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Terezie Štyglerová – Kryštof Zeman – Markéta Pechholdová – Michaela Němečková – Roman Kurkin

Section of Articles based on the Population Projection of the Czech Republic of Czech Statistical Office 2018–2100

CZECH STATISTICAL OFFICE

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AN INTRODUCTION TO THE POPULATION PROJECTION OF THE CZECH REPUBLIC OF THE CZECH STATISTICAL OFFICE 2018–2100

Terezie Štyglerová[1)]

In November 2018, the Czech Statistical Office (CZSO) issued a new population projection for the Czech Republic. The CZSO currently processes and publishes demographic projections at approximately 5 year-intervals, and the previous one was released in July 2013. Since the latest projection the CZSO population forecast has been assigned an official role in the pension system.

THE LEGISLATIVE BACKGROUND

Working out projections of demographic development is assigned to the Czech Statistical Office by the Act on the State Statistical Service. However, further details about periodicity, regional level, time horizon, or the demographic characteristics according to which the projection should be made are not set out in this legislation. No obligation to use the data from the CZSO population projections for some policies has been established in legislation (contrary to the number of inhabitants, which has been used in several cases in public administration). Since January 2018, an amendment of the Act on the Organisation and Execution of the Social Security System has come into force, where an obligation for the CZSO concerning the processing of population projections has been stated. In connection with the change in the retirement age threshold (in the Act on the Pension System), the CZSO must work out a Report on the future development of mortality, fertility, and migration ('Report') in the calendar years ending in the figure 3 or 8 (up to 31 December). The Report must also contain the age at which persons of given birth cohorts still have a quarter of their life to live, and the proportion of the estimated life expectancy left to live upon reaching the retirement age threshold according to the Act on the Pension System. These indicators must be given for the birth cohorts reaching the age of 25 to 54 in the calendar year following the year of the Report's release. The average life expectancy for men and women calculated as a simple arithmetic mean has to be considered. The Report must also include information about the expected development of fertility, mortality, and migration rates for the period of at least the next 50 years. This demographic Report is meant to be used by the Ministry of Labour and Social Affairs to prepare the Report on the state of the Czech pension system and its expected development with regard to the demographic situation of the Czech Republic and the country's expected population and economic development on a regular basis at 5-year intervals in the years ending in 4 and 9 (up to 30 June).

One of the impulses to change previously valid legislation related to retirement age threshold was

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the Council's recommendation on the Czech Republic's national reform programme in 2014. There was a recommendation to ensure the long-term sustainability of the public pension scheme, in particular by accelerating the increase in the statutory retirement age threshold and by linking it more clearly to the changes in life expectancy. The second important incentive was the system of automatically increasing the retirement age threshold without a limit that existed at that time. Dealing with and solving these two main issues was the task for the Expert Committee on Pension Reform established by the then government in 2014. It had to propose a mechanism for the regular assessment of the retirement age threshold. The approved amendment of the relevant Act was based on its recommendation; however, it was not fully implemented for several reasons.

GENERAL APPROACH

The new legal obligation has had an impact on the process of preparing population projections since the CZSO has (logically) decided to join the 'standard' projections of population size and demographic structures with the information requested by the relevant Act. Thus, now a minimal periodicity, the exact years of the projection's release, or the time horizon of the projections are predetermined. In addition, fulfilling all the data requirements must be taken into account. This mainly concerns the production of mortality data in a cohort perspective for the purpose of the Report on the future development of mortality, fertility, and migration. Along with the responsibility that the Czech Statistical Office has been assigned with, the CZSO has considered and partly revised the general approach to calculating population projections, particularly with respect to the methodology for parameters estimation. It should be noted, however, that the procedures and techniques used so far worked quite well. The team of authors working on the new population projections was extended to include external experts – namely, Tomáš Fiala and Markéta Pechholdová from the University of Economics in Prague, the former head of the Demographic Statistics unit at the CZSO Miroslav Šimek, and Kryštof Zeman from the Vienna Institute of Demography.

The assumptions (and the projection results) have been kept as deterministic, with three basic scenarios – medium, low, and high. The deterministic approach seems to be demanded more by users in the Czech Republic than the stochastic approach. The medium scenario represented, from the point of the view of the authors, the most plausible expected future development of all the components of population change, and in scientific terminology it constituted a population forecast. The low and high scenarios signified the boundaries of possible development. In the low scenario, the target levels of all the main indicators – total fertility rate, life expectancy at birth, and net migration – were the lowest of all three scenarios, and for the high scenario, it was the other way around. Thus, the extreme scenarios could also be regarded as expressing the uncertainty of the medium scenario. In addition to the three basic scenarios, the medium scenario without considering migration was calculated to show the sensitivity of international migration to the population size and the sex and age structure of the Czech Republic.

Like other forecasts/projections, the new population projection of the Czech Statistical Office also estimated the future demographic development as fluent, since the effect of sudden changes in the external circumstances of any actor, either small or large, on the development of mortality, fertility, and migration in a short- or long-term perspective could not be predicted. Although there are differences in the reproductive behaviour of the populations of certain social/economic/migratory characteristics, all subpopulations were expected to have uniform reproductive behaviour.

DEFAULT METHODOLOGICAL INFORMATION

The 2018 CZSO population projection was processed using the cohort-component method by units of age and for every year of the projection period, which was set as ending by the year 2100 (the same year as in the previous CZSO projection). The projection threshold was the population structure by sex and age as at 01/01/2018, which was obtained from the results of the last population census (2011) and the annual population balances, and the last projected demographic structure was that on 01/01/2101. The first projected annual indicators on demographic development were the ones for 2018. The population of the Czech Republic consists of all persons with permanent residence in the country irrespective of their citizenship, third-country foreign nationals staying in the country on a visa for a period of 90 days or more and those with a long-term residence permit, EU citizens with a temporary stay permit, and persons who have been granted asylum status. No change in the definition of the population base was assumed in the projection.

OUTPUTS

Publication of the results of the latest CZSO population projection was divided into two outputs. The first output, released in November 2018, consisted of the results of a pure demographic projection (all three scenarios including the medium scenario based only on natural population change) supplemented with written commentary on the methodology used and on the basic results. The whole output is available on the CZSO website under the section dedicated to population statistics.

A month later, in December 2018, the Report on the future development of mortality, fertility, and migration according to § 10b of the Act on the Organisation and Execution of the Social Security System was released in a special section of the CZSO website (Information according to special acts). The assumptions and results corresponded to the medium scenario of the projection, and the content of the Report focused especially on the information required under the terms of the Act and only the most basic results were included.

CONCLUDING REMARKS

It is obvious that a population projection for 80-year period is burdened with a considerable degree of uncertainty, which rises with time. Only real development will show which scenario is ultimately the one closest to reality. However, it can be assumed with great certainty that future development will be within the range given by the low and high scenarios. This range is relatively narrow in the coming years, as the women from the generations that will give birth to children are already living now, and unless some unpredictable situation with greater impact occurs, it is not expected that the mortality rate will change significantly. However, the estimation of international migration is the least reliable estimation, even in a short-term perspective, because it depends so strongly on external conditions and the inertia of this process is relatively short. In the distant future, when new generations that are not yet living now will be the ones determining population development, the estimates are more complicated and more uncertain. This is particularly true for fertility and migration levels. In the case of mortality, it is generally expected that it will decrease further, but of course, it is not possible to predict whether the development of mortality will accelerate or reverse its course in response to major progress in medicine or, conversely, an epidemic of some known or even unknown diseases. Due to the uncertainty of the population projection's assumptions, it is always necessary to interpret the results conditionally in relation to the input assumptions.

The initial age structure of the population of the Czech Republic, which formed in the past, is very irregular, and it is clear that these irregularities are going to shift to a later age. Thus, it is very likely that the basic future tendency of the future development of the age structure that is outlined by the projection – population ageing – will indeed occur. Since the projected development will not be in line with the observed development even in a short-term horizon, the Czech Statistical Office expects the next revision of population projections in five years, again in connection with the duty to prepare a new Report on the future development of mortality, fertility, and migration.

The following articles deal with the methodology used to forecast the individual components of demographic development. The methods and principles used to formulate the fertility assumptions in the new CZSO Population Projection and the related fertility indicators are described by the Kryštof Zeman (a researcher at the Vienna Institute for Demography), while the mortality assumptions are presented by Markéta Pechholdová (University of Economics in Prague) and the procedure for making total and sex–age specific assumptions in the field of international migration is explained in the article prepared by Michaela Němečková (CZSO). In addition to this methodological section, the main results of the new demographic projection are presented by Roman Kurkin (CZSO).

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

Kryštof Zeman[1)]

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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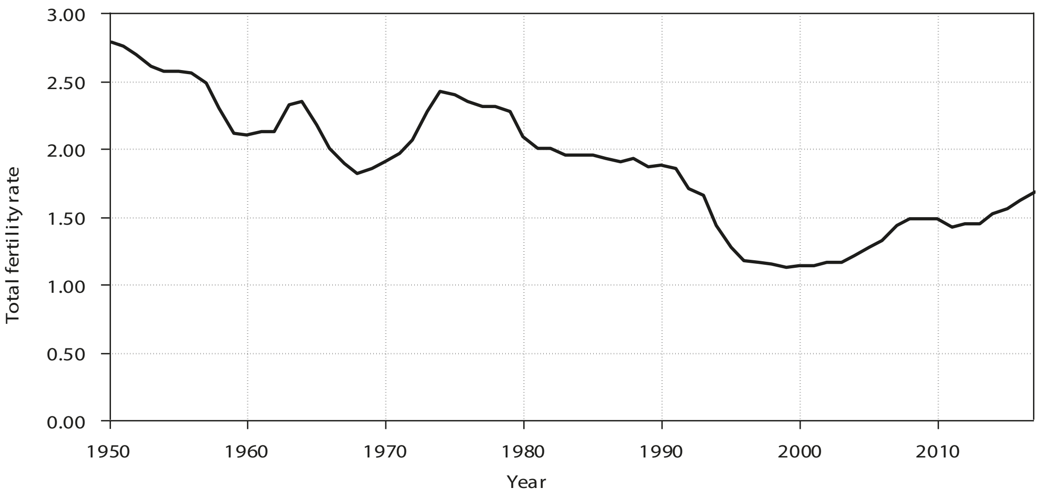
PAST FERTILITY DEVELOPMENTS

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.

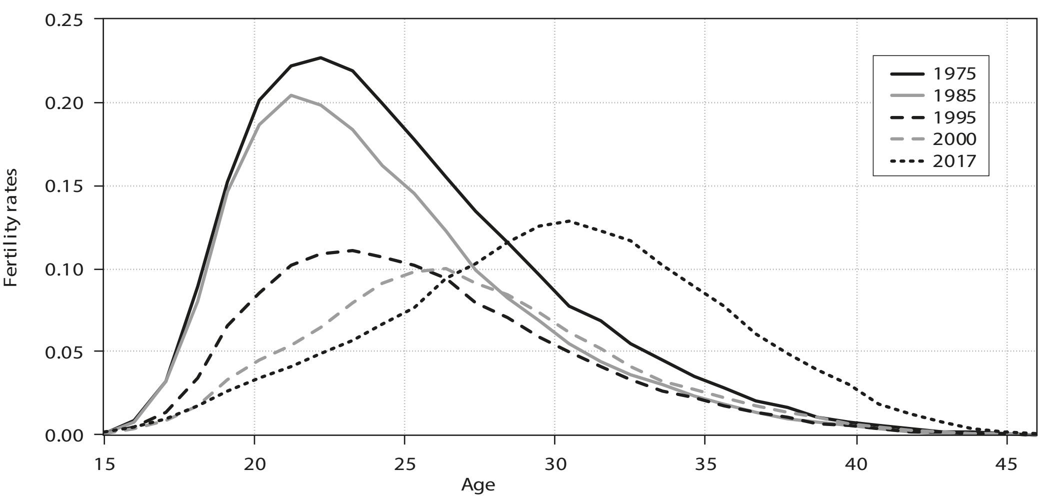
However, these changes were not homogeneous in terms of the mother's age and birth order. Figure 2

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



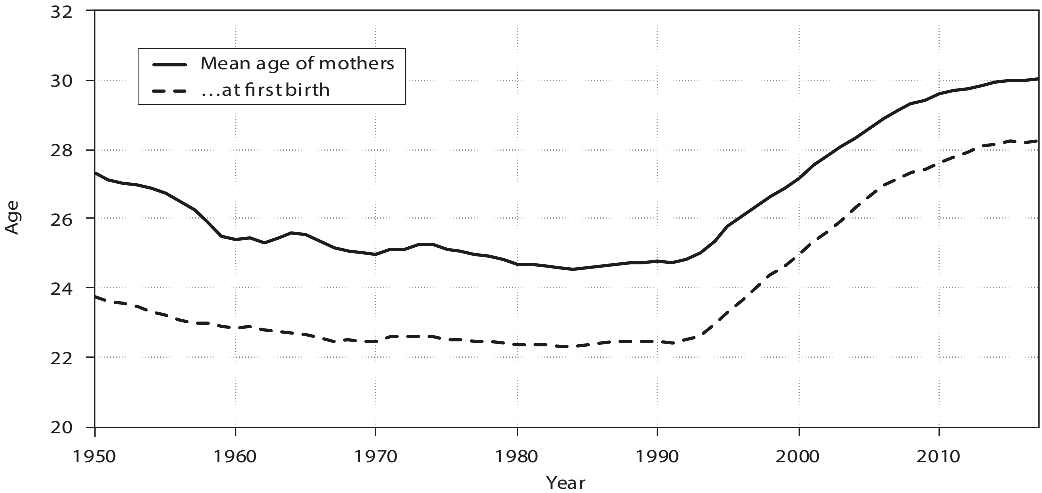
Source: Czech Statistical Office, 2018a.

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



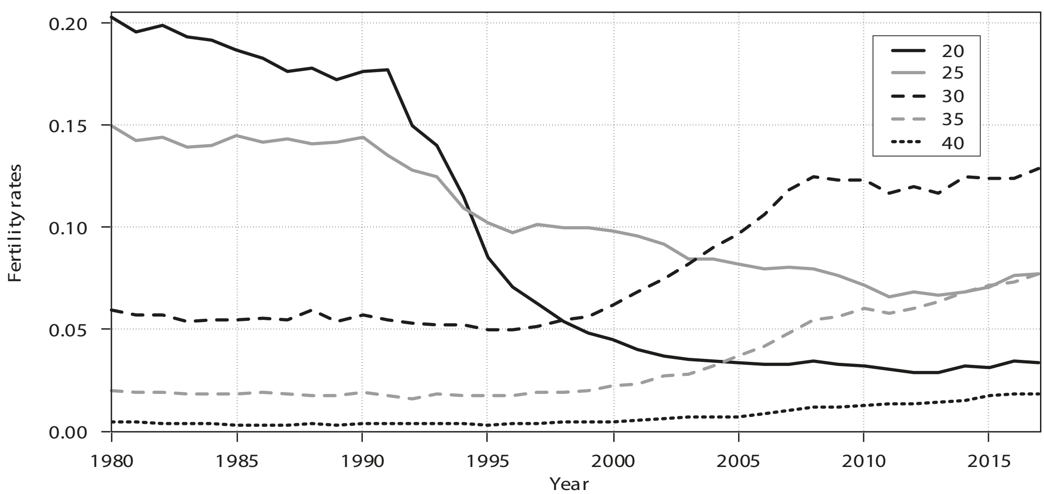
Source: Czech Statistical Office, 2018a.

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

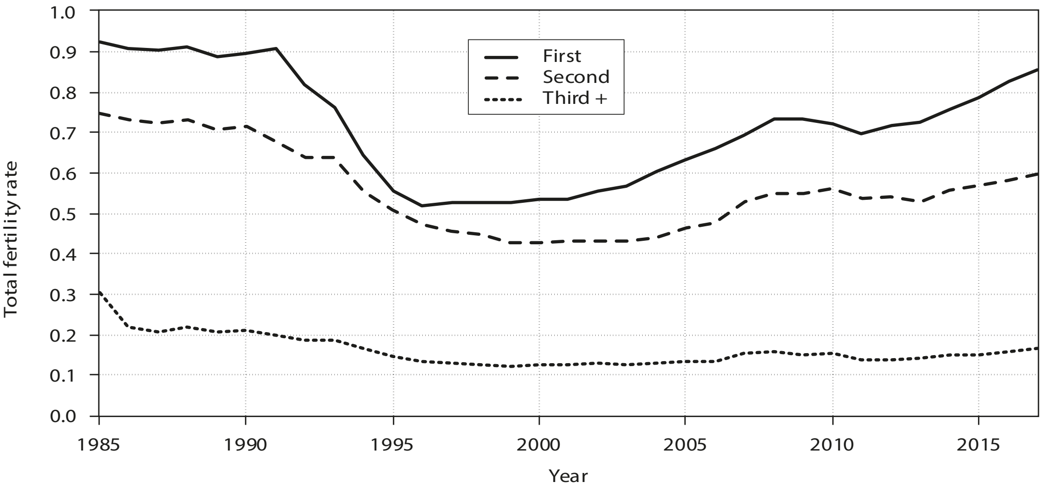


Source: Czech Statistical Office, 2018a.

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.

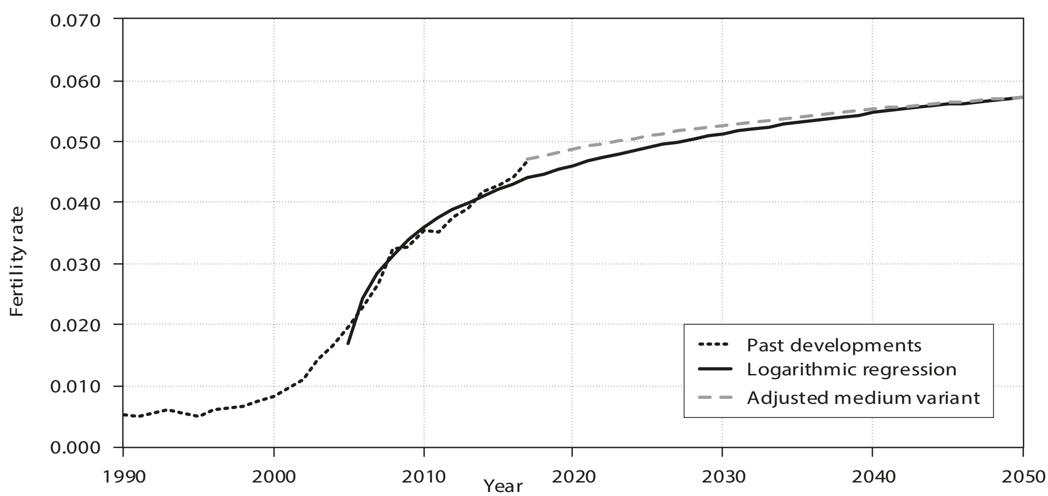
VARIANTS

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.

