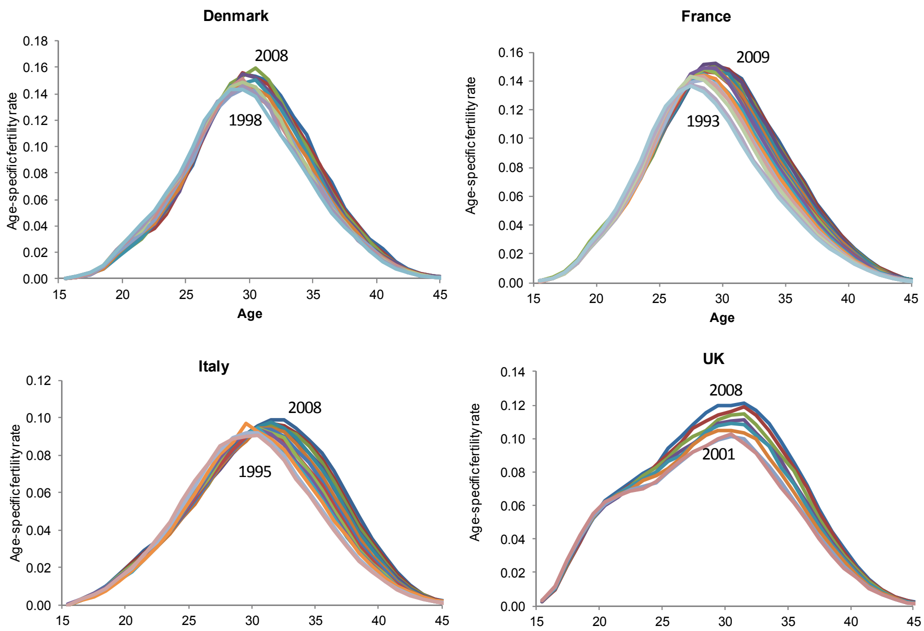

Table A1 Latest available completed cohort fertility (CFR) and period fertility indicators in year when the latest cohort observed (1967 or 1968) reached mean age at childbearing (by birth order, period indicators based on a 5-year moving average)

			Birth order			
		Total	**1**	**2**	**3**	**4+**
Czech	CFR (Cohort 1968)	1.897	0.919	0.716	0.189	0.072
Republic	TFR_p*	1.934	0.929	0.759	0.180	0.065
	TFR*	1.898	0.909	0.746	0.177	0.066
	PATFR*	1.795	0.932	0.731	0.100	0.031
	TFR	1.634	0.889	0.564	0.126	0.055
The	CFR (Cohort 1967)	1.766	0.817	0.645	0.217	0.086
Netherlands	TFR_p*	1.758	0.813	0.640	0.217	0.088
	TFR*	1.739	0.807	0.629	0.215	0.089
	PATFR*	1.673	0.803	0.618	0.190	0.063
	TFR	1.575	0.724	0.567	0.201	0.083
Sweden	CFR (Cohort 1967)	1.980	0.878	0.724	0.269	0.109
	TFR_p*	1.971	0.888	0.724	0.256	0.104
	TFR*	1.969	0.906	0.710	0.249	0.104
	PATFR*	1.811	0.891	0.665	0.207	0.048
	TFR	1.627	0.747	0.575	0.211	0.095
Spain	CFR (Cohort 1967)	1.597	0.864	0.579	0.119	0.035
	TFR_p*	1.557	0.872	0.542	0.115	0.029
	TFR*	1.458	0.788	0.537	0.103	0.030
	PATFR*	1.439	0.860	0.476	0.075	0.028
	TFR	1.176	0.605	0.440	0.100	0.031

Note: Indicators sorted from those approximating most closely the completed fertility rates to those that are most distant from them.