FERTILITY ASSUMPTIONS IN THE POPULATION PROJECTION OF THE CZECH REPUBLIC OF CZECH STATISTICAL OFFICE 2018–2100

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Abstract

The paper introduces the methodology used to estimate the fertility parameters for the population projection of the Czech Republic for 2018–2050. Birth order and the cohort perspective were both included in the process of estimating fertility rates. This methodology paper introduces the main principles and assumptions of the fertility estimation, input and output data, and details of the computations and estimations. The paper also analyses the estimated values of the summary fertility indicators and their plausibility from the period and cohort perspectives. Finally, it makes a comparison with past and alternative projections of fertility for the Czech Republic.

Keywords: Population projections, Czech Republic, births, fertility, age-specific fertility rates, total fertility rate, cohort fertility, mean age of mothers

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INTRODUCTION

This paper introduces a methodology for estimating age-specific fertility rates, which serve as input parameters for the population projection of the Czech Republic, published by the Czech Statistical Office (CZSO) in 2018 (CZSO 2018b). The population projection for 2018, like previous projections, is based on the classic deterministic principles and uses the cohort-component method. The input parameters of fertility are fertility rates at age 15–49 (age in completed years; or Lexis squares) for the calendar years 2018–2050. In the following period, 2051–2100, the rates are fixed at the values for the year 2050.

The process of estimating fertility rates was complex and included the dimensions of birth order and the cohort perspective. All the calculations were done using the R programming language. This methodology paper introduces the main principles involved in the fertility estimation, assumptions, input data, the details of the computations and estimations, and output data. The paper also analyses the estimated values of summary fertility indicators and their plausibility from period and cohort perspectives. Finally, it makes a comparison with the CZSO's past projections and with alternative fertility projections for the Czech Republic.

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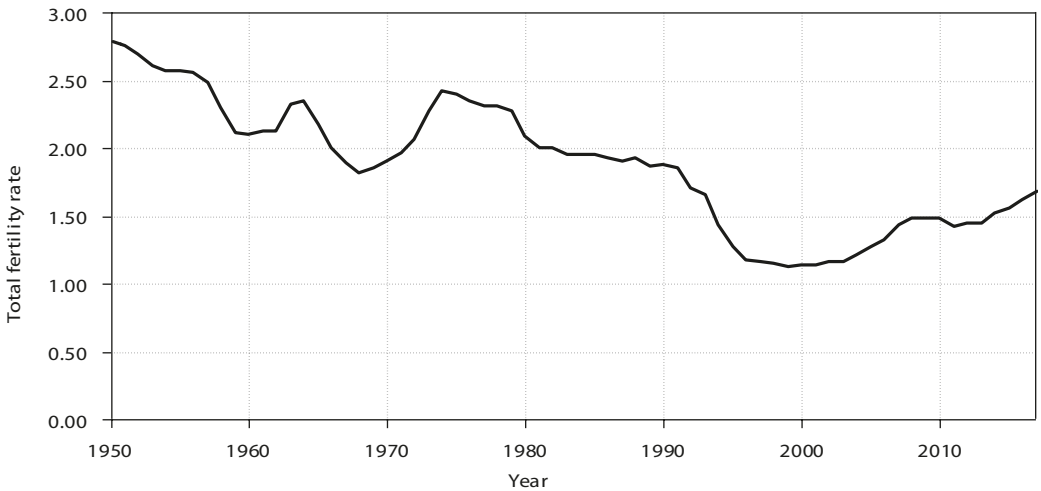
PAST FERTILITY DEVELOPMENTS

Predictions of future fertility levels proceed from the experience of past developments, especially since the year 1990. The development during the period since then has been characterised by two main phenomena: a significant decline in fertility levels and the postponement of fertility timing towards older ages (*Sobotka et al.*, 2008). The decline in the total fertility rate (TFR) to a level below 2.1 had already begun in the 1980s (Figure 1). The acceleration of the decline was only triggered by the revolutionary changes that occurred after 1989. The total fertility rate bottomed out at a low of 1.13 in 1999, and since then it has been increasing again (except in 2009 and 2011). Since 2014 the increase has been significant, growing by about 0.05 per year.

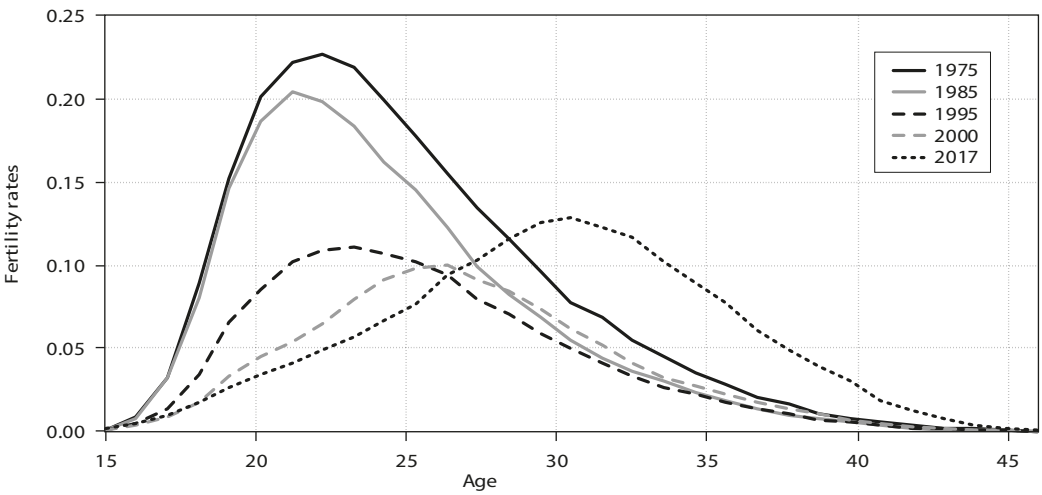
However, these changes were not homogeneous in terms of the mother's age and birth order. Figure 2