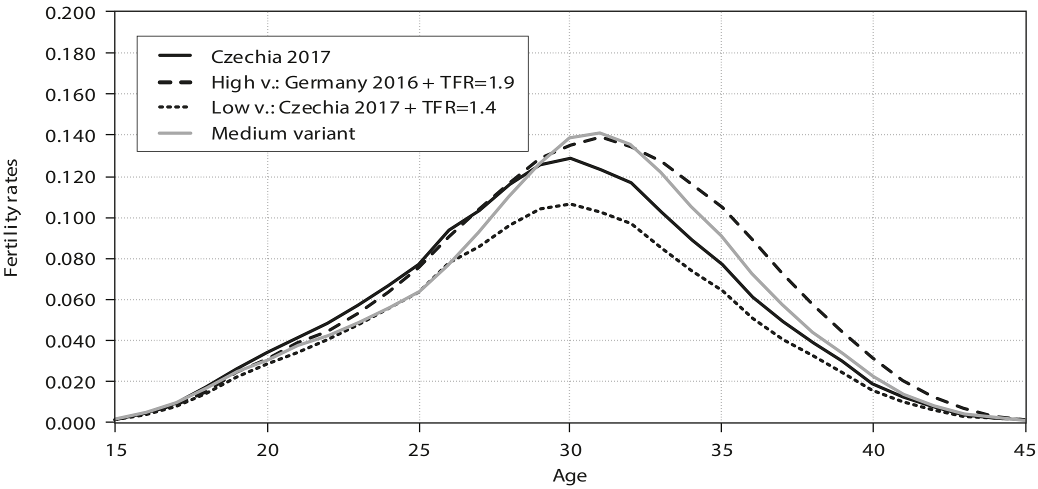
The low and high variants of the TFR begin to deviate from the medium variant deliberately already in 2018, which captures the random component of fertility fluctuations. Between 2017 and 2018 the low variant TFR drops by 5 percent from 1.69 to 1.60, while the high variant TFR increases also by 5 percent 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



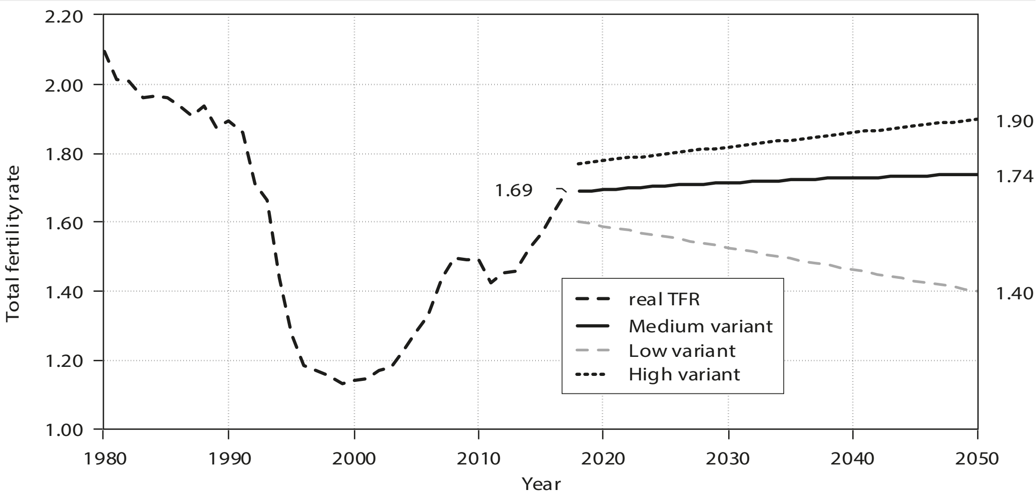
Source: Czech Statistical Office, 2018a; authors' calculations.

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 Repubic, 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

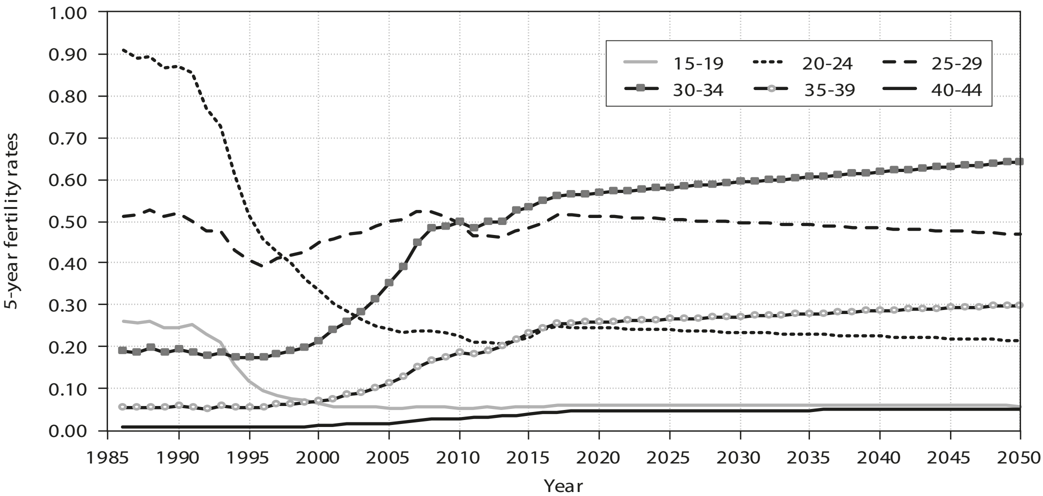
The total fertility level has already been commented on in a previous section. This section discusses age and birth-order components of fertility change according to the medium variant of the projection. The most significant decline was manifested in the 20–24 age group (Figure 9), and the decline will 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

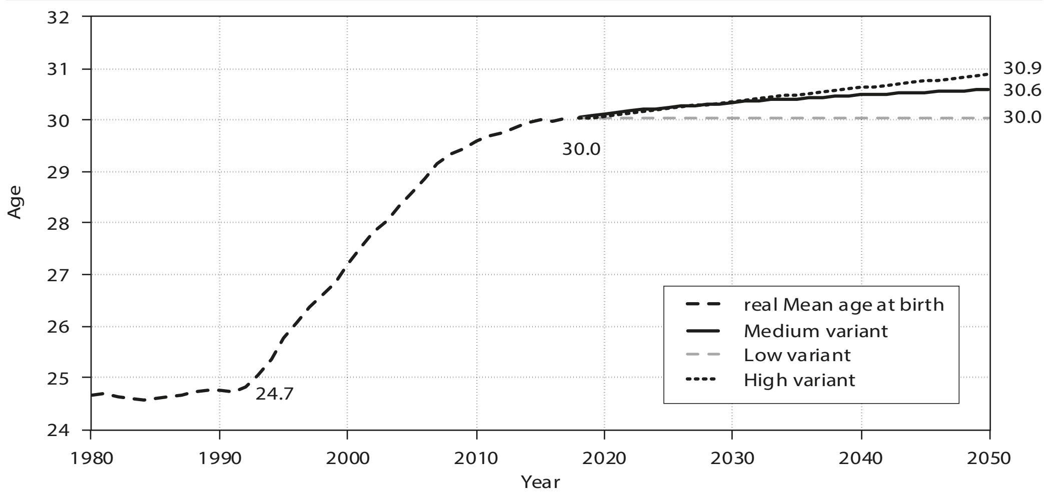
For the internal coherence of the model it is important that the estimated fertility indicators are plausible

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:

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

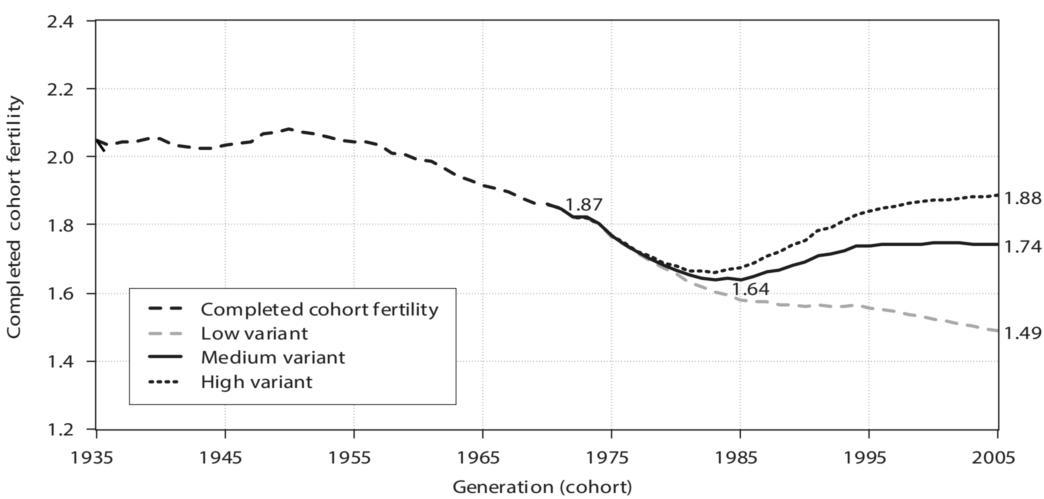
The resulting cohort completed fertility for the advanced generations (computed up to the 2005 cohort) converges to the level of the period fertility rate. More interesting is the analysis of recent cohorts that live in the age of maximum fertility now or have just reached the end of that period (Figure 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

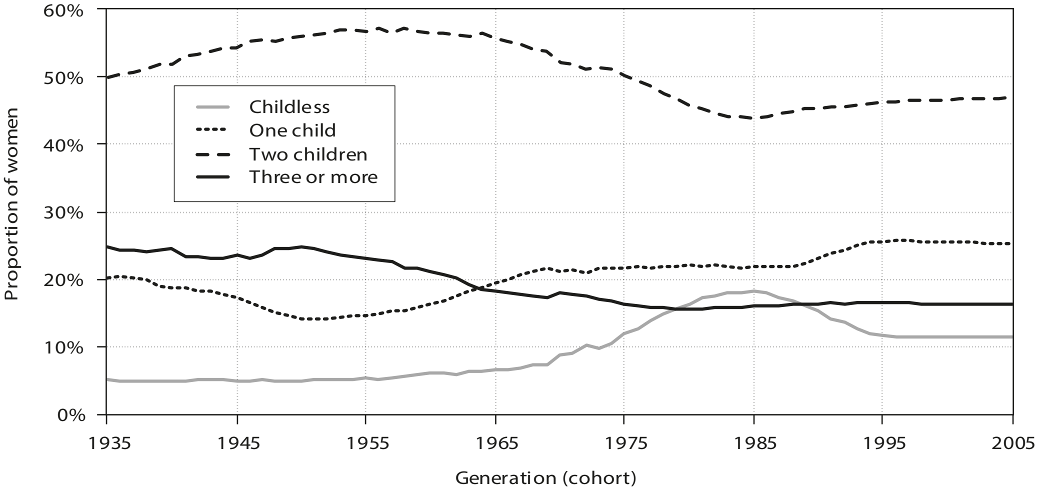
The Czech Statistical Office publishes population projections, depending on the needs of society, in roughly 5-year intervals. The last five projections were published in 1999, 2003, 2009, 2013, and 2018. In the 1990s the projections were issued every two years. When preparing a new projection, it is 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

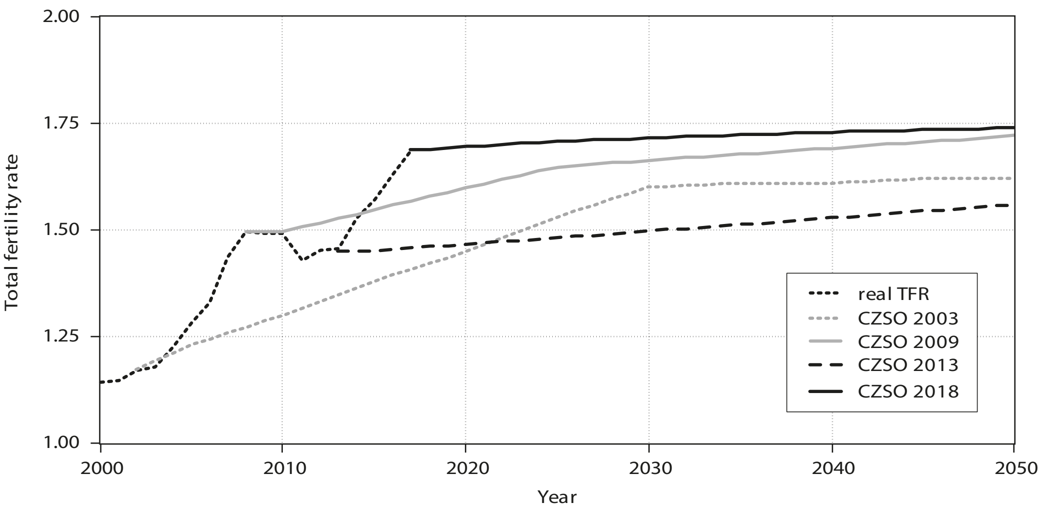


Source: Czech Statistical Office 2018a and 2018b; authors' calculations.

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)

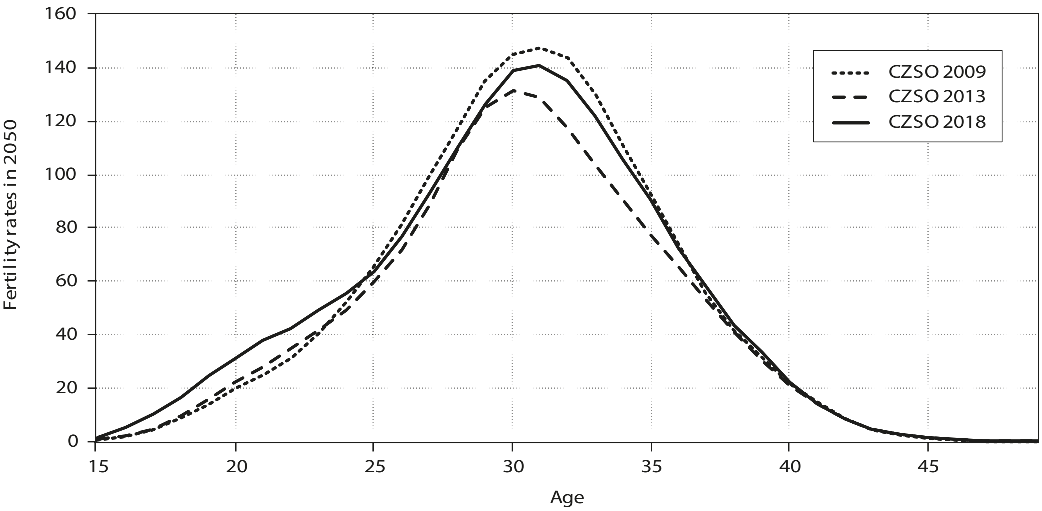


Source: Czech Statistical Office 2003, 2009, 2013, 2018a and 2018b; authors' calculations.

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.

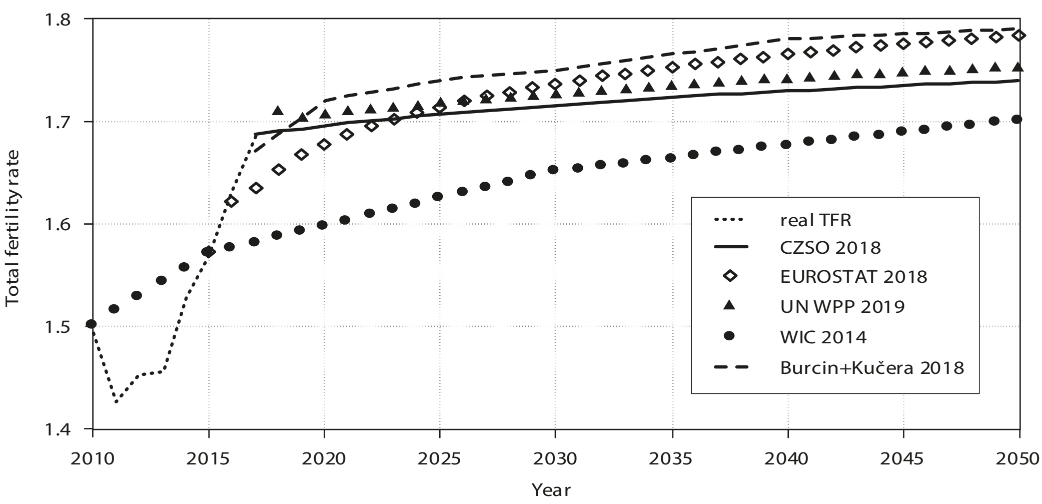
It is also interesting to look at the way in which the TFR estimates increased. In the 2003 projection, a fast increase to 2030 is followed by a slowdown in 2030–2050. Similar two-stage trends in the future

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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MORTALITY ASSUMPTIONS AND FORECASTING METHODOLOGY: POPULATION PROJECTION OF THE CZECH REPUBLIC FROM THE CZECH STATISTICAL OFFICE, 2018–2100

Markéta Pechholdová[1)]

Abstract
The present study describes the methodology of the new mortality forecast for Czechia. The author presents a brief review of existing forecasting approaches. Mortality trends in Czechia are then thoroughly assessed in comparison to other European countries in order to extract a realistic pattern of the recent mortality decline. Mortality dynamics are analysed with the Lee-Carter functional model and from the perspective of the rates of mortality decline. The new model is based on deterministic assumptions about the age-specific patterns of future mortality change. Three scenarios are presented, reflecting three possible future mortality settings. The projection results appear plausible both in terms of internal coherence (such as the gender gaps) and compared to other existing mortality forecasts for Czechia.

Keywords: mortality, forecast, projection, ageing, life expectancy.

Demografie, 2019, **61: 261–280**

INTRODUCTION

The modelling and forecasting of future mortality trends are a common centre of interest among demographers, actuaries, and population economists. Mortality forecasts, an inherent part of population forecasting, are essential for making estimates of the expected rates of population ageing and future longevity risk (*De Waegenaere et al.,* 2010).

Increases in longevity have been the main drivers of the mortality trends observed in developed countries since the 1970s, starting with the process of the cardiovascular revolution, which established the new trajectory of a decline in old-age mortality and delayed the age of onset of fatal chronic circulatory conditions. Along with parallel improvements in lifestyles and increasing awareness in the domain of individual responsibility towards health status, improvements in other conditions have also been occurring, particularly among elderly populations, resulting in an increasing concentration of life-expectancy gains among elderly age groups.

The countries of Central and Eastern Europe have long stood outside of this trend. Unlike in western populations, life expectancy in the East stagnated or even deteriorated between the 1960s and the 1980s (*Meslé,* 2004). In the 1990s, however, a new stage

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of rapidly increasing life expectancy occurred, with Czechia being among the most notable examples thereof (*Rychtaříková*, 2004).

This uneven development, however positive, represents an issue when future mortality is to be predicted. In classical extrapolative approaches, mortality forecast arises from the observation of past trends. Should this trend be long and regular enough, future mortality can merely be estimated as a statistical extension of the observed trend, under the condition that the main features of the past trend are well captured by the model.

This study deals with the task of computing mortality forecast for the projection of the Czech Statistical Office. The results of this projection, which is updated every five years, are to be used in optimising the parameters of the future pension system. In order to serve this purpose, the mortality of all cohorts already born needs to be predicted, which requires extending the projection horizon to at least the year 2100. Thus the length of the predicted period by far exceeds the length of time during which the recent mortality improvements have been occurring and the task calls for a novel approach.

This paper will first discuss recent approaches to mortality forecasting along with their advantages and disadvantages. Then, based on analytical results, we will present the methodological rationale for the 2018 mortality forecast. In the next section, the model itself will be explained together with a description of how uncertainty was dealt with. Finally, main results of the mortality forecast will be presented.

AN OVERVIEW OF THE LITERATURE

Mortality forecasting has a long history and experience has shown that under stable conditions mortality trends tend to be quite predictable (*Booth*, 2006).

The empirical approaches used to forecast mortality can be roughly divided into those that start with a prediction of a synthetic indicator, such as life expectancy, followed by assumptions on age profiles (a top-down approach) and those that start with modelling and forecasting the stratified elements of a mortality curve, such as age patterns and cohort effects (a bottom-up approach). In the top-down approach, the target life expectancy is obtained by means of statistical extrapolation or by expert judgment. An age-specific pattern is then estimated to converge to the targeted aggregate levels. Such an approach has been used previously in the Czech Statistical Office's mortality forecasts.

The bottom-up types of approaches seek first to capture age-specific patterns, which are then used to compute future life tables. In the first step, the mortality age pattern is formalised into a representative model. The model can be based on experience from other countries, such as the so-called *model life tables* for different population types (*Coale and Demeny*, 1966). In *relational models*, a standard life table is modified based on observed point estimates of the death rates at given ages (*Brass* 1974). The Brass relational model is still widely used in mortality forecasting, especially in countries with a lower quality of mortality data. Another, alternative way to formalise and predict mortality age patterns is represented by the large family of *parametric models*, which impose a parsimonious mathematical relation between age and the force of mortality. These models include exponential (*Gompertz*, 1825; *Makeham*, 1860), logistic (*Thatcher et al.*, 1998) or polynomial relations, or their combinations (*Heligman and Pollard*, 1980). The main disadvantage of these models is that they cannot be fitted to a complete age scale, unless a large number of parameters are used. Since the 1990s *functional models* have been proposed, further developed, and widely applied (*Lee and Carter*, 1992; *Lee*, 2000; *Hyndman and Booth*, 2008). Functional models and their modifications are among the most widely used projection models in countries that have high-quality data. The most recent direction in mortality forecasting then employs Bayesian models, taking advantage of the possibility to estimate future mortality schedules along with their natural uncertainty (*Czado et al.*, 2005; *Girosi and King*, 2008, *Wiśniowski et al.*, 2015). The United Nations have used elements of Bayesian forecasting in the recent versions of the World Population Prospects series.

Other approaches have focused on patterns of mortality change rather than the mortality age pattern itself (*Haberman and Renshaw*, 2012). This group of models introduces a new variable, the mortality improvement rate, which, in a continuous setting, equals the first derivative of the force of mortality. According to *Hunt and Villegas* (2017), this approach is particularly appreciated among practitioners of mortality forecasting, where more attention is paid to the actual mortality change in specific age groups, typically seniors. The method of discrete mortality improvement rates (the annual percentage changes in death rates) was recently used in the ONS 2016 population forecast for the UK (*ONS,* 2017). The difficulty with estimating rates of improvement lies in their high yearly volatility and lack of empirically grounded assumptions about their past and future trends.

In addition to the age and period perspective, models are sometimes enhanced by adding a cohort component. Functional models with cohort components were proposed, as well as cohort-sensitive Bayesian models; cohort mortality improvement factors have been discussed, for example, in *Haberman and Renshaw* (2013). However, a study of the surface plots of the mortality improvement rates has shown that cohort effects had a negligible impact on mortality trends between 1950 and the present day in Czechia (*Rau et al*., 2018), where, like in other post-socialist countries, mortality change was almost entirely driven by period (and age) effects.

Age effects themselves were also rather irregular over time. In young age groups, mortality rates are currently approaching biological minimums, while the declines keep accelerating at higher ages. In mortality forecasting terminology, the coincidence of the deceleration of young-age mortality decline and the acceleration of old-age mortality decline is referred to as a 'rotation' and it is recommended that it be taken into account especially in long-term mortality projection models, as ignoring it may result in unrealistic mortality age patterns (*Li et al.,* 2013).

DATA

The core dataset used for the forecast consisted of life table death rates based on the new life table methodology introduced by the Czech Statistical Office in 2018. The new life table methodology uses non-parametric adaptive smoothing of death rates based on the *p*-spline method (*Eilers and Marx*, 1996) and applies logistic parametric model for the old-age mortality curve, with parameters computed using the maximum likelihood estimation procedure. The input life tables were available for 1-year age intervals (0–110+) for the period 1960–2017.

To compare the Czech mortality change with trends observed recently in other developed European countries, we retrieved population and mortality data from Human Mortality Database (www.mortality.org).

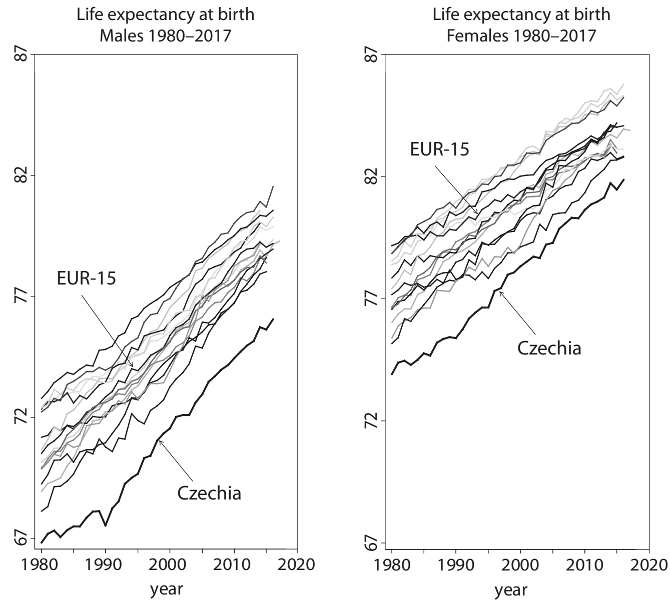
AN ANALYSIS OF RECENT MORTALITY TRENDS

For analytical purposes, a higher-level population was created based on the sums of population exposures and death counts in 15 developed West European countries. The countries were chosen to reflect diverse mortality experiences observed since 1980. The following countries were included: Austria, Belgium, Denmark, Finland, France, Great Britain, former West Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden and Switzerland. In the text below, this population is referred to as the EUR-15.

The continuous increase in life expectancy at birth is the main feature of the mortality change in recent decades. This change is shown in Figure 1, where Czechia is placed next to the EUR-15 countries. All countries shift upwards at a similar pace. Among males, a slight homogenisation of life expectancy levels is observed among the EUR-15 countries. Regarding females, several countries (namely Denmark, Netherlands, and the UK) have experienced a slower life expectancy increase than others, resulting in them lagging behind the vanguards. Among both sexes, the trend observed for Czechia was roughly parallel to that in the EUR-15, while in terms of levels of life expectancy Czechia still lags two decades behind the most progressive Western countries.

As noted earlier, recent mortality improvements are not evenly distributed across ages. It is well known that the main toll of the mortality decline is progressively shifting to more older ages. Less is known about the role of premature and young age mortality in the present pattern of decline. In order to assess the shape of the mortality decline in Czechia and compare it with the EUR-15 population, we decomposed the mortality change into the effect of average levels, age-specific change, and the period effect using the Lee-Carter mortality model.

Figure 1 Life expectancy at birth in EUR-15 countries and in Czechia by sex between 1980 and 2017



Source: Human Mortality Database, 2018.
Note: EUR-15 includes Austria, Belgium, Denmark, Finland, France, Great Britain, former West Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden and Switzerland. The countries are not labelled individually.

In the Lee-Carter model, the logarithm of age-specific mortality in the given year $ln(m_{x,t})$ is expressed as the following combination of vector parameters:

$$\ln\left(m_{x,t}\right) = \alpha_x + \beta_x \kappa_t + \varepsilon_{x,t},$$

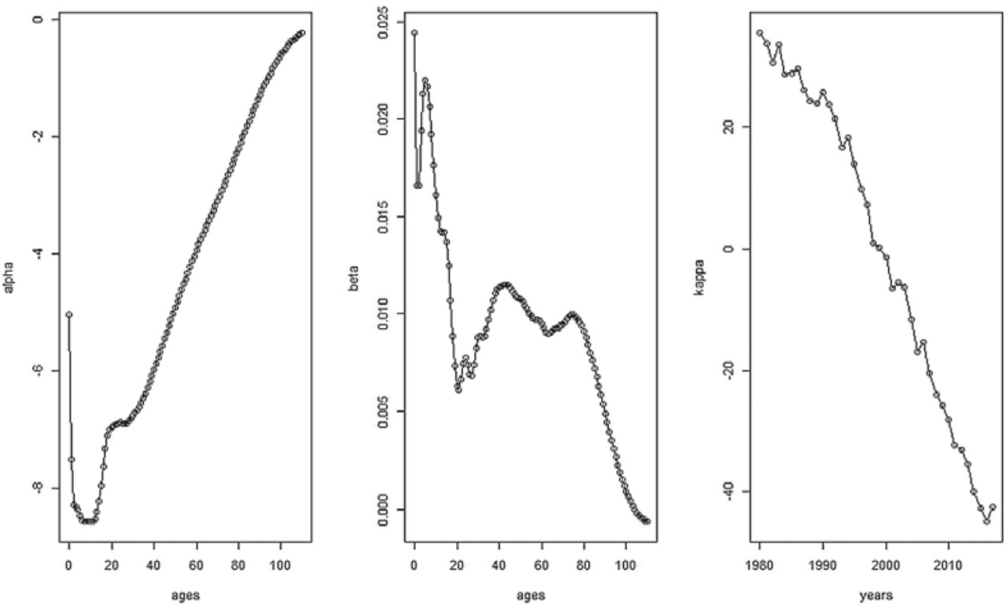
Where α represents a vector of the averaged death rate logarithms, β is the vector of the age-specific response to the mortality change, κ stands for the effect of the period, and ε adds an error term. The multiplicative terms β and κ are estimated by means of the singular value decomposition after the initial data matrix was subtracted with α. For estimation feasibility, the sum of β_x is forced to equal to 1 and the sum of κ_t is constrained to 0.

Figure 2 represents the results of the Lee-Carter model applied to Czech mortality data for the period 1980–2017. The left panel shows the average log-mortality pattern (α), the middle panel displays the age-specific mortality change (β), and the right panel visualises the parameter of time (κ). The time parameter is straightforward to interpret: the mostly unidirectional mortality decline occurred throughout the period of observation, with a slight acceleration in the 1990s. Regarding the age-specific pattern of this decline, the change was the most pronounced among infants and children and was observed least among the oldest-old (the improvements drop rapidly after age 80). Among males, important improvements took place in the 30–60 age group, pointing to the particular role played by the decline of male premature mortality in the recent mortality change in Czechia, especially in comparison with females.

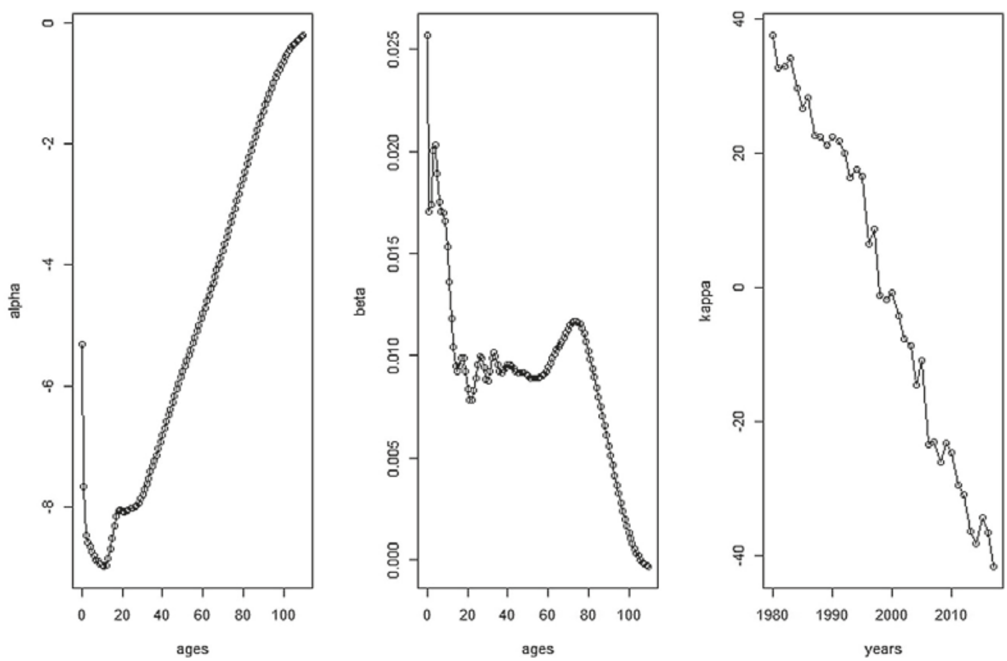
These results were then compared with the same model fitted to the aggregate EU-15 population for the 1980–2014 period (Figure 3). The tempo of the mortality decline, expressed as the kappa parameter, was similar as that in the case of Czechia. However, we do not see as much premature mortality improvement in the beta parameter among either of the sexes. We interpret this finding as a result of a compensational pattern of mortality decline observed in Czechia and we hypothesise that such a compensational pattern is temporary and will not be sustained in a long-term perspective. Instead, Czechia will more likely follow the European pattern of gradual mortality decline. However, transferring the European experience onto Czech data is not technically possible within the framework of the Lee-Carter model.

Figure 2 Lee-Carter mortality model components for Czechia by sex, 1980–2017

a. Males



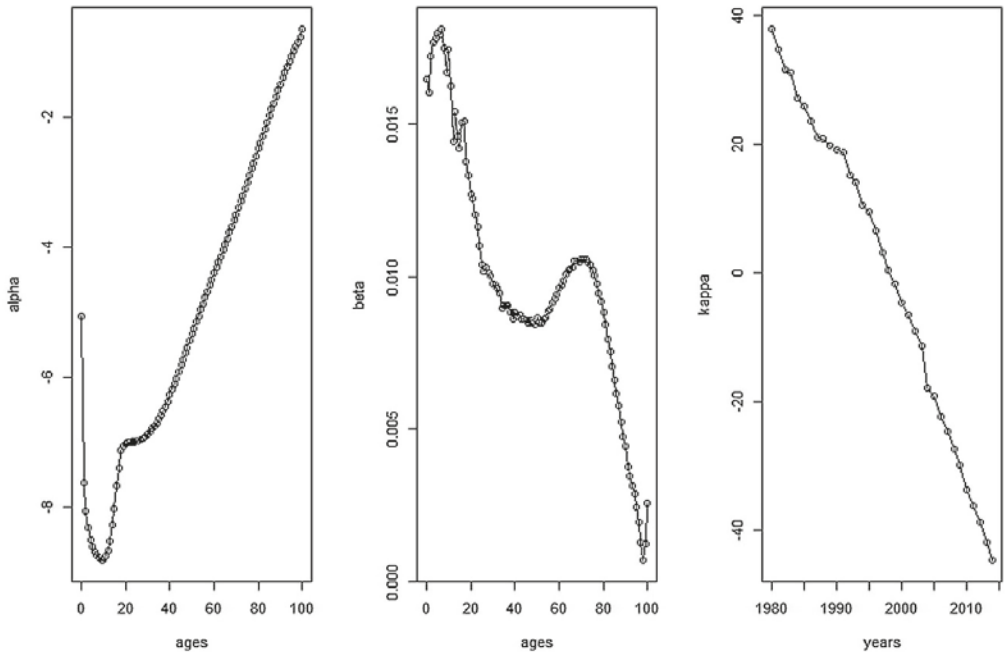
b. Females



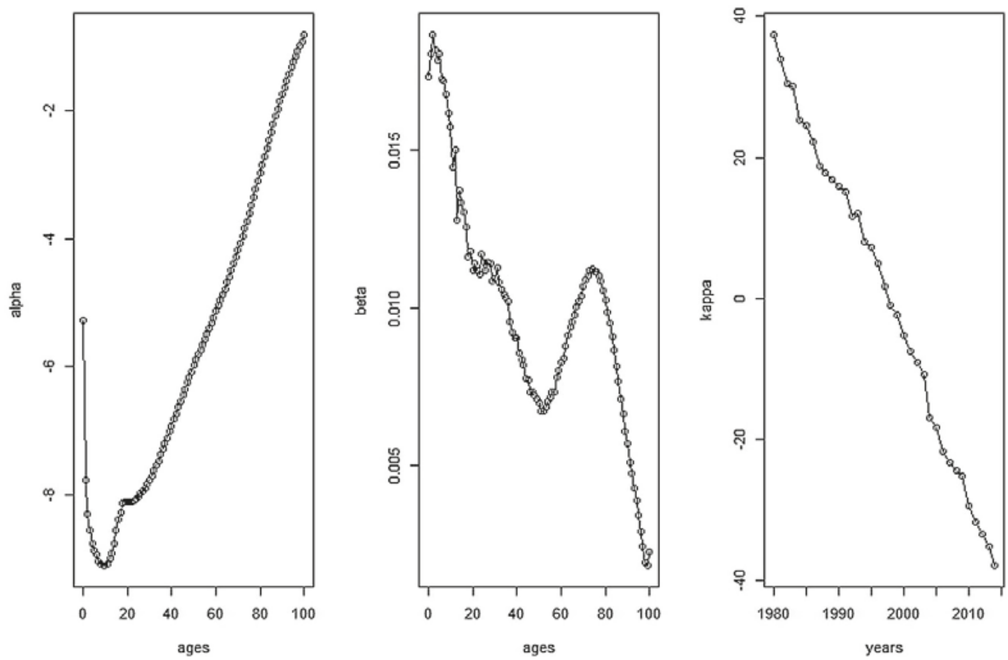
Source: Czech Statistical Office, 2018c.

Figure 3 Lee-Carter mortality model components for the EUR-15 population by sex, 1980–2014

a. Males



a. Females



Source: Human Mortality Database, 2018.

THE STOCHASTIC FORECAST OF LIFE EXPECTANCY

The fitted Lee-Carter model was then used to directly predict future Czech mortality rates using a random walk with drift as the estimation procedure for the kappa parameter. The primary and inherently subjective input in both the deterministic and the stochastic forecasting process is the choice of the base period, i.e. the period that is taken as the basis for model parameters estimation. In good forecasting practice, this period should be as long as possible, ideally at least as long as the predicted period. We performed an analysis of the sensitivity of the Lee-Carter model to the choice of base period in the particular demographic context of Czechia. We used base periods starting in 1960, 1970, 1980, and 1990. The results of this analysis expressed in terms of life expectancy at birth in 2100 (Table 1) point to the important impact of the chosen base period: male life expectancy derived from the Lee-Carter forecast based on 1960–2017 data differs by 6.5 years from the one derived from the base period 1990–2017. Even more apparent is the sensitivity of the model to the base period in the case of the sex difference in life expectancy at birth, which ranges from 4 years to less than 1 year in 2100. This result is not surprising given the above-mentioned irregularity of Czech mortality trends, characterised by substantial mortality turnaround in the late 1980s.

Although choosing the longest base period is justified in countries with a gradual mortality transition, in post-communist countries this period includes mortality experience based on conditions that are not likely to be reproduced in the future (such as the socialist health crisis followed by a rapid positive turnaround). For more recent but shorter time periods (such as 1980–2017), lack of robustness and volatility of the estimated parameters of the Lee-Carter model for Czechia (see Figure 2) significantly distorts the mortality age pattern if the prediction period extends over several decades. For these reasons, a purely stochastic approach was excluded as main forecasting methodology.

PROJECTION METHODOLOGY

The further search for an optimal mortality forecast method was driven by the wish to take into account the observations pointed out above and to allow for maximum flexibility in terms of future patterns of age-specific mortality change. These conditions are closely met by the projection model based on rates of mortality improvement. In this model, we first derived the age-specific rates of mortality change in the EUR-15 population, projected them for the whole period of prediction, and modified them in order to reflect three alternative mortality scenarios.

The rates of mortality improvement $r_{x,t}$ were defined in this setting as the annual prospective age-specific mortality-reduction coefficients:

$$r_{x,t} = \frac{m_{x,t}}{m_{x,t+1}},$$

Where $m_{x,t}$ and $m_{x,t+1}$ stand for two subsequent mortality rates at the given age x.

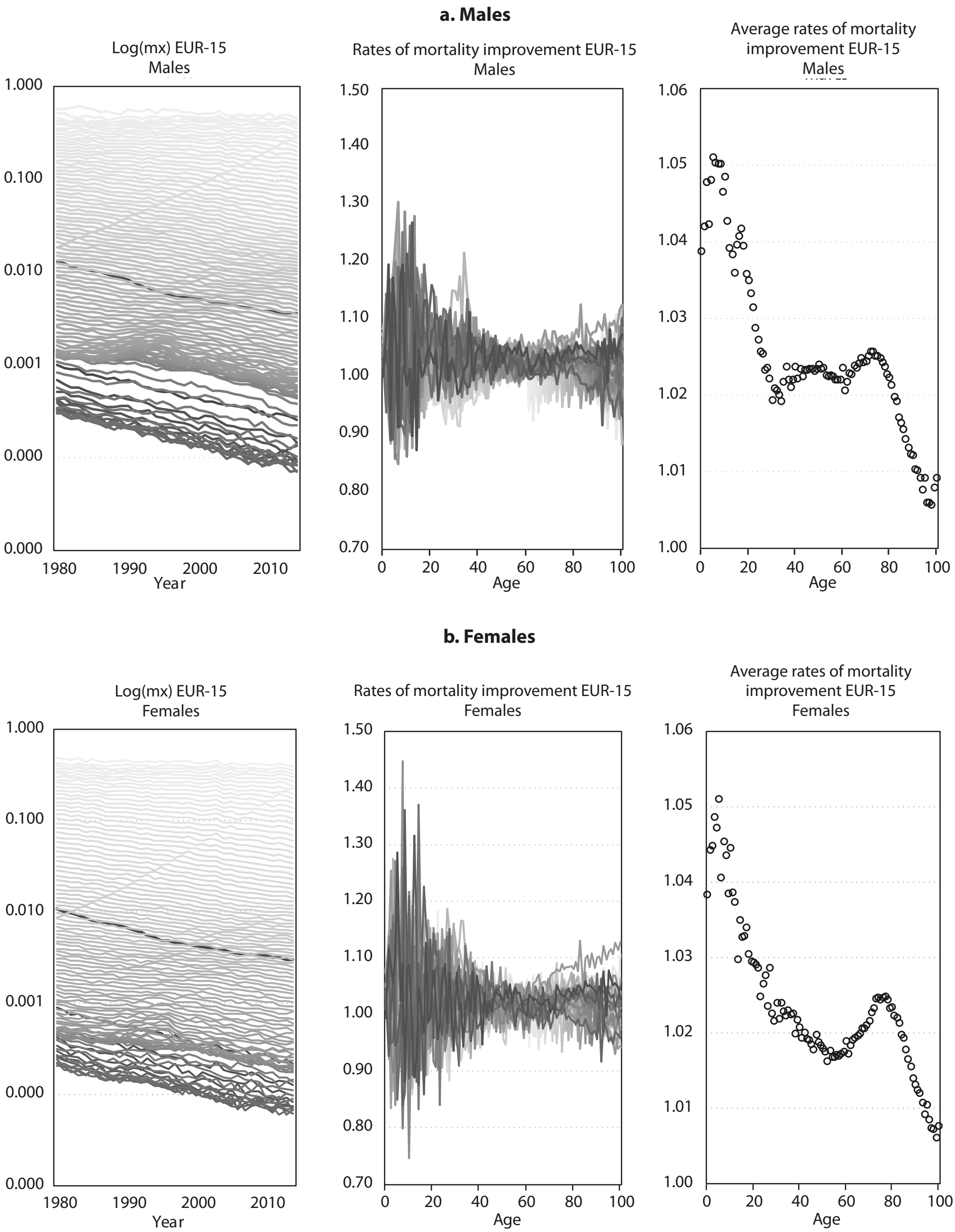
In Figure 4, the EUR-15 mortality rates, the rates of mortality improvement, and their averages are displayed in the left, middle, and right panels, respectively. The left panels show the surface of the age-specific mortality rates and their change in time (each line represents one single-year age group between 0 and 100). The middle panels show the rates of mortality improvement and their volatilit

Table 1 Sensitivity of the Lee-Carter life expectancy at birth forecasts by sex (for year 2100) to the choice of the base period in the Czech Republic

Base period	1960–2017	1970–2017	1980–2017	1990–2017
Life expectancy at birth in 2100:				
Male	85.07	88.23	90.12	91.47
Female	89.06	90.94	92.27	92.35
Sex difference	3.99	2.71	2.15	0.88

Source: Source: Czech Statistical Office, 2018c; author's calculations.