Figure 1 The total fertility rate in the Czech Republic, 1950–2017



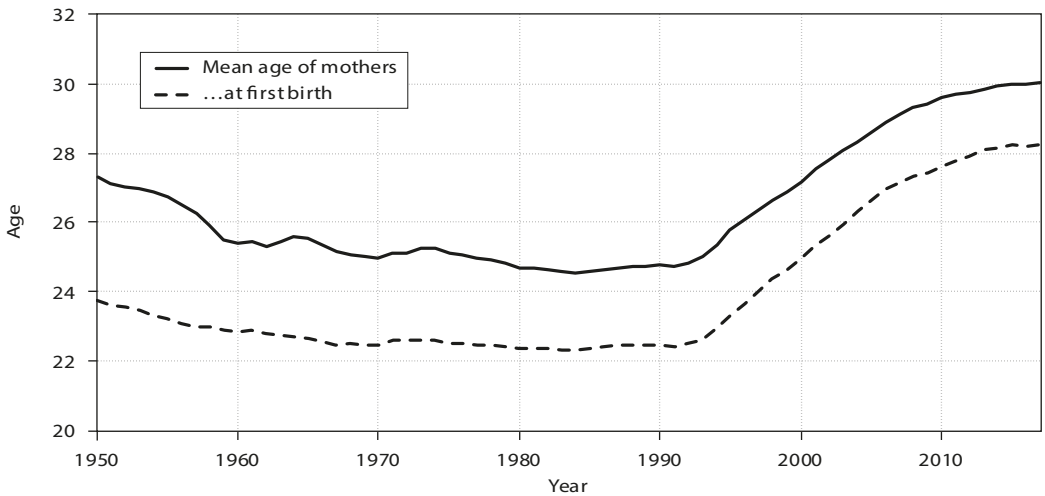
Source: Czech Statistical Office, 2018a.

Figure 2 Age-specific fertility rates in the Czech Republic, 1975, 1985, 1995, 2000, 2017



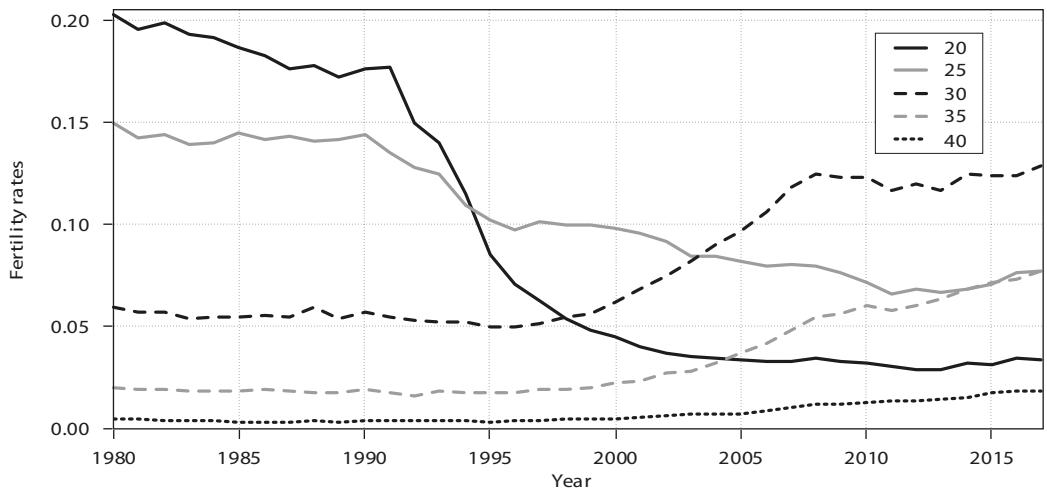
Source: Czech Statistical Office, 2018a.

Figure 3 Mean age of mothers, total and at first birth, in the Czech Republic, 1950–2017



Source: Czech Statistical Office, 2018a.