Figure 4 Age-specific mortality rates (left), rates of mortality improvement (middle), and average rate of mortality improvement (right) for the EUR-15 population by sex, 1980–2014



Source: Human Mortality Database, 2018.
Note: EUR-15 aggregates Austria, Belgium, Denmark, Finland, France, Great Britain, former West Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden and Switzerland.

(each line represents the age-specific mortality change in a given calendar year). The variation is extremely high at young ages where mortality is low. However, when these rates are averaged over time (the right panel), the resulting pattern of age-specific mortality improvement comes out as more systematic and is similar to the beta parameter of the Lee-Carter model shown previously. Once again we observe increased mortality dynamics among males aged 30–60 years, which is explained by the relative stagnation of premature male mortality in the 1980s followed by a recovery since the 1990s (see age-specific rates in the left panel). The HIV/AIDS epidemic is the likely cause of this peculiar trend (*Valdes,* 2013), and once again, this trend is not likely to be repeated in the near future.

The projection model

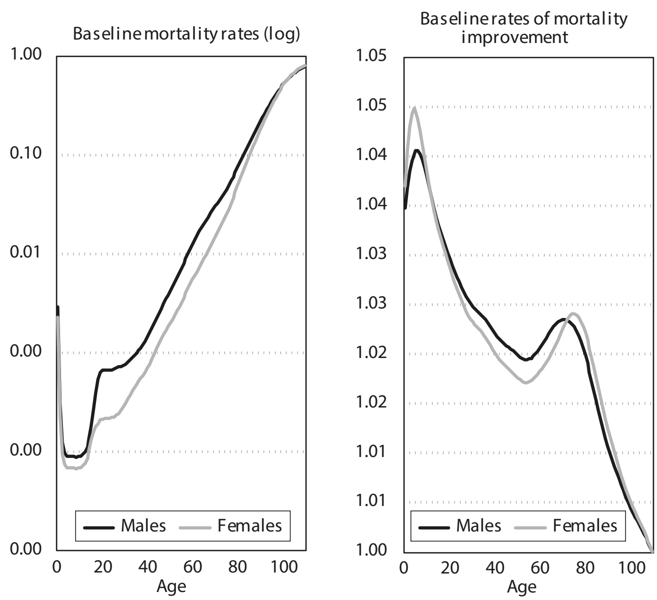
The projection model based on the observed rates of mortality improvement was created in the following steps:

- Define the baseline mortality pattern
- Define the baseline rates of mortality improvement
- Formulate assumptions about future patterns of mortality change
- Predict future death rates

The baseline mortality pattern differs from the last observed data year. Because of the relatively small size of the Czech population and the scarcity of deaths or exposures at young and old ages, the observed data cannot directly serve as a projection basis. In the present approach, the baseline mortality curve was estimated as the latest five-year average of the age-specific mortality rates numerically adapted to the linear extrapolation of life expectancy in 2018 based on the last five years (the 2018 life expectancy at birth was estimated as 76.19 years for males and 82.03 years for females). Baseline mortality curves for males and females are shown in Figure 5 (left panel).

The baseline rates of mortality improvement were based on the arithmetically averaged EUR-15 $r_{x,t}$. Slight modifications were adopted: the excess rates of improvement among adult males were removed; the male and female patterns of change were thus made more similar, while still allowing for slightly bigger reductions among males aged 30–60. The rates were finally smoothed using locally weighted

Figure 5 Medium scenario of the baseline mortality age-pattern and baseline rate of mortality improvement in the Czech Republic by sex, 2018



Source: Czech Statistical Office, 2018b.

regression (loess with 0.1 bandwidth). The resulting rates of improvement are displayed in the right panel of Figure 5.

Accounting for uncertainty

The forecast was designed in three scenarios reflecting the limits of the future mortality change as expected according to observed trends and related hypotheses. The scenarios are labelled 'low', 'medium', and 'high', in conformity with both with the predicted levels of life expectancy and with the predicted population size. In the very first year of the projection (2018), the low and high scenarios were defined as increasing or decreasing the baseline mortality estimate by 2.5% at every age.

The three main scenarios of expected mortality decline are shown in Figure 6. In the 'medium' and most likely scenario (middle panel), it is assumed that mortality reductions will initially follow the baseline rates of mortality improvement. Over time, the rates of improvement will decline and this decline will be more pronounced among younger ages. This scenario thus reflects the concept of a rotation of the mortality-reduction age pattern.

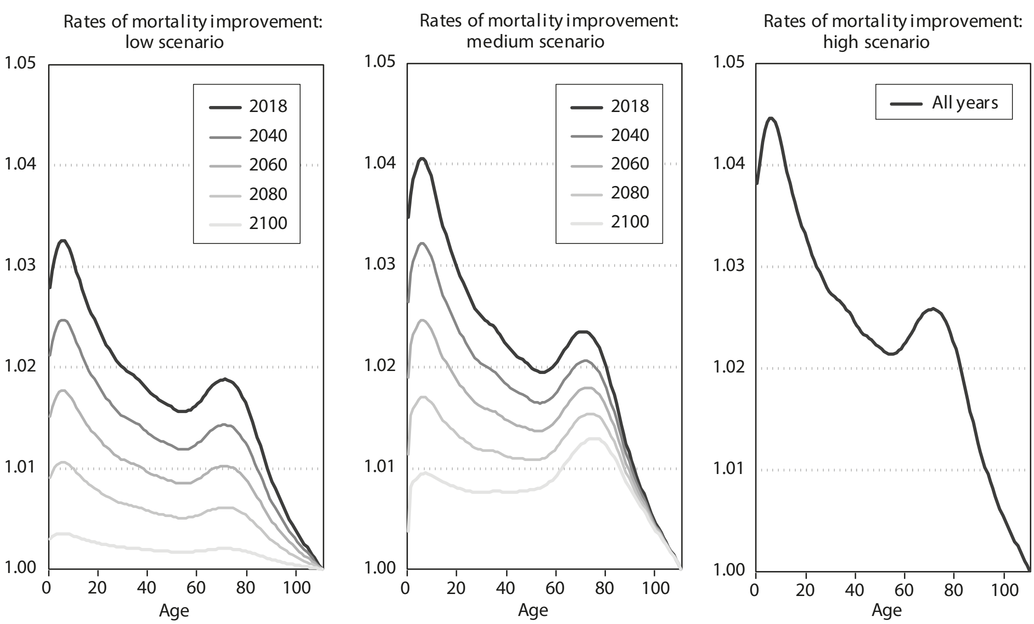
In the 'low' scenario (left panel), the initial mortality decline is set below the baseline levels and is projected to cease in 2150 (the rates of improvement gradually converge to 1). This scenario takes into account the possible eventual depletion of the biological and social reserves underlying further mortality improvements.

The 'high' scenario (right panel) considers a higher than baseline mortality improvement, which will be sustained in every year of the projection. This scenario represents the hypothesis that mortality decline will continue uninterrupted into the future, which is the scenario closest to the stochastic projections based on recent favorable mortality trends.

With the exception of the baseline year 2018, the mortality rates for every age and year $m_{x,t+1}$ were computed as ratios of the death rate observed in the preceding year $m_{x,t}$ and the respective predicted rate of improvement $r_{x,t}$:

$$m_{x,t+1} = \frac{m_{x,t}}{r_{x,t}}$$

Figure 6 Projected rates of mortality improvement in Czechia, males, low, medium, and high scenarios, 2018–2100



Source: Czech Statistical Office, 2018b.

RESULTS

Table 2 summarises the main results of the 2018 mortality forecast: life expectancy at birth according to different scenarios and the resulting sex difference. In 2100, life expectancy in the medium scenario is projected to reach 87.66 years among males and 91.22 years among females. The range between the low and the high scenario estimate equals 7 years in 2100. Compared to the stochastic forecasts presented in Table 1, the actual forecast results in higher but still decreasing sex differences in mortality (a drop to 3.56 years expected in 2100 in the medium scenario, and to only 3.03 years in the high scenario).

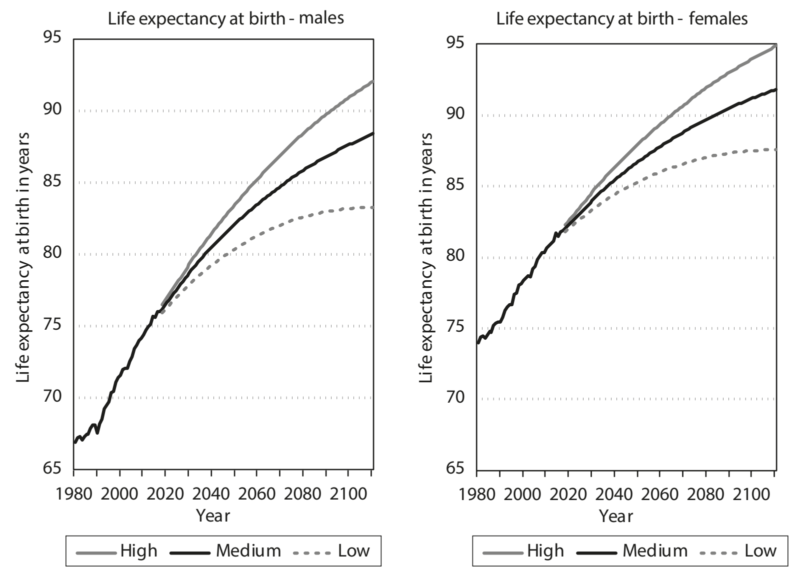
A more detailed outlook on the projected life expectancy can be seen in Figure 7, where the annual figures are presented for all the projected years and

Table 2 Life expectancy at birth by sex in 2017 (observed) and 2018–2100 (projected), Czechia, low, medium, and high scenarios

Year	Males			Females			Sex difference		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
2017	-	76.01	-	-	81.84	-	-	5.83	-
2018	75.93	76.19	76.47	81.80	82.03	82.25	5.87	5.84	5.78
2020	76.28	76.64	76.96	82.09	82.38	82.66	5.81	5.74	5.70
2030	77.90	78.71	79.32	83.36	84.02	84.59	5.46	5.31	5.27
2040	79.27	80.53	81.50	84.44	85.46	86.36	5.17	4.93	4.86
2050	80.40	82.14	83.49	85.32	86.73	87.97	4.92	4.59	4.48
2060	81.33	83.55	85.31	86.04	87.86	89.43	4.71	4.31	4.12
2070	82.05	84.79	86.95	86.61	88.86	90.75	4.56	4.07	3.80
2080	82.60	85.87	88.44	87.04	89.74	91.95	4.44	3.87	3.51
2090	82.98	86.83	89.77	87.34	90.52	93.02	4.36	3.69	3.25
2100	83.21	87.66	90.97	87.51	91.22	94.00	4.30	3.56	3.03

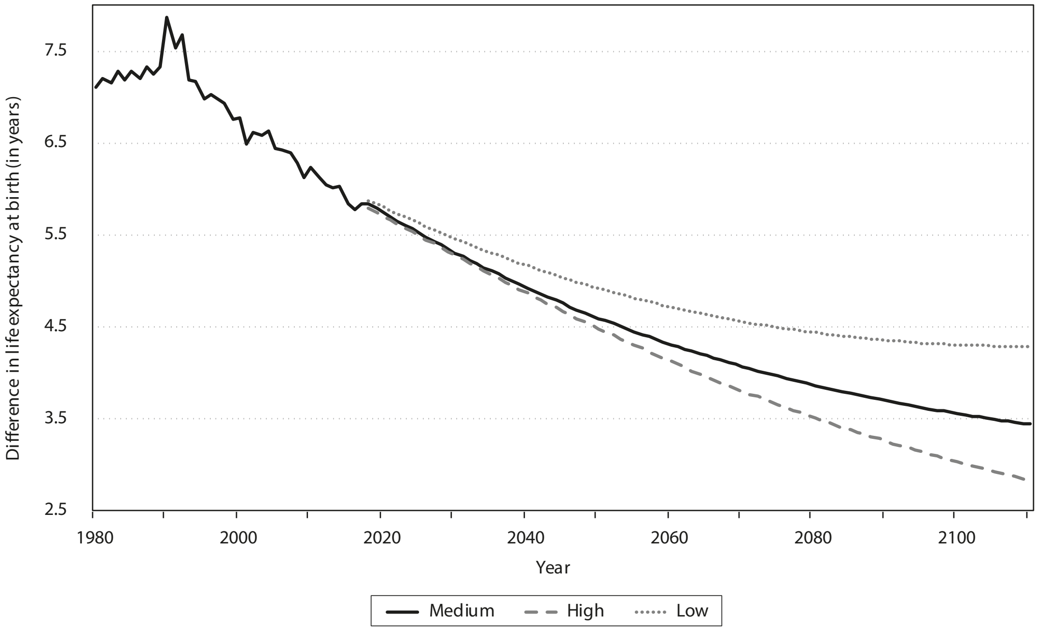
Source: Czech Statistical Office, 2018a and 2018b.

Figure 7 Life expectancy at birth by sex between 1980 and 2017 (observed) and for 2018–2100 (projected), Czechia, low, medium, and high scenarios



Source: Czech Statistical Office, 2018b and 2018c.

Figure 8 Sex difference in life expectancy at birth, 1980–2017 (observed) and 2018–2110 (projected), Czechia, low, medium, and high scenarios



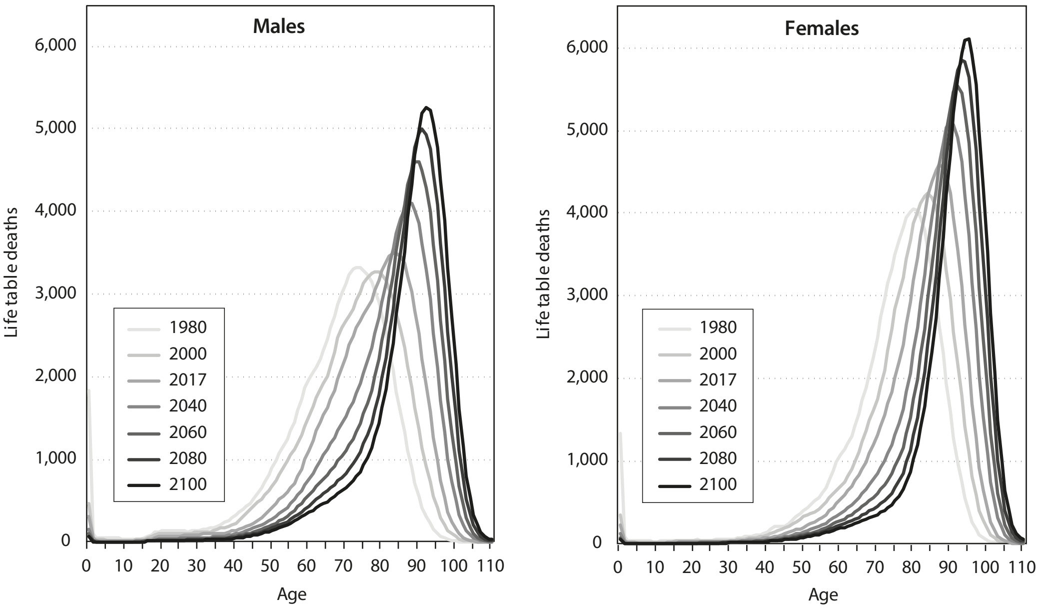
Source: Czech Statistical Office, 2018b and 2018c.

for the three mortality improvement scenarios. In the medium scenario, life expectancy increases continuously throughout the entire projected period; however, the pace of increase declines with time (due to the incorporated assumption of a decrease in and the rotation of mortality improvements). In the low scenario, the increase in life expectancy slows down even more rapidly and from 2080 the progress becomes negligible. In the high scenario, life expectancy increases the most rapidly as a result of the conservative pattern of mortality improvement, but even here, the increase is not linear, which suggests that even if the rates of improvement remain constant, the life expectancy increase will decelerate in the long run.

Figure 8 depicts the observed and predicted levels of sex difference in life expectancy at birth for each of the three scenarios. The assumptions applied in the scenarios produce different trajectories of sex differentials. In general, it is assumed and accepted that sex mortality differences will decrease in the future. The second half of the 20th century was a period of exceptionally high excess male mortality in both the East and the West, and Figure 8 confirms that this was also the case in Czechia, where sex differences reached a maximum in the late 1990s and have rapidly declined since then. If the mortality improvement rates were fixed in the future for both sexes (the high scenario), the sex difference would eventually drop to 3 years in 2100. This result is due to the fact that mortality improvement rates are derived from the base period that is characterised by more rapid declines in male mortality, especially at adult ages. The medium and low scenarios assume slower declines in adult mortality, which leads to higher sex differences.

Figure 9 shows how the expected mortality changes will affect the distribution of life table deaths (the d_x function of a life table). As a result of further reductions in premature mortality and the shift in deaths to older ages, the modal age at death will move upwards and deaths will be increasingly concentrated around it, i.e. the variance of age at death will decline. This phenomenon is referred to as the compression of mortality (*Myers* and *Manton,* 1984).

Figure 9 Distribution of life table deaths by sex in Czechia (dx): 1980–2017 (observed) and 2018–2110 (projected), medium scenario



Source: Czech Statistical Office, 2018b and 2018c.

The modal age at death (also called the normal length of life and derived as the age at which the maximum life table deaths occur) will increase in the medium scenario by 8 years among both sexes between 2017 and 2100. As Table 3 shows, in 2100 men will most likely die at the age of 92 years while the typical age of death for women will be 95 years. The sex difference in the modal age at death is lower than that of life expectancy: in 2017 only a sex difference of only 3 years is observed, and this difference will go unchanged over the projected period.

Figure 10 displays the curves of life table survivors by age, according to the medium scenario. The survival curves provide additional insight into the shape of future mortality patterns. As the number of life table births is constant (100,000), survival curves allow us to directly read the quantiles of the length of life (e.g. the age at which 50,000 of life-table born are still alive is called the median length of life). In 1980, the median length of life was 70 years for men and 77 years for women. In 2017, the median length of life increased to 78 years for men and 84 years for women. In 2100, 50% of the population will live to at least 90 years of age (men) or 93 years (women). The increasing proportions of people surviving to increasingly older ages are visible in Figure 10 as the increasingly rectangular shape of the survival curve. This process of rectangularisation will slow down in the second half of the projected period.

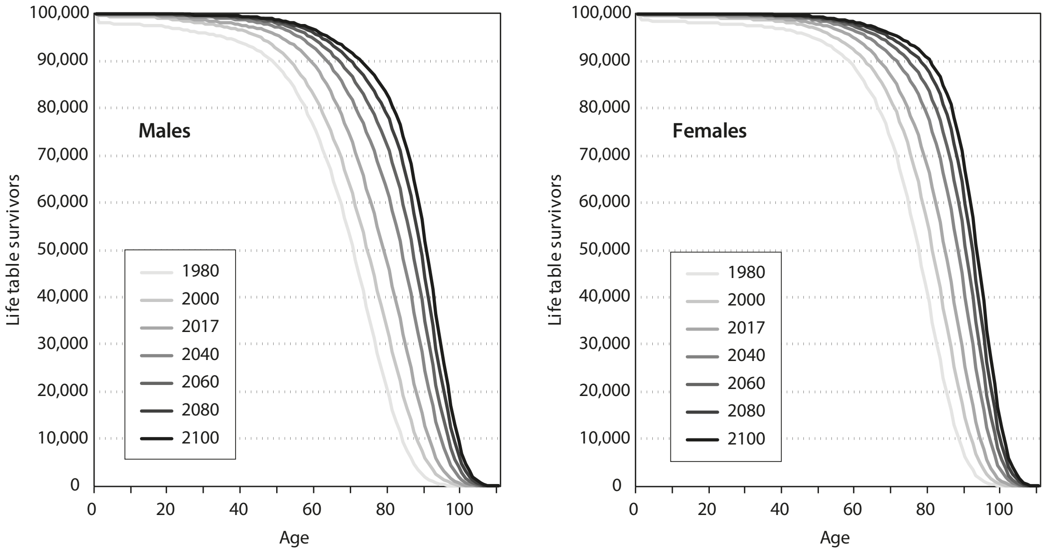
The probability of surviving up to the discussed threshold for the retirement age (65 years) is projected

Table 3 Modal age at death by sex in Czechia: 1980–2017 (observed) and 2018–2110 (projected), medium scenario

Year	1980	2000	2017	2040	2060	2080	2100
Males	73	78	84	87	90	91	92
Females	80	84	87	90	92	93	95

Source: Czech Statistical Office, 2018b and 2018c.

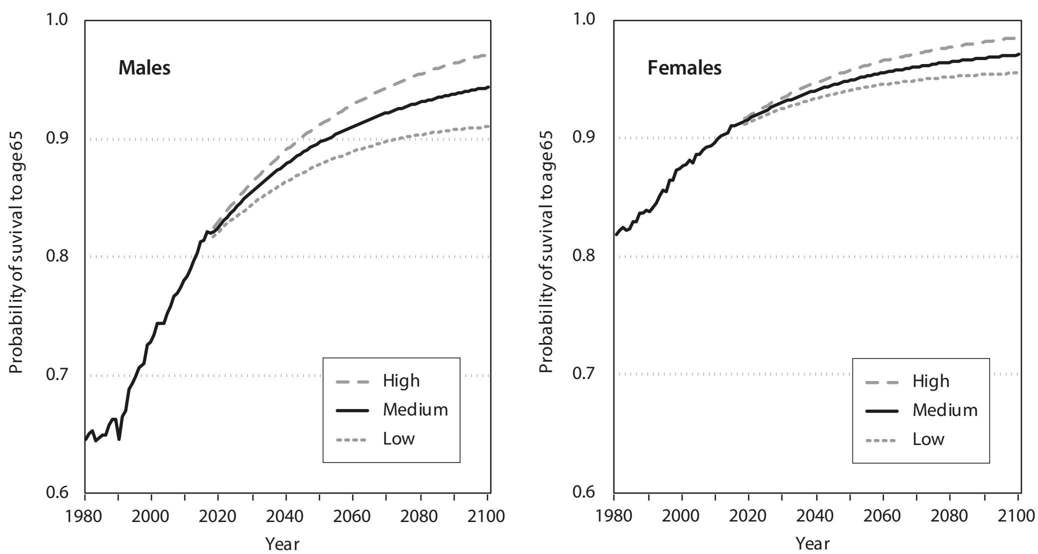
Figure 10 Distribution of life table survivors (lx) by sex in Czechia: 1980–2017 (observed) and 2018–2100 (projected), medium scenario



Source: Czech Statistical Office, 2018b and 2018c.

to further increase in all three scenarios and this increase will be more pronounced in the population of males due to the greater reductions in male premature mortality (Figure 11). Male chances of living to the age of 65 already increased steeply between 1980 and 2017 (from 0.65 to 0.82), and a further increase to 0.94 is expected by 2100. Among females, the chance of surviving to the age of 65 was already 0.91 in 2017 and will increase to 0.97 in 2100, suggesting that almost every woman will survive to this age.

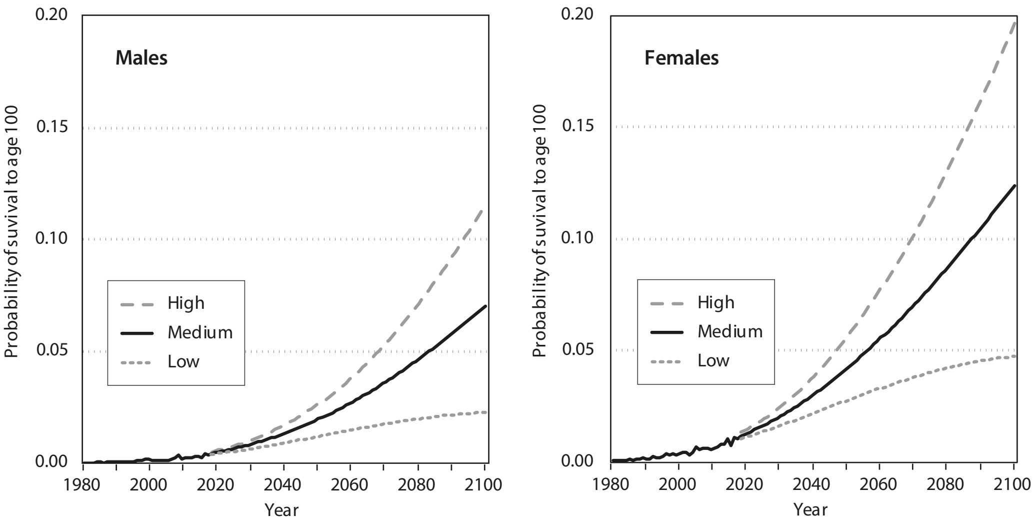
Figure 11 Probability of survival to age 65 by sex in Czechia, 1980–2017 (observed) and 2018–2100 (projected)



Source: Czech Statistical Office, 2018b and 2018c.

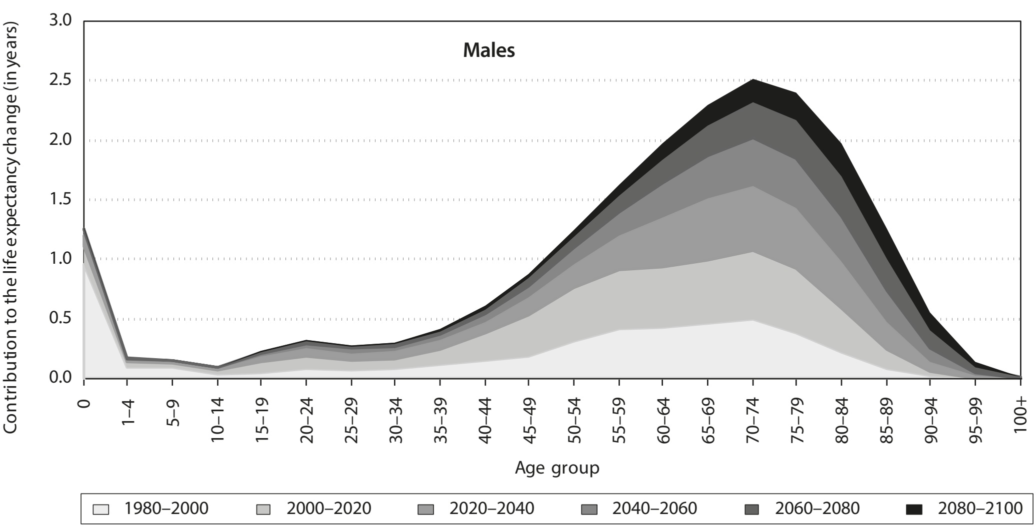
Figure 12 shows the trend in longevity, operationalised here as the chances of becoming a centenarian. Between 1980 and 2017, the chance of living to the age of 100 increased from almost zero to 0.004 in men and to 0.011 in women. Survival to age 100 will, however, improve at increasing rates and is expected to reach 0.07 and 0.12 in 2100 for men and women, respectively (7% of men and 12% of women born in 2100 will live to the age of 100 or more according to the 2100 period life table estimate, i.e. under the assumption that mortality conditions remain constant to the year of the predicted life table).

Figure 12 Probability of survival to age 100 by sex in Czechia, 1980–2017 (observed) and 2018–2100 (projected)



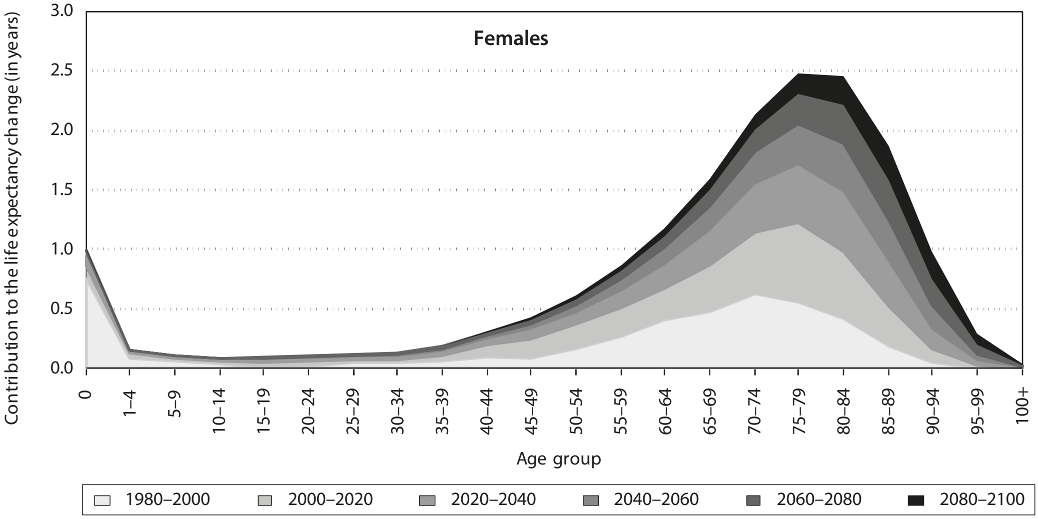
Source: Czech Statistical Office, 2018b and 2018c.

Figure 13 Contributions to the change in life expectancy at birth in Czechia between 1980 and 2100, medium scenario, males



Source: Czech Statistical Office, 2018b and 2018c.

Figure 14 Contributions to the change in life expectancy at birth in Czechia between 1980 and 2100, medium scenario, females



Source: Czech Statistical Office, 2018b and 2018c.

Past and expected gains in life expectancy were further decomposed into the contributions of 5-year age groups. Figures 13 and 14 depict these contributions for six twenty-year periods of time covering the total period of 1980–2100. The lower and lighter areas in the graphs show the improvements already achieved (1980–2020), while the darker shades of grey display future contributions to life expectancy change by age (2020–2100). Two main structural features are apparent: life expectancy gains will become increasingly concentrated among older age groups and will diminish with time.

Table 4 Contributions of selected age groups to the observed and projected life expectancy at birth change by sex in Czechia, 1980–2100, medium scenario

Period	1980–2000	2000–2020	2020–2040	2040–2060	2060–2080	2080–2100	Total
Age group	*Males*						
0	0.96	0.15	0.10	0.04	0.02	0.01	1.27
1–64	2.11	2.64	1.52	0.99	0.65	0.42	8.33
65–79	1.34	1.65	1.56	1.19	0.86	0.61	7.22
80+	0.33	0.57	0.72	0.79	0.79	0.75	3.96
All ages	**4.74**	**5.01**	**3.90**	**3.02**	**2.32**	**1.79**	**20.78**
	Females						
0	0.75	0.11	0.08	0.04	0.02	0.01	1.00
1–64	1.35	1.25	0.76	0.49	0.32	0.21	4.39
65–79	1.65	1.59	1.17	0.83	0.57	0.39	6.21
80+	0.66	1.03	1.06	1.04	0.97	0.87	5.63
All ages	**4.41**	**3.99**	**3.08**	**2.40**	**1.88**	**1.48**	**17.23**

Source: Czech Statistical Office, 2018b and 2018c.

The main numerical results of the decomposition are presented in Table 4. In total, a gain of almost 21 years of life expectancy is expected by 2100 compared to 1980 for men and 17 years for women. For both sexes, the life expectancy gains achieved between 1980 and 2020 are similar (in size) to those expected between 2020 and 2100. The age pattern of past and future development is, however, different. In 1980–2000, a major role in life expectancy improvement was still played by infant mortality, followed (among males) by ages below 65. With time, the importance of infant mortality in life expectancy falls to almost zero and the contributions of ages below 65 decrease steadily. For both sexes, life expectancy gains are increasingly determined by mortality at ages 80 and above (as of 2080, ages 80 and over will be the most important drivers of life expectancy change for both sexes).

A COMPARISON WITH OTHER PROJECTIONS

The results of the 2018 forecast were compared to alternative mortality forecasts published recently for Czechia. To our knowledge, these include the Eurostat population projection 2017 (based on 2015 data), the United Nations World Population prospects 2017, the population forecast created by the Department of Demography and Geodemography of Charles University in Prague published in 2018 (*Bleha et al.* 2018), and the previous CZSO forecast from 2013 (Table 5). All of the cited forecasts are based on deterministic cohort-component methods. The Eurostat projection uses the top-down approach: life expectancy in each member country is assumed to converge to a predefined target and the speed of this convergence differs according to the determined scenario. The Charles University forecast employs expert judgement assumptions about the change in future life expectancy, as does the previous CZSO 2013 projection.

In 2060, which is the last year covered by all the alternative forecasts, the life expectancy estimates differed by less than 0.5 years between each other for males, while more variation was observed for females. The highest estimates of life expectancy were given by the previous CZSO 2013 forecast. For the year 2100 we can only compare the CZSO 2018 results to the UN WPP and the CZSO 2013. The male life expectancy estimate in 2100 is almost identical to the UN WPP, while the CZSO 2018 projection estimates higher life expectancy for females, resulting in higher estimates

Table 5 Projected life expectancy at birth by sex for Czechia – a comparison of medium-scenario projections, 2017–2100

Year	Eurostat 2017		WPP 2017**		B&K 2017***		CZSO 2013		CZSO 2018	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
2017*	75.4	81.5	75.59	81.47	76.08	81.78	76.25	82.05	76.01	81.84
2020	76.8	82.6	76.51	82.10	76.78	82.37	77.01	82.76	76.64	82.38
2030	78.6	84.1	78.40	83.33	78.93	84.08	79.51	85.13	78.71	84.02
2040	80.3	85.5	80.33	84.51	80.73	85.51	81.26	86.55	80.53	85.46
2050	82.0	86.8	82.10	85.65	82.36	86.81	83.00	87.98	82.14	86.73
2060	83.5	88.1	83.46	86.77	83.73	87.93	83.72	88.61	83.55	87.86
2070	84.9	89.3	84.66	87.88	-	-	84.44	89.24	84.79	88.86
2080	86.20	90.40	85.74	88.99	-	-	85.15	89.88	85.87	89.74
2090	-	-	86.83	90.07	-	-	85.87	90.50	86.83	90.52
2100	-	-	87.65	90.91	-	-	86.59	91.13	87.66	91.22

* or latest available
** WPP estimates were interpolated to fit the required years
*** Projection by B. Burcin and T. Kučera, as published in Bleha et al. (2018)

of life expectancy difference. This result is linked to the fact that the UN forces gender-specific coherence in their forecasts – male mortality is estimated as a function of female mortality to assure a reasonable gender gap even in the long run.

DISCUSSION AND SUMMARY

The presented study proposed a bottom-up deterministic model of future mortality change. The model takes into account the age-specific profile of mortality change and its tempo, both based on observations from developed countries in the recent period, assuming that Czechia will follow a similar trajectory. The proposed model is based on a prediction of the annual discrete change in age-specific mortality rates. The uncertainty is expressed in scenarios of a differential pattern of distribution of the tempo of mortality decline across ages and time.

Implementation of the proposed method is straightforward. As the dynamic input variable is derived from the higher-order external population, the results are insensitive to the choice of the base period in the country of interest. Keeping the dynamic component stratified by age and period enables flexibility in terms of assumptions and scenarios. The method does not distort the age-specific mortality profile and even in a very long horizon of 100 years yields results that prove realistic in terms of different life table measures, such as life expectancy, life table deaths, probabilities, and survivors. Given the universality of the assumptions, the scenarios derived from this projection can be directly applied to sub-populations such as regions and can be easily adapted to new trends.

The projection is deterministic in nature and therefore prone to subjectivity and errors in expert judgement. However, we believe that the subjectivity is partially reduced by a thorough analysis of international patterns of mortality change. As for other deterministic projections, it is not possible using the applied method to directly compute uncertainty measures. However, in the horizon of 100 years, the stochastic uncertainty of a mortality forecast for a population of 10 million inhabitants with only a short series of consistent mortality trends would not be very informative.

According to the medium scenario, life expectancy will further increase by 11.7 years for men and by 9.4 years for women to 2100. Unlike recent improvements, the future life expectancy change will be dominated by mortality improvements in the elderly population groups. The chances of surviving to the age of 65 years will increase to 94% for men and 97% for women, i.e. almost everyone will be able to live to retirement age. By the end of the projection period, men would most typically die at the age of 92 years while women at the age of 95 years. These profound shifts in the age pattern of mortality will further intensify population ageing in Czechia.

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INTERNATIONAL MIGRATION ASSUMPTIONS IN THE CZECH STATISTICAL OFFICE'S POPULATION PROJECTION FOR THE CZECH REPUBLIC 2018–2100

Michaela Němečková[1)]

Abstract

The article describes the background and the main principles of the migration forecast for the Czech Republic, processed by the Czech Statistical Office in 2018. The model is based on assumptions about the volume of migration flows and the sex and age-specific structure of migrants. Three projection scenarios are presented.

Keywords: migration, immigrants, emigrants, population projection, forecast

Demografie, 2019, **61: 281–286**

INTRODUCTION

The migration component is generally reputed to be the most problematic part of population projections. Migration depends on many external factors that can change very quickly, mainly as a consequence of an economic cycle, changes in migration legislation (towards supporting or restricting immigration), the labour market, or the economic, social, and demographic situation in the source and target countries, and other factors. That's why it is not surprising that time series of the numbers of immigrants and emigrants often fluctuate and rarely have a clear long-term trend.

In addition, the migration statistics for the Czech Republic have been affected by changes in the source of data over the period of the last decade. The Czech Statistical Office draws its migration data (only data on international migration is relevant here) from administrative data sources. Since July 2012 the Directorate of the Alien Police has been the main source of data on the migration of foreign nationals, and the Information System of Inhabitants' Records (ISEO) the main source on Czech nationals. Previously, from January 2008 to June 2012, all migration data were taken from the ISEO. Retrospectively, data for 2008–2011 seem to be burdened by some non-specific error, which is indicated by the small number of emigrants, especially among Ukraine and Russian nationals. In general, migration statistics are encumbered by some (however difficult to specify) level of error as a consequence of the underestimation of emigration (not everyone who emigrates reports the termination of his/her stay in the Czech Republic), the problematic nature of recording the stay of EU

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nationals in the country, or possible administrative interventions in data systems (discarding people from the records after a residence permit's expiration date).

In the long-term view, the Czech Republic is a country with positive net migration. However, there is no clear (increasing/stable) trend to annual net migration or the volume of migration and noticeable year-on-year changes have been common. In 2008–2017 net migration ranged from -1,297 (in 2013) to +71,790 (in 2008); it was at its third-highest level (28,273) in 2017 (the last observed year before the projection period). The last ten-year average was 22,764.

PROJECTION ASSUMPTIONS

Owing to the above-mentioned reasons, the migration assumptions for the Population Projection (Czech Statistical Office, 2018) were based on the projected volume of immigrants and emigrants at a fixed level (except for the year of 2018) for the whole projection period (up to 2100). This level should be understood as the average of the expected net migration per year. Net migration at the level of 26,000 persons was incorporated into the medium scenario, and it was incorporated into the low scenario at the level of 18,000. In the high scenario the projected net migration starts at 40,000 in 2018 and gradually decreases to 26,000 in 2100. Thus, the basic assumptions are the continued attractiveness of the Czech Republic to foreign nationals and positive net migration.

The expected volume of migration in 2018 was based on preliminary data on the first half of the year 2018, which showed an increase in net migration in 2018 of more than 6,000 in a year-on-year comparison. The projection expected net migration to be higher in 2018 than in the following years, ranging from 33,000 (in the low scenario) to 40,000 (in the high scenario), and with 38,000 in the medium scenario.