Figure 4 Fertility rates at selected ages in the Czech Republic, 1980–2017

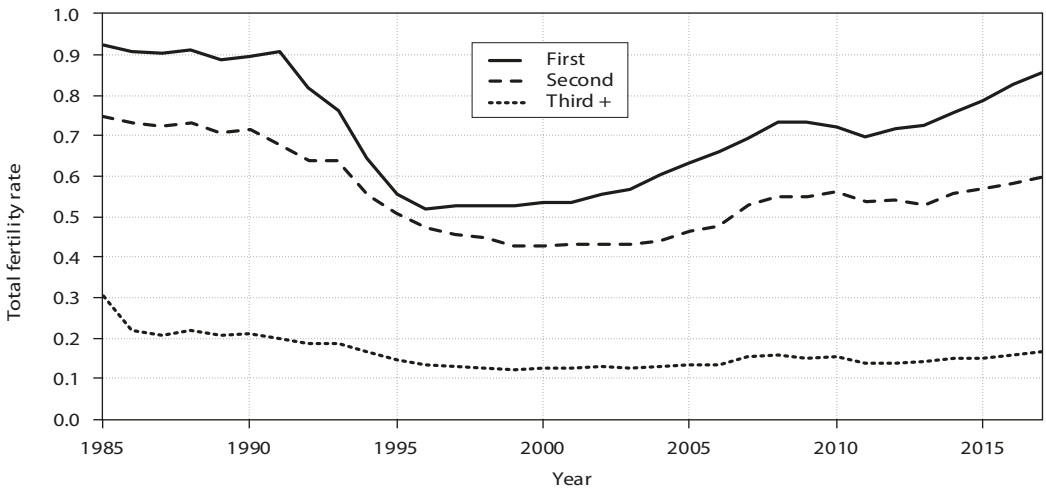


Source: Czech Statistical Office, 2018a.

shows how has the age structure of fertility changed along with the changes in fertility levels. While until the 1980s fertility was concentrated around the very young age of 21–22 years, after 1990 it quickly moved towards an older age owing to the 'postponement of fertility'. The shock of the 1990s first caused a quick drop in fertility across the whole age spectrum, gradually followed by increasing fertility among the 'postponing' mothers at older ages. From the period perspective this caused extremely low fertility levels at the end of the 1990s and a shift in maximum fertility towards ages around 30.

The mean age of mothers, which in the 1980s hovered around 25 years of age, started rising rapidly in the 1990s (Figure 3). Over the next two decades the mean age continued to increase, by 0.2–0.3 per calendar year, which alone contributed to a statistical distortion of fertility levels. The increase

Figure 5 Total fertility rates by birth order in the Czech Republic, 1986–2017



Source: Czech Statistical Office, 2018a.

has only slowed down in recent years, after reaching a hiigh of 30 years. From the age-specific fertility rates (Figure 4) it is clear that the strongest decline in fertility has been concentrated among the ages below 25. Conversely, among ages above 30 the fertility level has increased.

The fertility decline was also not homogenous across birth orders (Figure 5). The initial decline in the 1990s was mainly caused by the postponement of first births (total first-birth fertility decreased from 0.90 in 1990 to 0.52 in 1996–1997). By 2017 this decline had almost been offset (rising to 0.86). Total second-birth fertility was decreasing throughout the 1990s at a similar pace (from 0.71 to 0.42) but it has not yet been fully offset (it was at 0.60 in 2017). Births of third and higher order has participated on the overall decline just marginally.

THE MAIN PRINCIPLES AND ASSUMPTIONS OF THE PROJECTION

Estimations of future fertility draw on information about past fertility developments. This projection used as input the age-specific fertility rates for women at ages 14–50 (age in completed years) in 2005–2017. The projection itself does not require parameters specified by birth order, but the model estimates each birth order separately (first, second, third or higher) so as to control for the effect of projected fertility changes on cohort fertility and childlessness.

Future fertility rates are estimated using logarithmic regression, which follows the trend in recent years, but at the same time reduces its tempo, as that prevents the estimation from reaching non-realistic values further in the future (too high, or below zero). It also naturally flattens the curves, so from 2050 fertility is fixed on constant rates. For each age x and birth order i the logarithmic regression relates fertility rates $f_{x,i,t}$ to (relativised) calendar time t:

$$f^{*}_{x,i,t} = \mathrm{a} + \mathrm{b} \cdot \ln\left(t - 2004\right)$$

Parameters are derived from past fertility rates $f_{x,i,t}$ over the last thirteen years (2005–2017), as related to the logarithm of relative time (1–13). The length of this interval was chosen arbitrarily as a compromise; a longer interval would have included the decline of the 1990s (which has ended and will not repeat in the near future); a shorter interval would stress the fluctuations of recent years.

In the second step, the estimated values of fertility rates $f^{*}_{x,i,t}$ are further adjusted into the final projected fertility rates $f^{**}_{x,i,t}$ using three rules:

1) In 2017 they are equal to real values

$$f^{**}_{x,i,2017} = f_{x,i,2017}$$

2) Until 2050 they reach the estimated values

$$f^{**}_{x,i,2050} = f^{*}_{x,i,2050}$$

3) They keep the shape of logarithmic function curve:

$$f^{**}_{x,i,t} = f^{*}_{x,i,t} + \left(f_{x,i,2017} - f^{*}_{x,i,2017}\right) \cdot \frac{f^{*}_{x,i,2050} - f^{*}_{x,i,t}}{f^{*}_{x,i,2050} - f^{*}_{x,i,2017}}$$

This two-step process is depicted in Figure 6 on the example of the fertility rate for the first birth order at age 32. The logarithmic regression estimates the future value in 2050. The model assumes the increase will continue so that in 2050 it will reach the estimated value, but in 2017 it reaches the real value. Birth order-specific fertility rates are then summed by birth order, and by age, to the total fertility rate. All the rates increase up to the year 2050, after which they are fixed constantly at the 2050 level.