Given the irregular age distribution of the Czech population and the fact that the volume of migration depends more on the economic situation than on the number of people at exact ages living in the country, the absolute numbers of migrants, and not the migration rates, were used as input. In the medium scenario, the projected number of emigrants at 16,000 was based on the average number of persons who emigrated from the Czech Republic in the 2008–2017 period. The projected number of 42,000 immigrants resulted from the projected level of net migration at 26,000 for the whole projection period. In the low scenario the projection envisions 17,000 emigrants and 35,000 immigrants per year; in the high scenario it expects 15,000 emigrants and a (steady) decline in the number of immigrants from 55,000 to 41,000 between 2018 and 2100.

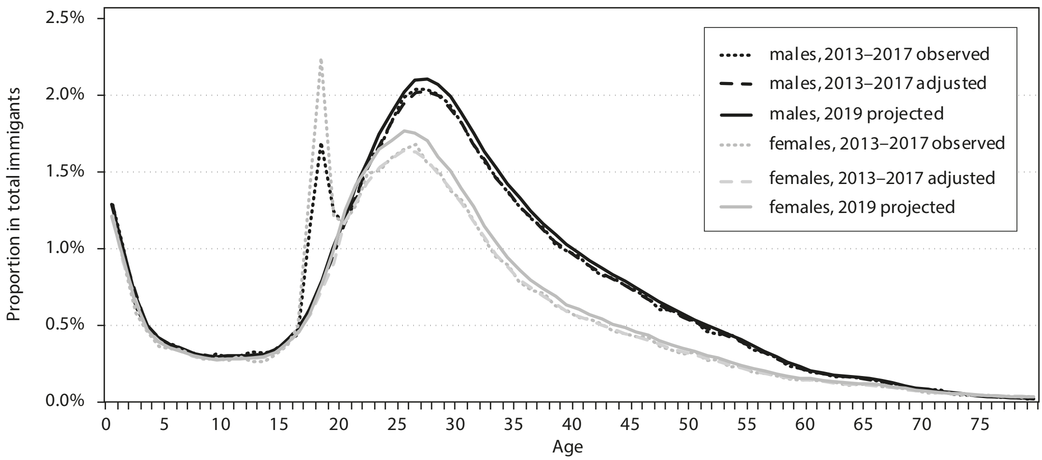
THE SEX AND AGE STRUCTURE OF MIGRANTS

Concerning the sex distribution of migrants, all the projection scenarios assumed a 56% share of men in the immigration flow in 2019; this is equal to the observed share for the period of 2013–2017. In the following years, the projection expected a slight increase in the share of women among immigrants in connection with the expected higher demand for workers in social care and health services in response to progressive population ageing in the future. A moderate decrease in the share of men to 53% in 2050 was assumed and then the share was fixed at this level. Since the data for the last year show a partly different sex and age distribution than the 5- (10-)year averages, the age-sex distribution of immigrants for the year 2018 was used as a transition and was estimated as the average of the level from the last real observed data (2017) and the level of the first projection (2019).

For the migration flow out of the Czech Republic, the shares of men and women were fixed at 56% men in all the projection scenarios throughout the projection period. (The figure being the average for the shares measured in 2013–2017.) This meant that there were 9,024 emigrating men out of a total of 16,000 emigrants. As a result of these assumptions, the projection expected there would be a decreasing share of men within net migration. At the beginning of the projection the figure would be around 57% men, whereas by 2050 the share of men would be 51%.

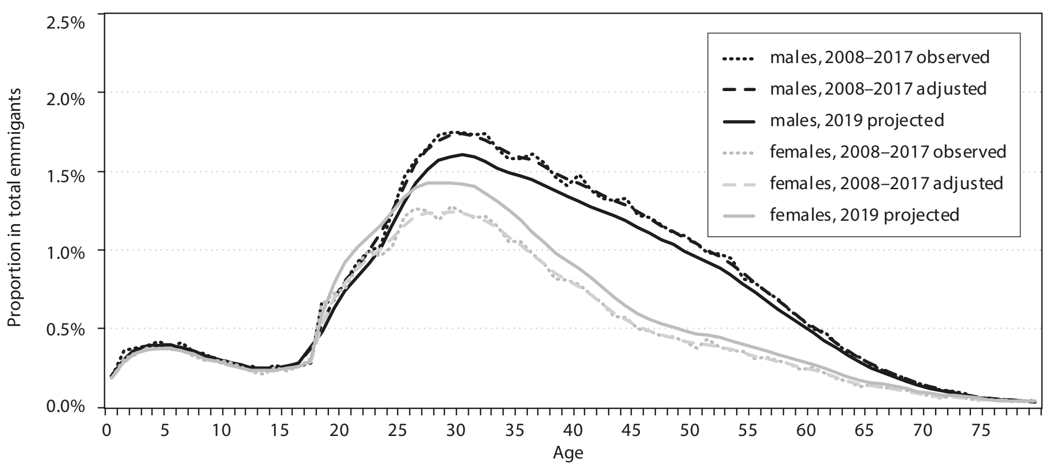
The age distributions of migrants in both directions were based on the data from previous years: the age structure of immigrants is based on the average for 2013–2017, and the age structure of emigrants is based on the average for 2008–2017. These averages seemed to be sufficiently robust and at the same time corresponded to recent trends. Nevertheless, some adjustments were made. First, the sex distribution of both immigrating and emigrating children (aged 0–17) was adjusted so that the shares of men and women (0.515 and 0.485, respectively) at these ages were stable. Then, the age-distribution curves were smoothed using the method of the three-year moving average, and migration was set as zero for people at the oldest ages (above 95). In addition to this, the observed share of immigrants aged 17–20 was not fully implemented in the projection because it was obvious that these people coming to the Czech Republic were often students residing temporarily in the country and weren't expected to fully participate in the reproduction of the Czech population during their stay. After further smoothing with the three-year moving average method (see the 'adjusted' curves in Figure 1 and Figure 2), the age distribution was finally adjusted to the projected share of men/women among migrants (where the share of males and females was only changing among people aged 18–74; see the 'projected' curves in Figures 1 and 2).

Figure 1 Immigrants by sex and age in the Czech Republic – observed, adjusted and projected data (in %)



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

Figure 2 Emigrants by sex and age in the Czech Republic – observed, adjusted and projected data (in %)



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

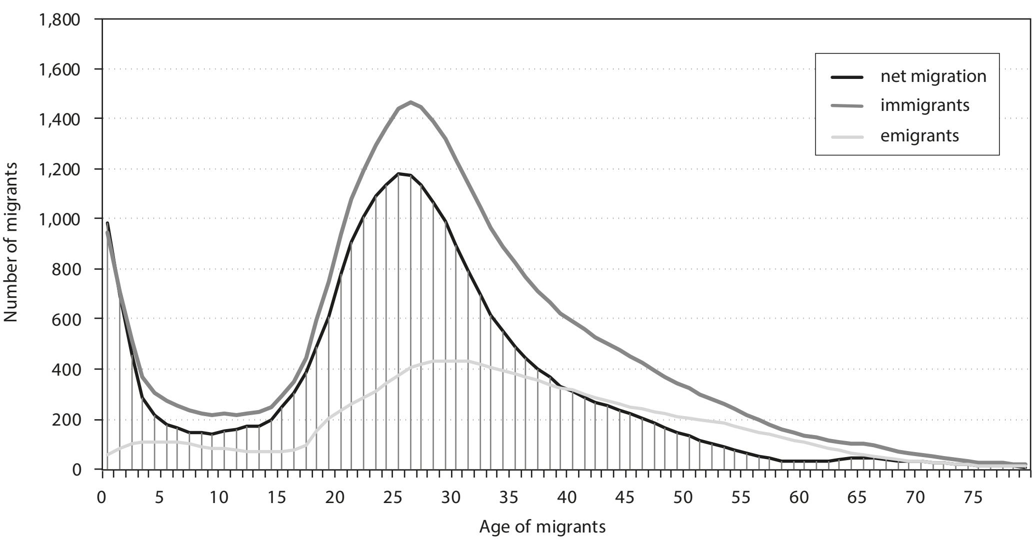
Table 1 Projected number of migrants by sex and age, 2019, 2050–2100, medium scenario

Year/ Period	Immigrants				Emigrants		Net migration			
	2019		2050–2100		2019–2100		2019		2050–2100	
Age	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
0–14	2,958	2,786	2,958	2,786	754	710	2,204	2,077	2,203	2,077
15–19	1,375	1,320	1,327	1,382	325	347	1,050	974	1,002	1,036
20–24	3,289	3,172	3,080	3,440	744	857	2,546	2,316	2,335	2,583
25–29	4,323	3,496	4,048	3,790	1,183	1,111	3,140	2,385	2,865	2,679
30–34	3,450	2,429	3,231	2,634	1,243	1,068	2,207	1,360	1,989	1,565
35–39	2,456	1,561	2,300	1,693	1,126	834	1,330	727	1,174	858
40–49	3,215	1,978	3,011	2,145	1,853	1,026	1,363	952	1,159	1,118
50–64	1,972	1,255	1,847	1,361	1,503	787	468	468	344	576
65+	482	482	458	510	293	235	188	245	165	272
Total	23,520	18,480	22,260	19,740	9,024	6,976	14,496	11,504	13,236	12,764

Note: The total number could slightly differ from the sum of the numbers for the different age groups due to the rounding of net migration by sex and age.
Source: Czech Statistical Office, 2018b; author's calculations.

The 2018 Projection expected that the highest amount of net migration would remain in the 25–29 and 20–24 age groups and then also in the 30–34 age group. It is projected that these three age groups together will account for slightly more than one-half of total net migration.

Figure 3 Projected number of migrants by age, 2050, medium scenario



Source: Czech Statistical Office, 2018b; author's calculations.

COMPARISON WITH OTHER PROJECTIONS

In comparison with the assumptions incorporated in the previous population projection of the Czech Statistical Office (released in 2013), the expected positive net migration is higher in all the scenarios of Projection 2018. The numbers (18,000 in the low scenario, 26,000 in the medium, and net migration of between 40,000 and 26,000 in the high scenario) are closer to the migration assumptions in the CZSO's Projection 2009. The vision of future development (the size of the population gains from international migration) has been linked to some extent to economic circumstances. In 2013, negative net migration was recorded in the Czech Republic and it was a time of economic crisis, while in 2018 there was a very low unemployment rate and a high demand for foreign workers (like in 2009).

Burcin and Kučera (2018) presented figures that are not markedly different from the new CZSO projection in their projection that was published in 2018, while their medium scenario for net migration was a figure 4,000 higher. On the other hand, the projection released by Eurostat in 2018 expected slightly lower net migration for the Czech Republic at the beginning of the projection period, followed by a decline in net migration to 8,300 in 2100. But the projection methodology was specific in that case (see https://ec.europa.eu/eurostat/cache/metadata/en/proj_esms.htm). Eurostat used a convergence model (zero net migration beyond the projection horizon) and the replacement migration.

Table 2 Expected net migration in projections for the Czech Republic

	Burcin & Kučera (2018)			EUROPOP 2018	CZSO (2013)			CZSO (2009)		
	Low	Medium	High	Baseline	Low	Medium	High	Low	Medium	High
2020	23,000	30,000	37,000	23,479	328	10,082	19,841	15,000	25,000	40,000
2030	20,000	30,000	40,000	20,613	2,226	11,659	21,110	15,000	25,000	40,000
2040	20,000	30,000	40,000	24,467	3,933	13,079	22,259	15,000	25,000	40,000
2050	20,000	30,000	40,000	18,377	5,571	14,384	23,291	15,000	25,000	40,000
2100	x	x	x	8,255	10,350	17,671	25,400	x	x	x

Source: Burcin and Kučera, 2018; Czech Statistical Office, 2009, 2013; Eurostat, 2018.

Sources of data:

- Burcin, B. – Kučera, T. 2018. In: B. Bleha, B. Burcin, T. Kučera, B. Šprocha and B. Vaňo (2018). The Population Prospects of Czechia and Slovakia until 2060. *Demografie 3(60)*: 219–233. Available at: <https://www.czso.cz/csu/czso/demografie-revue-pro-vyzkum-populacniho-vyvoje-c-32018>
- Czech Statistical Office. 2009. *Projekce obyvatelstva České republiky do roku 2065 (Population projection of the Czech Republic up to 2065).* Prague: CZSO. Available at: <https://www.czso.cz/csu/czso/projekce-obyvatelstva-ceske-republiky-do-roku-2065-n-58t98jgowg>.
- Czech Statistical Office. 2013. *Projekce obyvatelstva České republiky do roku 2100 (Population Projection of the Czech Republic up to 2100).* Prague: CZSO. Available at: <https://www.czso.cz/csu/czso/projekce-obyvatelstva-ceske-republiky-do-roku-2100-n-fu4s64b8h4>.
- Czech Statistical Office. 2018a. *Internal database of demographic evidence.*
- Czech Statistical Office. 2018b. *Projekce obyvatelstva České republiky - 2018 – 2100 (Population Projection of the Czech Republic - 2018 – 2100).* Prague: CZSO. Available at: <https://www.czso.cz/csu/czso/projekce-obyvatelstva-ceske-republiky-2018-2100>.
- Eurostat. 2018. *Population Projections at National Level (2018–2100)*. Eurostat. Data available at: <https://ec.europa.eu/eurostat/web/population-demography-migration-projections/population-projections-data>

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THE MAIN RESULTS IN THE POPULATION PROJECTION OF THE CZECH REPUBLIC OF CZECH STATISTICAL OFFICE 2018–2100[1)]

Roman Kurkin[2)]

Abstract
This article summarises the basic descriptive results in the Population Projection of the Czech Republic of Czech Statistical Office between 2018 and 2100 and also analyses the demographic indicators of the age structure with a focus on population ageing and older age groups. It also compares the latest projection with older population projections or population projections of the Czech Republic from different institutions. The central focus is on the medium variant of the 2018 Projection, as it is expected to be the most likely variant of population development.

Keywords: population projection, Czech Republic, population structure, population ageing

Demografie, 2019, **61: 287–295**

INTRODUCTION

The Czech Statistical Office published a Population Projection of the Czech Republic for the period 2018–2100 in 2018 (hereinafter Projection 2018). The methodology and assumptions relating to future population development are described in detail in other articles in this issue of the journal Demografie. The main goal of this article is to describe the basic results and to analyse the demographic indicators of the age structure with a focus on population ageing. A comparison with other relevant population projections is also included. The analysis is mainly based on the medium variant of Projection 2018, which is considered the most likely variant of population development in the future.

THE PROJECTED POPULATION

According to the medium variant, and provided the assumptions behind it are fulfilled, the population of the Czech Republic will increase in the first years of Projection 2018 and will reach its highest number on 1 January 2029 (10,784 thousand). On the other hand, the projected lowest number is expected to be reached in 2081 (10,411 thousand). A population

1) Detailed results and assumptions are available at https://www.czso.cz/csu/czso/projekce-obyvatelstva-ceske-republiky-2018-2100. Labels of tables are in English. Text is in Czech only.

2) Czech Statistical Office, roman.kurkin@czso.cz.

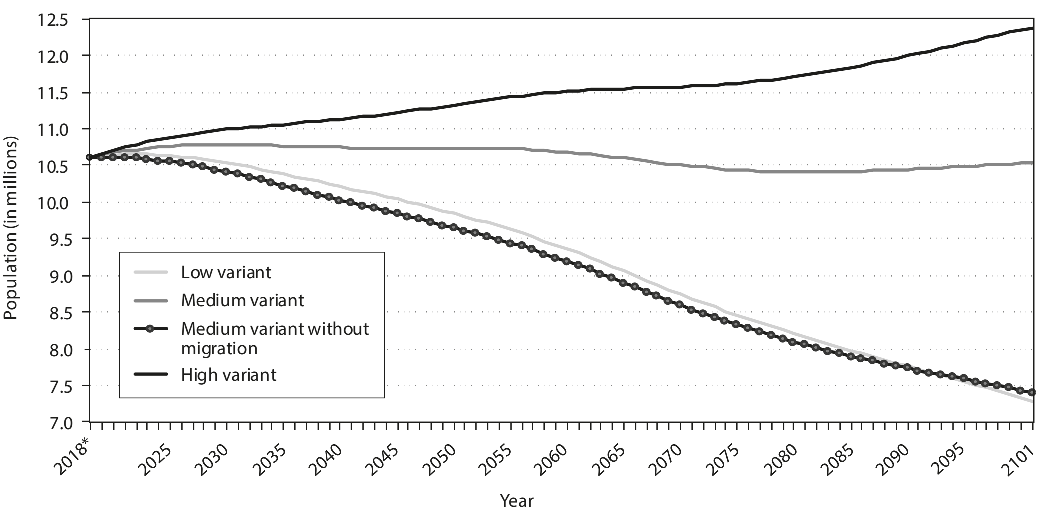
decrease is predicted to occur every year between 2029 and 2080 (except for a modest increases in 2047, 2048, and 2049), and then, from 2081 onwards, the population will, conversely, increase every year and reach 10,527 thousand in 2101.

Since net migration is projected to remain at a constant level of 26 thousand in the medium variant (except in 2018 – when it was 38 thousand), the main factor of uneven population development is expected to be natural change. Natural population change is projected to be positive only in the year 2018 (1 thousand). Between 2018 and 2028 it should decrease to -24 thousand, but net migration is expected to compensate for this decrease. However, from 2029 to 2035 the difference between the number of deaths and live births is expected to be even higher – reaching its local maximum in 2034 (-31 thousand). Due to a rise in a number of live births the natural population decrease is projected to be slightly lower between 2035 (-31,000) and 2047 (-26,000) than in previous years. However, the further development of the projected natural decrease is very unfavourable, with it reaching -45 thousand in 2066 (the absolute low in the projected years). This development will probably be driven by both a rise in the number of deaths and a decline in the number of live births. The trend in natural population change is predicted to reverse once again, while the decrease will diminish to -18 thousand in 2093 in connection with the lower number of deaths. In the rest of the projected period, the natural population decrease will rise again to 21 thousand in 2100. To sum up, future population development according to the medium variant is relatively stable. The different between the population number in 2018 and the maximum and minimum (projected) numbers is 1.6% and 1.9%, respectively

The low and high variants of Projection 2018 represent the extreme limits that probably won't be exceeded. The high variant (high fertility, low mortality, high net migration) shows a population increase every year. The size of the population in 2101 (on 1 January) is projected to be 12,380 thousand. The most population gains should be reached at the beginning and end of the projection period.

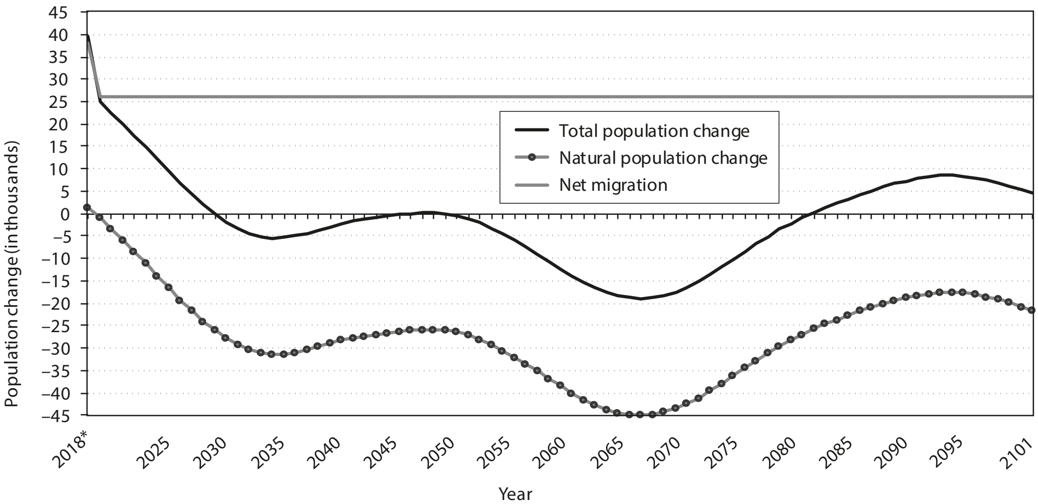
Low variant (low fertility, high mortality, low net migration) predicts total population only until 2022. After that the population should shrink yearly to 7,279 thousand in 2101. The medium variant with zero migration shows an even smaller number of inhabitants for most of the projection years compared to the low variant (except 2093–2101), but this scenario is only hypothetical given that the assumptions about net migration are not realistic.

Figure 1 The projected population of the Czech Republic on 1 January, by variants, 2018–2101



Note: * Observed data.
Source: Czech Statistical Office, 2018a and 2018b.

Figure 2 Projected population change in the Czech Republic, medium variant, 2018–2100

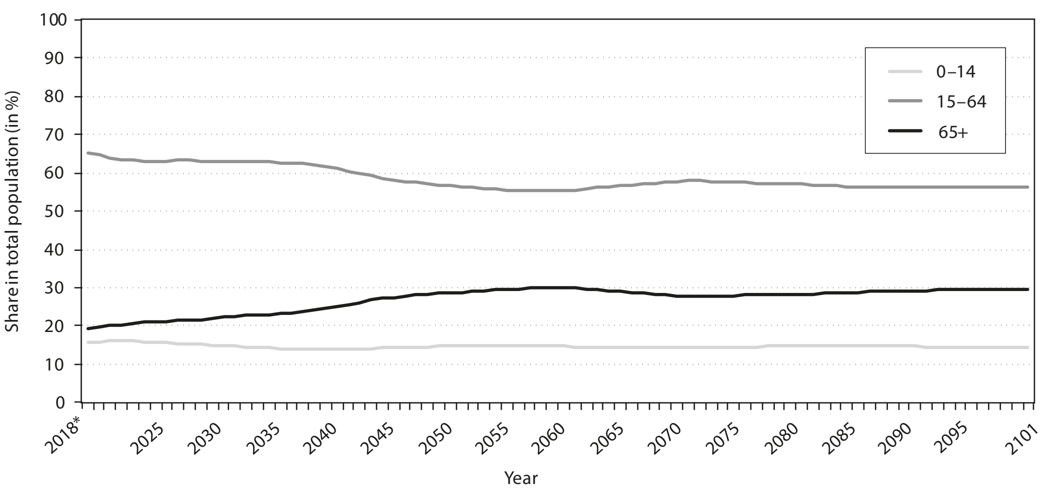


Note: * Observed data.
Source: Czech Statistical Office, 2018a and 2018b.

PROJECTED AGE STRUCTURE OF THE POPULATION

Demographic ageing will take effect mainly from the top of the age structure. The share of people aged 65 and over in the population is predicted to increase from 19.2% in 2018 to 30.0% in 2059 in the medium variant. After a slight decline to 27.8% in 2072, a further rise to 29.5% in 2101 is expected. For the youngest age group (0–14 years) the maximum proportion of the population is projected to be 16.1% in 2021, while the minimum is predicted to be 13.9% in the years 2037–2040. However, the variability of this indicator is quite low. The productive population (15–64 years) should follow a declining path from

Figure 3 Projected structure of the population of the Czech Republic by main age groups, medium variant, 2018–2101 (on 1 January)



Note: * Observed data.
Source: Czech Statistical Office, 2018a and 2018b.

65.0% in 2018 to 55.3 % in the years 2057–2059. Afterwards it should slightly rise, but it should never exceed 58.0%. Because of the assumptions embedded in Projection 2018 and relatively even in the population structure in 2070, the shares of the main population groups are quite stable roughly after 2070.

Projection 2018 assumes that the most profound changes in population numbers will occur among the oldest population groups. In 2101 compared to 2018, the age group 65 years and over is expected to increase by more than 50% in the medium variant; however, among those aged 85 and over the number will be four times higher. An even more intense rise is predicted for the age group 95 and over from 9 thousand in 2018 to 128 thousand in 2101.

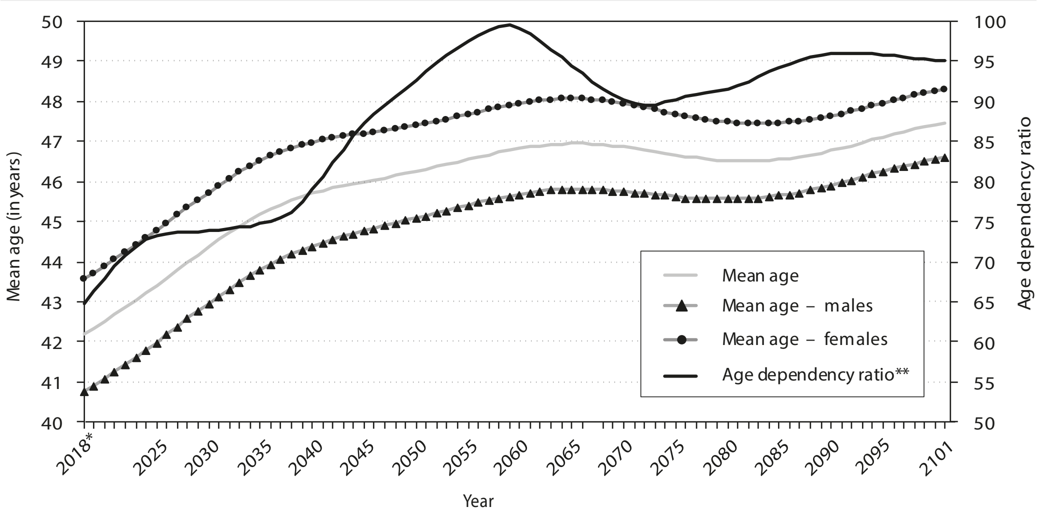
The mean age of the population is assumed to rise from 42.2 years in 2018 to 46.9 years in 2061–2070; then it will probably decrease slightly to 46.5 years in 2079–2085 and after that it will increase to 47.4 years in 2101. The mean age of men is expected to rise from 40.8 years in 2018 to 46.6 in 2101. The figures are 43.6 years and 48.3 years, respectively, for women in the same years. Uneven trends are similar to the trend for the total population. The age dependency ratio (the number of dependents aged 0 to 19 and 65 and over in relation to the total population aged 20 to 64) is predicted to rise significantly from 64.8 in 2018 to 99.4 in 2059 (the maximum value in projected period). A decrease to 89.4 in 2072 is projected, followed by a rise to 95.0-96.0 from 2086 onwards.

Table 1 Projected population by selected age categories in the Czech Republic (in thousands), medium variant, 2018–2100

Age groups	2018*	2020	2030	2040	2050	2060	2070	2080	2090	2101
65+	2,040	2,134	2,403	2,699	3,076	3,196	2,939	2,931	3,047	3,108
75+	786	851	1,247	1,372	1,592	1,910	1,912	1,694	1,817	1,987
85+	201	208	294	470	505	668	804	788	706	876
95+	9	11	18	32	54	64	102	118	126	128

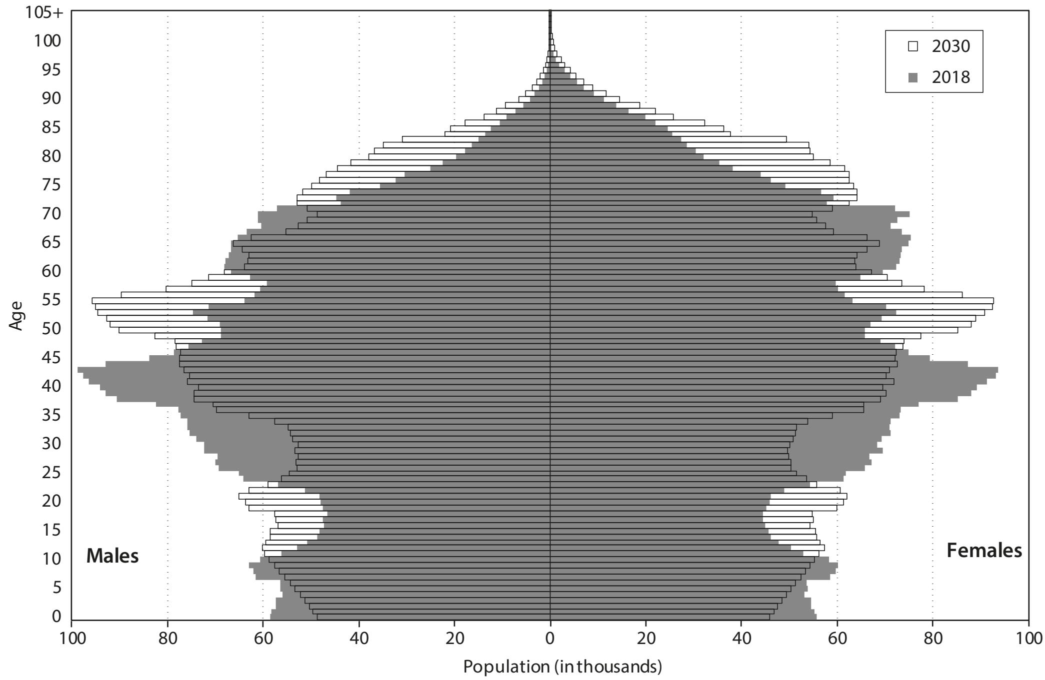
Note: * Observed data.
Source: Czech Statistical Office 2018a and 2018b; authors' calculations.

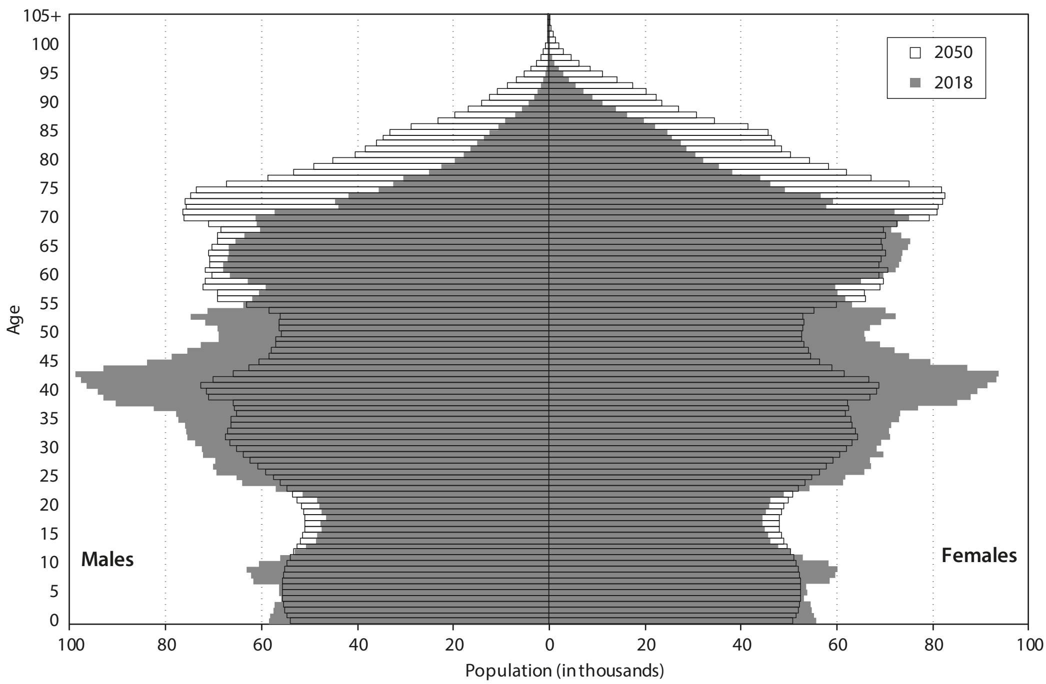
Figure 4 Projected indicators of the age structure in the Czech Republic, medium variant, 2018–2101 (on 1 January)

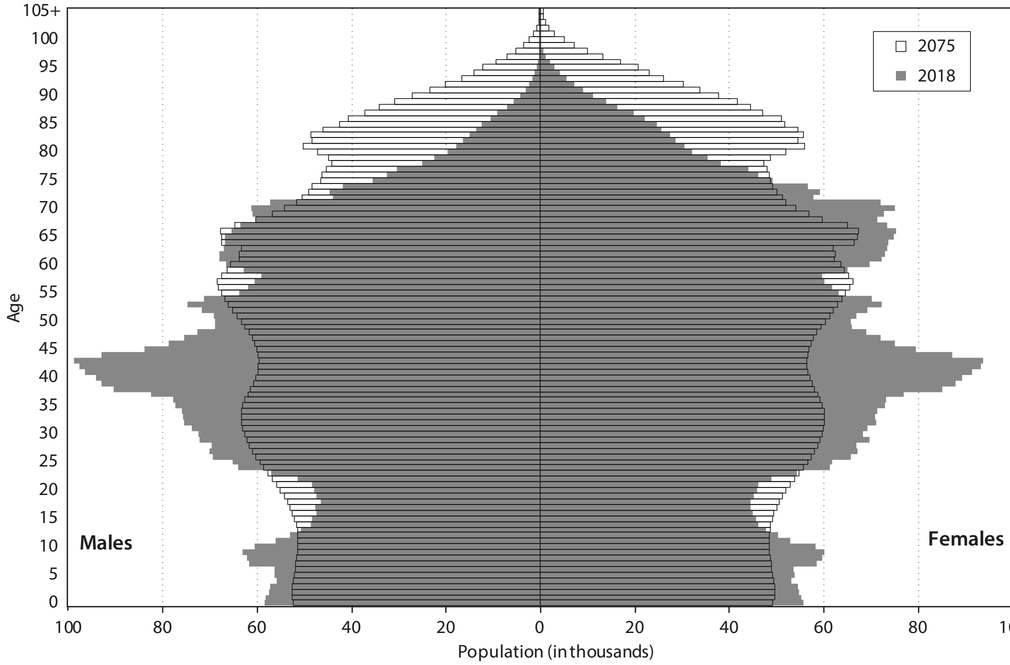


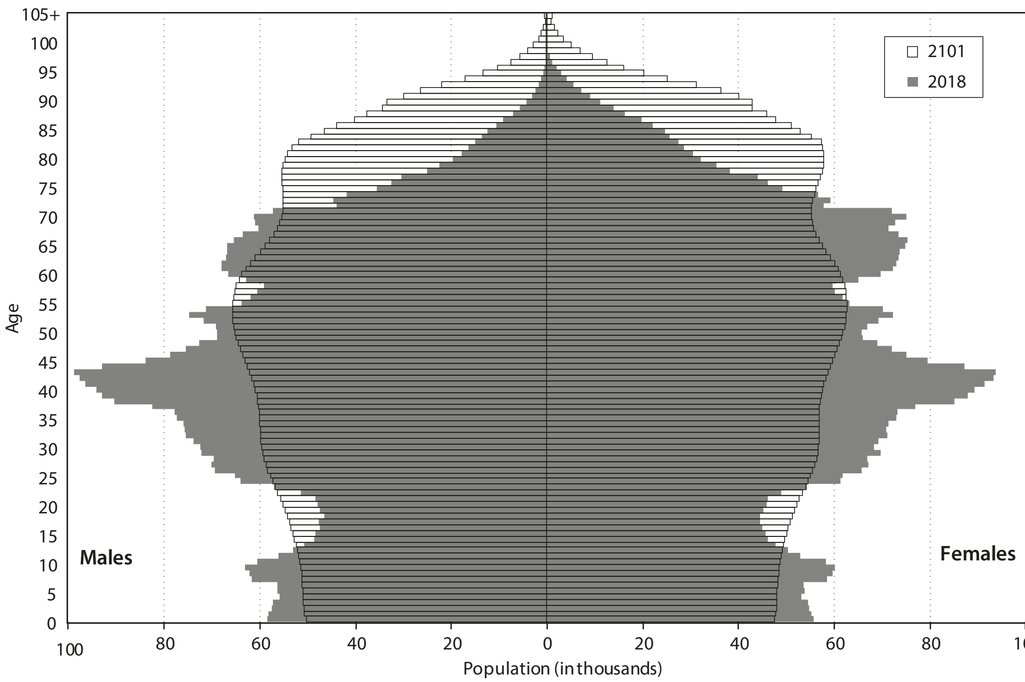
Note: * Observed data. ** Population aged 0–19 and 65+ per 100 population aged 20–64.
Source: Czech Statistical Office, 2018a and 2018b; authors' calculations.

Figure 5, 6, 7, 8 Projected structure of the population of the Czech Republic by age, medium variant, 2018*, 2030, 2050, 2075, 2101 (on 1 January)









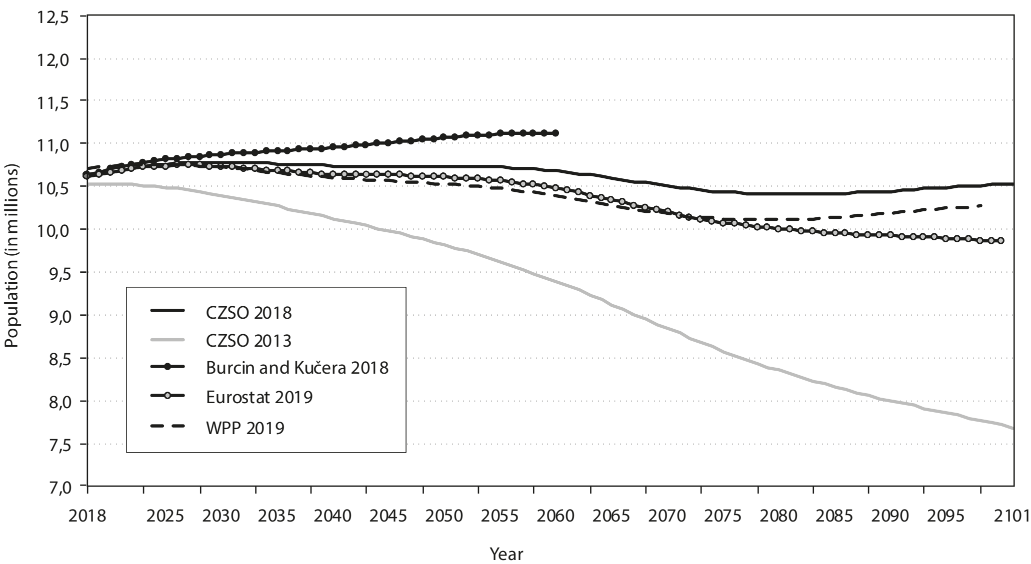
Note: * Observed data.
Source: Czech Statistical Office, 2018a and 2018b.

The population pyramids show the shifting of the population into older age groups and the gradual diminishing of the generation born in the 1970s (currently the most numerous generations). However, this generation is expected to be the largest until 2051. Starting in 2052 the 1980s generation should be the numerically largest generation. In 2057 the 2010s generation will take the position of the largest group and after that only generations that are not yet born will be the most populous ones. The age structure of the population is becoming more even than it was in the first year of Projection 2018 as a result of the smooth development of assumptions. The age at which there will be more females than males in the population is expected to move from 58 years in 2018 to 67 years in 2050 and then to 72 years in the last projected year. The share of males in the population is projected to increase from 49.2% in 2018 to 50.3% by the end of the project period (the 50.0% threshold should be surpassed in 2073). This development is mainly a consequence of the convergence of life expectancy by sex and also a result of there being more males in net migration (even though the share of men in net migration is decreasing).

A COMPARISON OF POPULATION PROJECTIONS

A comparison of the relevant population projections of the Czech Republic and their medium variants shows that the most pessimistic one was a previous projection by the Czech Statistical Office projection from 2013, which predicted lower total fertility rates and net migration than Projection 2018 does. Conversely, the most optimistic one in terms of population growth is a projection by Czech demographers Boris Burcin and Tomáš Kučera (Charles University in Prague). The projection horizon was set as the year 2060 and the population number was projected to be about 450 thousands higher than the size projected by Projection 2018 in 2060, because of the higher intensity of fertility and net migration. The Eurostat Projection (2019) is quite similar to Projection 2018 in the first years of the projection period; however, the population is expected to decrease in the long term and the difference between the projections for 2100 is almost 670 thousands. The latest Eurostat Projection uses a higher intensity of fertility and higher life expectancy at birth for both men and women, but lower net migration than Projection 2018. Finally, the World Population

Figure 9 Projected population of the Czech Republic on 1 January according to various projections, medium variant, 2018–2101



Source: Burcin and Kučera, 2018; Czech Statistical Office, 2013, 2018a and 2018b; Eurostat, 2019; United Nations, 2019.

Prospects 2019 by the United Nations assumes a higher population count than Projection 2018 up to 2024. From 2025 on the population number is lower and the difference is expected to grow to roughly 300 thousands around 2080, then it will decrease to almost 250 thousands in 2100. The United Nations Projection predicts a higher intensity of fertility, but lower net migration compared to Projection 2018 (life expectancy at birth is close).

CONCLUSION

To conclude, population development from 2018 to 2100 is predicted to be quite stable in terms of the absolute number of inhabitants. Net migration is assumed to compensate for the natural decrease. However, the most distinct phenomenon expected is population ageing 'from the top of the age structure'. The medium variant of Projection 2018 is much more optimistic than the same variant in Projection 2013 (10.53 million inhabitants in 2101 vs 7.68 million, a maximum population decrease of -45 thousand vs. -72 thousand, a smaller share of the population aged 65+) which is more similar to the low variant in the newer projection (7.28 million). The main differences between 2013 and 2018 medium variants are the higher fertility rates and the higher net migration assumptions in the more up-to-date projection. These assumptions are based on recent population development, which is in favour of higher intensity fertility and more positive net migration.