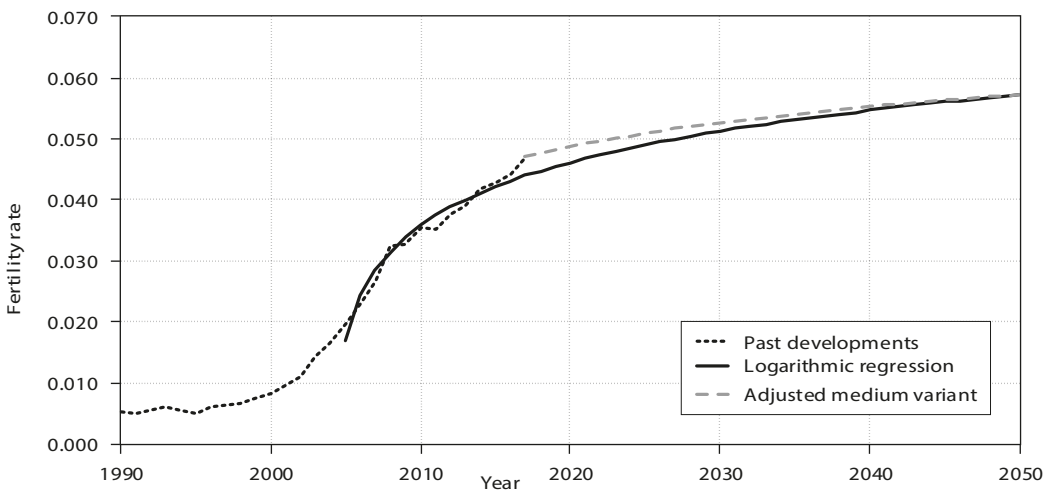
VARIANTS

In addition to a medium variant, which serves as input for calculating the main variant of the population projection, the projection also considers a low and a high variant of future fertility rates. The low variant assumes fertility postponement cessation and a reversal of the recent trend of moderate increases in fertility levels. The age-specific profile is fixed at the age distribution of 2017, and total fertility declines linearly to 1.40 in 2050 (Figure 7 and Figure 8).

The high variant assumes a further acceleration of fertility aging, taking as an example the age-specific profile of fertility in Germany in 2016. At the same time it assumes a linear increase in the total fertility level to 1.9 in 2050 (Figure 7 and Figure 8). Germany is used as an example for the following reasons. Germany is well advanced in the process of fertility postponement to older ages, with significant increases even after age 35 or 40. At the same time, fertility at a young age is not extremely low and is still comparable to the current levels in the Czech Republic. The total fertility level in Germany recently increased (to 1.57 in 2017 from 1.3–1.4 in 2000–2013), and this trend is likely to continue in the near future.

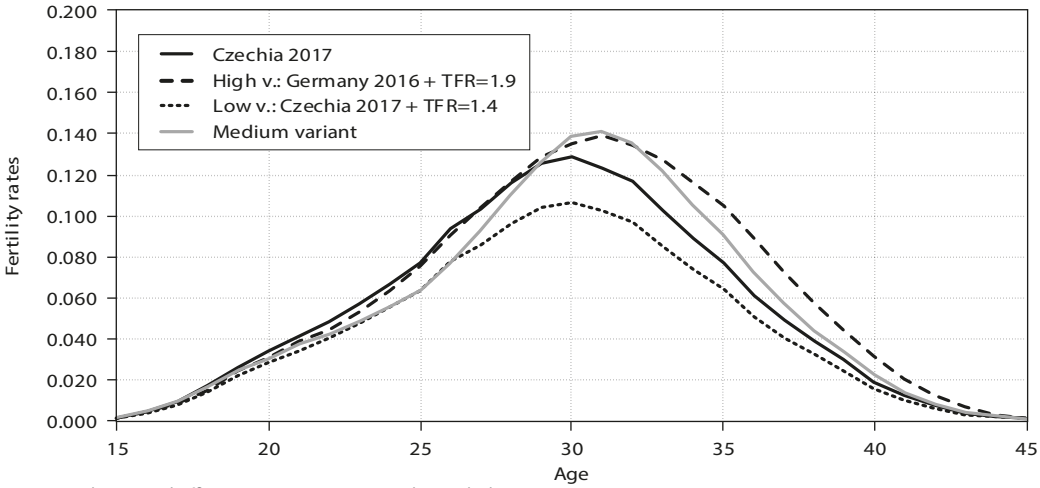
The low and high variants of the TFR begin to deviate from the medium variant deliberately already in 2018, which captures the random component of fertility fluctuations. Between 2017 and 2018 the low variant TFR drops by 5 percent from 1.69 to 1.60, while the high variant TFR increases also by 5 percent to 1.77. These sudden jumps are not impossible, given that in the recent years some inter-year changes amounted to as much as 0.10.

Figure 6 Estimation of the future development of first-order fertility rates at age 32 in the Czech Republic in 2018–2050 based on past real values in 2005–2017



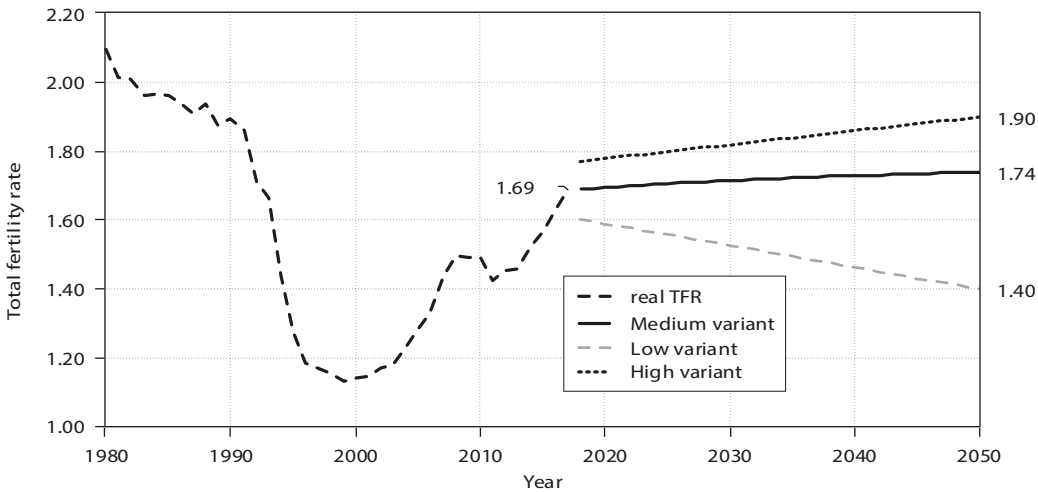
Source: Czech Statistical Office, 2018a; authors' calculations.

Figure 7 Target age-specific profiles of fertility rates in 2050 compared to 2017 in the Czech Republic; medium, low and high variants



Source: Czech Statistical Office, 2018a; Eurostat, 2019; authors' calculations.

Figure 8 Total fertility rate in the Czech Republic, observed (1980–2017) and projected (2018–2050) according to the low, medium, and high variants



Source: Czech Statistical Office, 2018a and 2018b; authors' calculations.

RESULTS – FERTILITY LEVELS IN 2018–2050

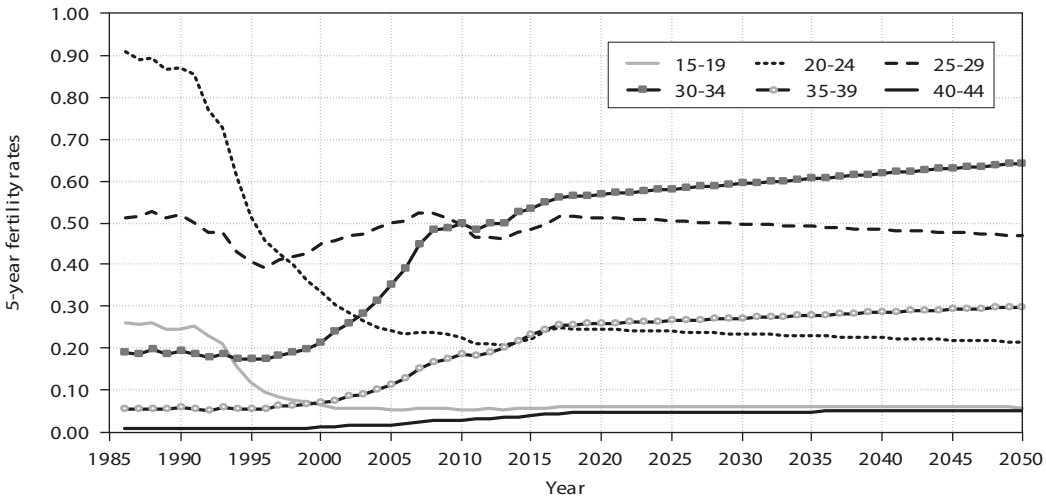
The total fertility level has already been commented on in a previous section. This section discusses age and birth-order components of fertility change according to the medium variant of the projection. The most significant decline was manifested in the 20–24 age group (Figure 9), and the decline will continue, similarly to evenyounger age groups. The fertility level in the 25–29 age group has already been stagnating for several years, and the projection assumes a slow decline. The centre of fertility will move to the 30–34 age group. Also, the level of fertility will increase at age 35–39. The number of mothers aged 40+ will increase, but they will continue to account for a marginal share of total fertility.

The resulting mean age of mothers (Figure 10) should slowly increase to 30.6 years according to the medium variant. In the high variant, which accentuates the postponement of fertility, the MAB should increase to 30.9 years, which corresponds to the current level in Germany. The low variant keeps the mean age constant at the level of 30.0. The mean age at first birth should increase in the medium variant from 28.2 to 28.9 and a similar increase is assumed among higher birth orders.

RESULTS – COHORT FERTILITY

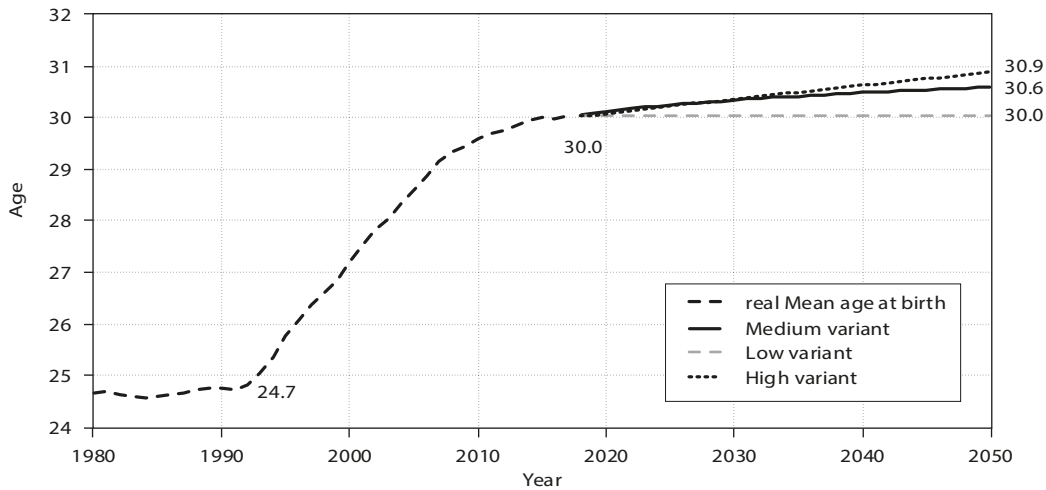
For the internal coherence of the model it is important that the estimated fertility indicators are plausible

Figure 9 Fertility rates for 5-year age groups in the Czech Republic, observed (1986–2017) and projected (medium variant, 2018–2050)



Source: Czech Statistical Office, 2018a and 2018b; authors' calculations.

Figure 10 Mean age of mothers in the Czech Republic, observed (1980–2017) and projected (2018–2050), according to the low, medium, and high variants



Source: Czech Statistical Office 2018a and 2018b; authors' calculations.

and meaningful also from a cohort perspective. Therefore, the period fertility rates were transformed to cohort fertility rates and summed according to the mother's year of birth (cohort). The transformation from Lexis squares (age in completed years x) into Lexis vertical parallelograms (the age reached during year X) was estimated by averaging the rates in neighbouring ages:

$$f_{X,i,t} = \left(f_{x-1,i,t} + f_{x,i,t}\right)/2$$

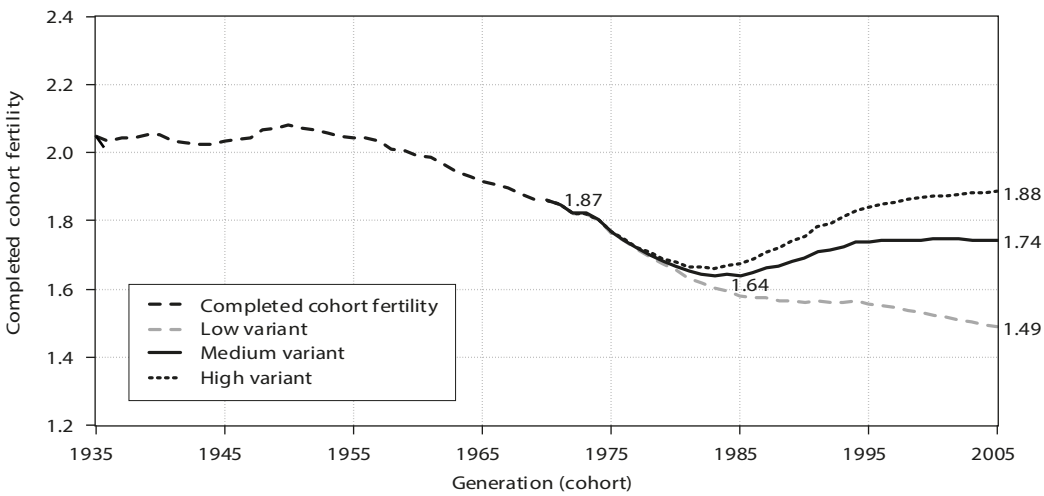
The resulting cohort completed fertility for the advanced generations (computed up to the 2005 cohort) converges to the level of the period fertility rate. More interesting is the analysis of recent cohorts that live in the age of maximum fertility now or have just reached the end of that period (Figure 11). The 1974 generation, which in 2018 reached the age of 44, have completed their fertility at the level of an average of 1.8 children per woman. The lowest number of children will be recorded among women born in 1982–1985, who will have on average 1.64 children. In the cohorts that follow, fertility is likely to start increasing again and to gradually converge to 1.74. At the same time, the mean age of mothers will increase to 30.9. If fertility follows the low variant, the completed cohort fertility will decline to below 1.5. If it follows the high variant, it will reach almost 1.9 children per woman.

It is also important to analyse the parity distribution of women, in other words, how many women will remain childless, with one child, with two children, and with three or more children. This distribution, according to the medium variant, is displayed in Figure 12. The share of childless women will increase to 18 percent among women born in 1983–1985. In the following cohorts the share will decrease again to 11 percent. At the same time, the proportion of women with just one child will increase to about one-quarter. The two-child model that was very popular in the past will weaken, and the share of women with two children will decrease from more than half to 45–47 percent. The share of women with more children will stabilise at around 16 percent.

A COMPARISON WITH PREVIOUS PROJECTIONS OF THE CZSO

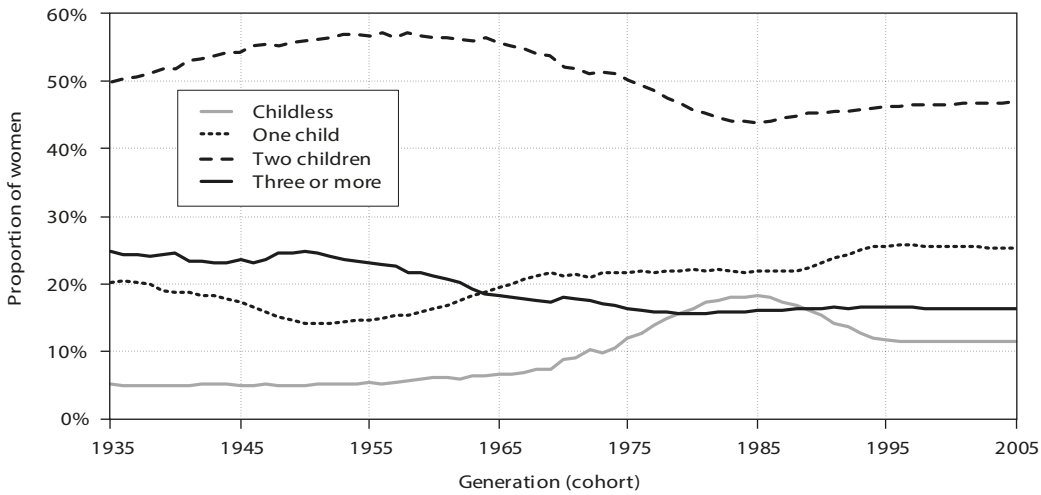
The Czech Statistical Office publishes population projections, depending on the needs of society, in roughly 5-year intervals. The last five projections were published in 1999, 2003, 2009, 2013, and 2018. In the 1990s the projections were issued every two years. When preparing a new projection, it is very important to get feedback from past projections and to compare their estimations to the real values. Therefore, this section analyses past projections from 2003, 2009, and 2013.

Figure 11 Completed cohort fertility in the Czech Republic, 1935–2005



Source: Czech Statistical Office 2018a and 2018b; authors' calculations.

Figure 12 Distribution of women by parity in the Czech Republic, medium variant, 1935–2005 cohorts

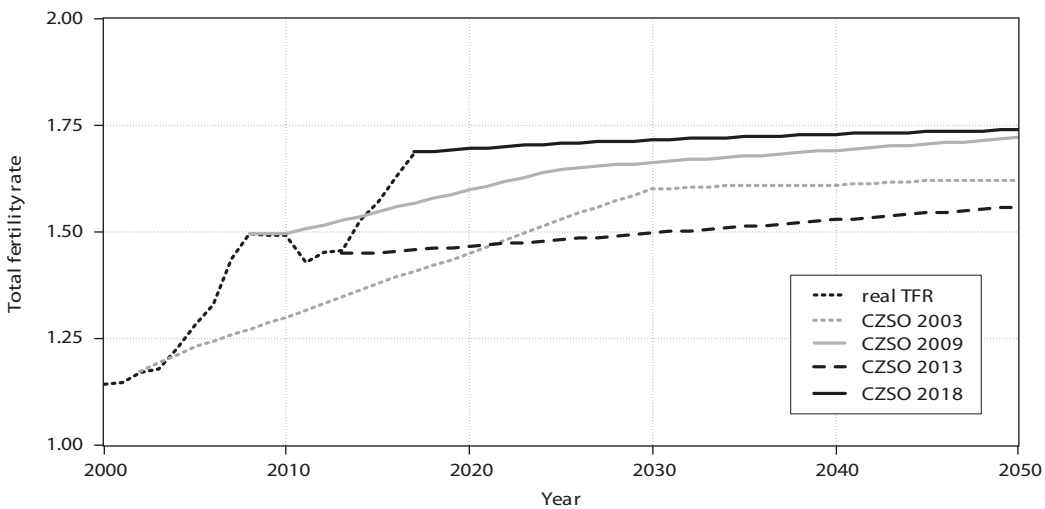


Source: Czech Statistical Office 2018a and 2018b; authors' calculations.

Figure 13 compares the projected medium variants of the TFR. The estimates of future fertility obviously follow actual fertility developments in the recent past. In the 2003 projection, when the TFR started to increase from the low it had reached, the projection optimistically predicted that the TFR would increase, but this prediction was even surpassed by the increases that occurred in reality. In the 2009 projection the predicted increase was already less steep, and in the 2013 projection, at the time of the fertility recession, the projected development was rather pessimistic.

After a couple of years it has already become clear that some predictions differ from reality. To capture

Figure 13 A comparison of CZSO projections of the total fertility rate for 2003, 2009, 2013, and 2018 (medium variants)

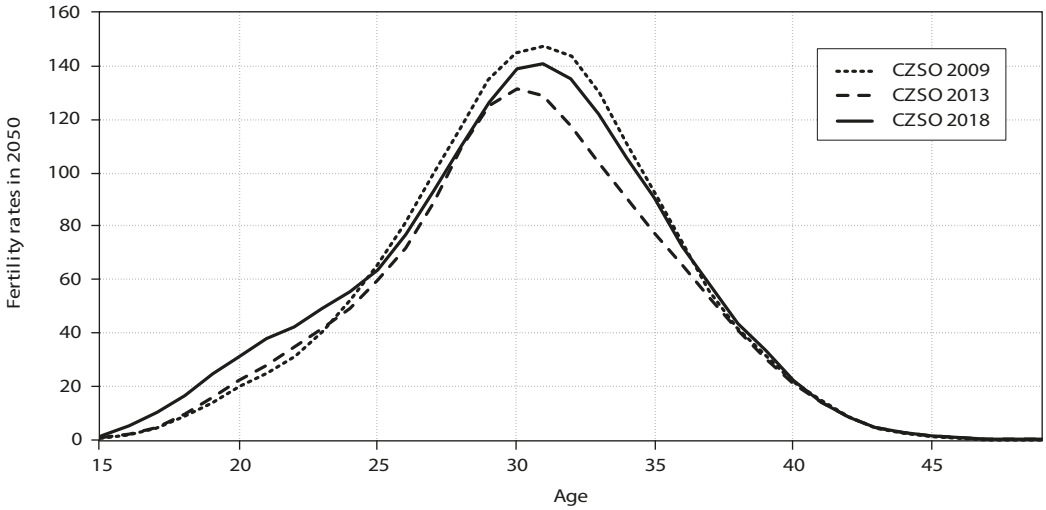


Source: Czech Statistical Office 2003, 2009, 2013, 2018a and 2018b; authors' calculations.

the complex nature of future developments, the projection uses the low and high variants. While in the 2009 projection, the variants for the year 2050 estimated the low and high fertility levels as 1.55 and 1.85, respectively, the 2013 projection used narrow variants with the 2050 target levels at a low and high of 1.45 and 1.61. The higher variant estimate for 2050 had then already been outperformed by 2016. In order to avoid such a mistake, the actual projection uses broader variant limits of 1.4 and 1.9.

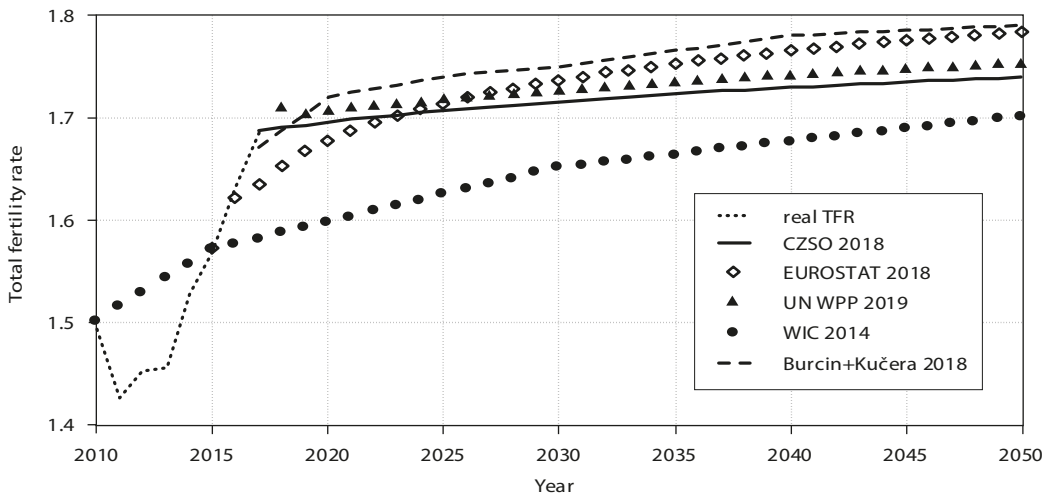
It is also interesting to look at the way in which the TFR estimates increased. In the 2003 projection, a fast increase to 2030 is followed by a slowdown in 2030–2050. Similar two-stage trends in the future

Figure 14 A comparison of the projected age-specific fertility rates in the Czech Republic for 2050 in the various projections of the CZSO (medium variants)



Source: Czech Statistical Office 2009, 2013, 2018b; authors' calculations.

Figure 15 A comparison of alternative projections of the total fertility rate for the Czech Republic, 2010–2050



Source: Burcin and Kučera, 2018; Czech Statistical Office 2018a and 2018b; Eurostat, 2018; United Nations, 2019; WIC, 2014; authors' calculations.

were projected in the 2009 projection (with 2025 as the break point). The actual projection and the 2013 projection assume just one stage – in the 2013 projection the increase is linear and the actual one follows the logarithmic trend.

With regard to the estimated shape of the age-specific fertility rates for 2050 it can be concluded that the last three projections follow the same principle, with the curve shifting to the right towards older ages and reaching a maximum at around 30–31 years. What is specific about the actual projection is that higher level of fertility remains also among the very young ages, capturing the ongoing pluralisation of lifestyles in Czech society. The mean age of mothers for 2050 is similar among all three projections: 31.0 in the 2009 projection; 30.8 in the 2013 projection; and 30.6 in actual projection.

Comparing recent alternative projections for the Czech Republic, all of them estimate a similar level of TFR at around 1.7–1.8 in 2050 (Figure 15).

CONCLUSION

The estimation of the future development of Czech fertility is relatively conservative. It excludes swift changes and concentrates on a continuation of the recent trend in fertility postponement accompanied by the increase in the fertility level. At the same time the projection does not assume any departure from deep-rooted family patterns and models, especially the two-child family, and predicts a relatively low level of childlessness. The projection variants are wide enough to capture unpredictable shifts in the future.

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