Sources of data:

- Burcin, B. – Kučera, T. 2018. In: B. Bleha, B. Burcin, T. Kučera, B. Šprocha and B. Vaňo (2018). The Population Prospects of Czechia and Slovakia until 2060. *Demografie 3(60)*: 219–233. Available at: <https://www.czso.cz/csu/czso/demografie-revue-pro-vyzkum-populacniho-vyvoje-c-32018>
- Czech Statistical Office. 2013. *Projekce obyvatelstva České republiky do roku 2100 (Population Projection of the Czech Republic up to 2100).* Prague: CZSO. Available at: <https://www.czso.cz/csu/czso/projekce-obyvatelstva-ceske-republiky-do-roku-2100-n-fu4s64b8h4>.
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APPENDIX

Appendix 1 Projected population on 1 January by variants, 2018–2101

Variant	2018*	2020	2030	2040	2050	2060	2070	2080	2090	2101
Medium variant	10,610,055	10,674,467	10,783,895	10,742,630	10,736,254	10,678,941	10,504,663	10,411,955	10,447,883	10,527,469
Medium variant without migration	10,610,055	10,608,983	10,414,691	10,027,139	9,651,496	9,192,066	8,597,551	8,092,986	7,736,995	7,402,347
Low variant	10,610,055	10,643,331	10,533,441	10,212,544	9,845,569	9,356,904	8,742,756	8,201,144	7,762,148	7,278,956
High variant	10,610,055	10,704,448	10,990,644	11,129,024	11,322,659	11,506,273	11,573,728	11,709,514	11,992,652	12,379,837

Note: * Observed data.
Source: Czech Statistical Office, 2018a and 2018b.

Appendix 2 Expected population change, medium variant, 2018–2100

Indicator	2018*	2020	2030	2040	2050	2060	2070	2080	2090	2100
Total population change	39,369	22,589	-1,810	-2,263	-448	-14,000	-16,364	-880	7,865	4,554
Natural population change	1,369	-3,411	-27,810	-28,263	-26,448	-40,000	-42,364	-26,880	-18,135	-21,446
Net migration	38,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000

Note: * Observed data.
Source: Czech Statistical Office, 2018a and 2018b.

Appendix 3 Expected population by main age groups, medium variant, 2018–2101 (on 1 January)

Age group	2018*	2020	2030	2040	2050	2060	2070	2080	2090	2101
0–14	1,670,677	1,708,986	1,607,203	1,494,217	1,590,935	1,569,846	1,502,505	1,538,190	1,538,515	1,496,955
15–64	6,899,195	6,831,139	6,773,419	6,549,646	6,069,732	5,913,237	6,063,579	5,942,549	5,862,235	5,922,669
65+	2,040,183	2,134,342	2,403,273	2,698,767	3,075,587	3,195,858	2,938,579	2,931,216	3,047,133	3,107,845
85+	200,834	207,924	293,687	470,469	505,383	667,843	803,529	787,661	705,993	875,843

Note: * Observed data.
Source: Czech Statistical Office 2018a, and 2018b.

Appendix 4 Expected indicators of age structure, medium variant, 2018–2101 (on 1 January)

Indicator	2018*	2020	2030	2040	2050	2060	2070	2080	2090	2101
Age dependency ratio**	64.8	68.0	73.9	79.0	92.6	99.1	90.1	91.5	95.8	95.0
Mean age	42.2	42.5	44.4	45.7	46.3	46.8	46.9	46.5	46.8	47.4
Mean age – males	40.8	41.1	43.0	44.4	45.1	45.7	45.8	45.6	45.9	46.6
Mean age – females	43.6	43.9	45.7	47.0	47.4	47.9	47.9	47.5	47.6	48.3

Note: * Observed data. ** Population aged 0–19 and 65+ per 100 population aged 20–64.
Source: Czech Statistical Office, 2018a and 2018b; authors' calculations.

FAMILY DEMOGRAPHY IN ASIA, A COMPARATIVE ANALYSIS OF FERTILITY PREFERENCES[1)]

Filip Hon

This new book by Edward Elgar Publishing Limited is the result of work of more than fifty authors and a new contribution to fertility analysis. Book is edited by Stuart Gietel-Basten, John Casterline and Minja Kim Choe.

The publication presents itself as the first book providing comprehensive and detailed view of the fertility situation in Asia, through the perspective of demographers. The aim is to investigate fertility preferences in terms of the factors that may affect them and generally find the reasons, which leads to the currently preferred family size in each state. In the case of the least developed countries, there are also no available a lot of demographic articles dealing with fertility, which the book tries to at least partly remedy. Another big theme of the book is the issue of gender preferences. In the case of Asia in particular, son preference. On nearly four hundred pages, there are twenty four chapters to find. The first chapter "Exploring Family Demography in Asia through the Lens of Fertility Preferences" is the work of two editors of the whole book, John Casterlin and Stuart Gietel-Basten. It can be considered as a general introduction that aims to very briefly present the situation of fertility preferences in whole Asia and factors affecting it. It also generally addresses why fertility issues in populous Asia are important for global demographic development.

The second chapter "Son preference and fertility: an overview" by Sylvie Dubuc deals with the introduction to the gender preferences in Asia.

Than follows the chapters of various authors, each dedicated to a particular country. In the alphabetical order of the name of each country, the chapters are devoted to the states Bangladesh, Brunei, Cambodia, Central Asia, China, India, Indonesia, Israel, Japan, Malaysia, Mongolia, Nepal, Pakistan, Papua New Guinea, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Timor-Leste and Turkey. It is not necessary to describe the exact title of each chapter, because they are all devoted to the same topic. Thus, a separate chapter with analysis of fertility for twenty-two Asian states can be found in the publication.

Basically, the authors of this chapters try to focus specifically on fertility preferences and put these issues into the overall context of family behavior and fertility in the country under review. In addition to second chapter, the section on gender preferences with the impact on fertility is also often addressed. From these two points of view, the publication maintains internal unity. Otherwise, the content of the chapter was obviously more about the choice of authors, because the analyzed data and points of view from which the issue is examined varies between chapters. Of course, this is partly necessary due to the large number of countries in different Asian regions that are at a different level of demographic development. For example, Taiwan is one of the countries with a world's lowest total fertility rate. The next chapter describes the situation in the young state of Timor-Leste, where, on the contrary, total fertility rates are similar to those

1) Stuart Gietel-Basten, John Casterline, Minja Kim Choe (eds.): *Family Demography in Asia: A Comparative Analysis of Fertility Preferences.* Cheltenham UK: Edward Elgar Pub, 424 p. The eBook version is priced from £22/$31 from Google Play, ebooks.com and other eBook vendors, while in print the book can be ordered from the Edward Elgar Publishing website.

prevailing in states before the first demographic revolution and are among the countries with the highest total fertility in the world. The availability of analyzable data and other understandable implications of this varying level of demographic development of countries are undoubtedly one of the reasons why the view of some countries is much more concise and others are analyzed from more points of view or with using advanced statistical methods and so on Many chapters begin with an interesting historical insight into the political development and population policy of the state, which is necessary for an ordinary reader because of the number of countries included in the publication. As a result, it is possible to observe the demographic consequences of war conflicts, uprisings or measures to facilitate the establishment of a family. At the same time, the authors do not neglect to focus on many factors affecting fertility preferences and gender preferences, such as the impact of changing the status of women in society, the spread of contraception and abortion, family planning, availability and length of education, inheritance, family patriarchism, or the influence of agricultural culture. Of course, a lot of space is devoted to describing differences between personal ideal number of children and actually realized fertility. The authors also focus on the specific features of the course of demographic transitions that differ from analyzed country to for example European countries. From a formal side, the book is on a high standard and does not contain serious flaws. The publication is a very interesting tool for demographers interested in the situation in Asia. It really offers a comprehensive view of fertility on this continent. Reading this book is very useful for getting to know this issue. Even to the professionals on the topic it will definitely bring them new knowledge due to the large amount of analyzed data in publication, some of them were even less accessible in past. The publication will also bring new pieces of knowledge to readers interested in genderpreferences.

The 11th Conference of "Young Demographers" will take place in February 2020

Traditionally, the Conference of Young Demographers offers an exceptional opportunity to spend three days discussing current demographic issues. It gives students and young scientists a chance to learn and get opinions and advice from their more experienced colleagues and teachers from all over the world in a very friendly environment.

The 11th annual Conference of Young Demographers will take place from **5th to 7th February 2019** in Prague at the Faculty of Science, Charles University (Albertov 6, Prague 2). The traditional topic of the conference *"Actual Demographic Research of Young Demographers (not only) in Europe"* is as wide as possible so that the conference can be open to demographers and other scientists with various research interests and orientations.

All the participants will have an opportunity to present their current research and discuss it with colleagues from other countries or fields of study. Although the conference is primarily intended for PhD students of demography, all young (or a bit older) researches (not only demographers) are welcome. The working language of the conference is English.

It is our pleasure to announce that this year there will be two keynote lectures given by Domantas Jasilionis and Tim Riffe, both from the Max Planck Institute for Demographic Research. In his research, Domantas is mainly focusing on socio-economic inequalities in health. Tim focuses on formal demography with a special emphasis on demographic data visualization.

As a part of a conference, there will also be a workshop organized by Alyce Raybould (London School of Hygiene and Tropical Medicine) and Michaela Šedovičová (London School of Economics and Political Science), both PhD students in Demography.

At the end of the conference, the SAS Institute of the Czech Republic and the Institute of Sociology of the Czech Academy of Sciences, partners of the conference, will hand out an award for the best presentation using SAS software and the best presentation with a social context.

A session for non-demographers is planned again. For this session, topics on which demographers may share common scientific ground with researches from other fields are planned and perhaps new areas of cooperation could be developed.

The final programme of the conference will be announced in January 2020.

Except from the Young Demographers, the event is supported by the Department of Demography and Geodemography, Geographical Institute (Faculty of Science of Charles University), SAS Institute of the Czech Republic and the Czech Statistical Office.

If you are interested in passive participation at the conference, please visit our website (www.demografove.estranky.cz/en/). The passive participation registration will be opened until 1st February. More information about the conference and workshop can be found online (http://www.demografove.estranky.cz/en) or you can follow us on Facebook (http://www.facebook.com/young.demographers). In case of any questions please feel free to contact us at the e-mail address (yd.demographers@gmail.com). We are looking forward to meeting you in Prague!

On behalf of the Organizing Committee.

Anna Altová, Oldřich Hašek, Klára Hulíková, Miroslav Chráska, Barbora Janáková, Olga Kurtinová, Kateřina Maláková a Jitka Slabá

IN BETWEEN CITY AND VILLAGE: THE DEVELOPMENT OF SPATIAL PATTERNS OF CZECH SUBURBANISATION 1997–2016

Martin Ouředníček[1] – Adam Klsák[2] – Petra Špačková[3]

INTRODUCTION

Although the suburbanisation process is one of the most studied issues within CEE urban studies, most work published during the last two decades has looked at separate case studies of individual cities (*Kok–Kovács,* 1999; *Nuissl–Rink,* 2005; *Ouředníček,* 2007; *Krišjāne–Bērziņš*, 2012; *Šveda–Madajová–Podolák*, 2016). The comparison of the scope and intensity of suburban development on the national level lacks a common methodological approach and a generally accepted definition of the process itself. Consequently, relatively different measurements used in the case studies (*Timár–Váradi,* 2001; *Tammaru et al.,* 2013) obstruct any rigorous comparison of the process between cities and countries.

Moreover, many social and demographic processes are influenced by uneven regional distribution of population, migration and demographic behaviour. Groups of municipalities classified according to population size are almost solely employed as a crucial descriptive tool for the spatial and hierarchical distribution of population in Czechia. However, these groupings are often inadequate for distinguishing geographical position within the settlement system. One of the best-known efforts to distinguish the horizontal position of settlements is the classification of exposed municipalities (*Hampl–Gardavský–Kühnl,* 1987: 124–128 and Figure 2). Today, the suburbanisation process has a distributive function in new migration in terms of age and social status and creates spatial differences between peripheral and suburban municipalities. Thus, the geographical position of the municipality plays a crucial role for the evaluation of contemporary demographic, social and economic processes within the settlement system.

The assessment of the scope of suburbanisation within the hinterlands of Czech cities is one of the core issues of both pure and applied research of settlement geography and related disciplines. The main objective of this article is to furnish a coherent methodology for the delimitation of suburban municipalities in Czechia, to describe and explain the scope and spatial distribution and to compare the development of residential suburbanisation during two distinct periods: 1997–2008 and 2009–2016. The article uses the delimitation of zones of residential suburbanisation (*Ouředníček–Špačková–Novák,* 2013; *Ouředníček–Špačková–Klsák,* 2018), as an analytical tool for the evaluation of positional aspects of municipalities within the Czech settlement system.

DEFINITION OF SUBURBANISATION AND SUBURBAN MUNICIPALITIES

Suburbanisation is defined as process of deconcentration of population and its activities from

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the cores of metropolitan regions to their hinterland (similarly *Timár–Váradi,* 2001; *Tammaru et al.,* 2013). The deconcentration of economic and leisure time activities, logistics, offices, industry and services is not evaluated in this article. Instead, we focus on residential suburbanisation, as a partial process of suburbanisation closely linked to the population and housing function. Using Czech statistical information, residential suburbanisation can be taken as migration (change of permanent residency) of population from the core cities of metropolitan regions towards their hinterlands.

A matrix of nine different urbanisation processes is presented in Table 1. According to the analytical matrix, traditional urbanisation processes (urbanisation, suburbanisation, counterurbanisation and reurbanisation) are results of migration from different types of settlement – i.e. urbanisation is migration from countryside to cities, counterurbanisation from cities and suburbs to the countryside etc. The change of residential environment is a crucial factor in the urbanisation process which creates tensions and gradual adaptations of the incoming population to a new physical, functional and social environment. These tensions are consequently the main topics of empirical investigation in urban geography, sociology and demography (*Špačková–Ouředníček,* 2012). Moreover, the inflow of new residents and new residential construction are also crucial problems for the decision-making sphere, municipalities and planning authorities (*Feřtrová–Špačková–Ouředníček*, 2013). On the other hand, migration within the same type of settlements is much less interesting for academic research, even when migration moves within the urban space or between rural municipalities make up by far the largest group of moves between different types of settlements. The impact of this type of migration on tensions between the aspirations, requirements and wishes of the newly incoming population and the actual equipment, conditions and social structure of target settlements is relatively small.

To refine the definition of suburbanisation, we can distinguish seven different processes of suburban development (*Ouředníček,* 2007) and we argue that these processes have specific consequences for the local social and functional environment. Therefore, the character and minimal intensity of new housing construction was considered as the second factor of our definition. In the case of migration from the core city to the suburban hinterland there are four special migration streams according to types of housing: (i) suburbanisation (migration to a new house); (ii) migration to older houses (former villages); (iii) elderly migration (to social care institutions); and (iv) migration to recreational houses (cottages). All these types of migrations are relatively common within the hinterlands of Czech cities. Finally, suburbanisation is defined as the migration of population from the core city to new houses constructed within its hinterland. Our approach to the delimitation of suburban space used in empirical part of the article is based exactly on this definition. A suburban municipality is delimited as a place with a certain minimal level of housing construction (see Table 2) and share of new population in-migrated from the core city. The exact values of indicators are described in the following methodological section.

METHODS AND DATA

The main idea of the methodological approach is to distinguish three basic types of Czech municipalities: (i) cities and towns as core source

Table 1 Matrix of source and target types of settlement and definition of suburbanisation (and other urbanisation processes)

Type of settlement		Target of migration		
		City	Suburb	Countryside
Source of migration	City	Intra and inter-city migration	SUBURBANISATION	Counterurbanisation
	Suburb	Reurbanisation	Tangential migration	Counterurbanisation
	Countryside	Urbanisation (reurbanisation)	Urbanisation	Rural migration

areas of suburban migration and representatives of an urban environment; (ii) suburban municipalities; and (iii) rural villages and small towns which are only marginally influenced by suburban development. Municipalities with 10,000 or more permanently resident inhabitants were selected as cores of suburban migration (total number of 130 core municipalities). This population threshold was chosen during the 2000s when it was not likely that towns smaller than the centres of administrative districts (*okres*) would be significantly influenced by suburbanisation process. However, today it is more and more obvious that all selected cores of suburbanisation have at least one suburban satellite settlement and it is highly probable that some smaller towns also generated decentralisation of the residential function to their own hinterlands. To secure similar samples of core cities for the two periods of observation, we have decided to maintain the same threshold of 10,000 inhabitants[4)] for the newer delimitation.

As a second step, we developed a method for the selection of suburban municipalities. Based on the theoretical and methodological discussion of the delimitation of suburbanisation process above, we can measure residential suburbanisation in the specific context of Czech statistical evidence. We employ two statistical sources, which are available at the level of municipalities and are supplied annually by the Czech Statistical Office: (i) records of migration; and (ii) data on housing construction. Although both statistics have some drawbacks, they provide relatively massive samples which are available at the level of municipalities. Moreover, we use longer periods of evaluation to smooth annual variations in the case of less populous municipalities.

The combination of a minimal intensity of housing construction and the number of completed apartments serves as criteria for the distribution of municipalities into three zones of suburbanisation. We decided to employ a slightly different criterion for the threshold values of new housing construction within the first and second periods. These values are described in the Table 2 below. Suburbanisation is defined as migration from the core cities to municipalities within their hinterland. We measured the share of in-migrated persons on the total number of in-migrated persons to the municipality in selected periods (1997–2008 and 2009–2016). Then, the minimal share of migration from the core city to a municipality was set at 30 per cent in the case of one core city and 40 per cent in the case of two or three core cities[5)]. The whole set of suburban municipalities was then structured into three zones with different intensities of housing construction (see Table 2). We also delimitated a fourth zone containing all municipalities which met the criteria in the past, but whose migration and housing construction have weakened or become restricted and do not fulfil the threshold values for the current delimitation. We have distinguished two different periods of suburban development: an initial phase

Table 2 Threshold criteria for the delimitation of three zones of residential suburbanisation in 1997–2008 and 2009–2016

Zones according to intensity of suburbanisation	Minimal average intensity of annual housing construction in both periods	Minimal absolute number for housing construction in 1997–2008 (2009–2016 respectively)
Zone 1	10 apartments per 1000 inhabitants	50 (34) apartments
Zone 2	5 apartments per 1000 inhabitants	30 (20) apartments
Zone 3	-	20 (14) apartments

Source: *Ouředníček–Špačková–Novák*, 2013; *Ouředníček–Špačková–Klsák*, 2018

4) Municipalities, which meets the conditions for being classified as suburbs by its characteristics are not considered as core cities. This is the case of Říčany, Brandýs n. Labem-Stará Boleslav, Čelákovice and Milovice in Prague Metropolitan Area and Kuřim in Brno Metropolitan Area. These exceptions were determined manually with respect to the context and qualification of authors.

5) There are also suburban municipalities with two or more sources (core cities) in Czechia. So, the threshold of minimal in-migration share was set-up to 40 percent of in-migration from the two and three core cities altogether.

and gradation of suburbanisation during 1997–2008 and the period of economic crisis and contemporary development during 2009–2016.

The methodology for the first evaluated period (1997–2008) is thoroughly described and discussed in the final chapter of the book *Sub Urbs* (*Ouředníček–Špačková–Novák*, 2013), the new delimitation is published on the website www.atlasobyvatelstva.cz (*Ouředníček–Špačková–Klsák,* 2018). The methodology was officially certified by the Ministry of Regional Development (*Ouředníček–Špačková–Novák,* 2014) and the two older delimitations are presented in the form of specialised maps (Špačková *et al.,* 2012; 2016). The distribution of Czech municipalities into the three categories: core cities, suburbs and rural municipalities is available in the form of geodatabase and excel file online: http://www.atlasobyvatelstva.cz/cs/zony-2016.

SCOPE OF RESIDENTIAL SUBURBANISATION

The scope of residential suburbanisation in Czechia can be measured by the absolute and relative numbers of municipalities or inhabitants living within suburban zones (Tables 4 and 5). It is not surprising that all the indicators used here grow through the evaluated periods. The structure of municipalities sorted into the three basic categories – cities, suburbs, and rural municipalities – through the four different delimitations of residential suburbanisation is shown in Table 3. The stable sample of core cities and the gradually growing share of municipalities within the first and second zone are pronounced. On the other hand, the number of municipalities within the third zone was increasing only till 2010 and since then has slowly fallen. However, by definition, municipalities once influenced by suburban development remain as a specific category under zone 4, and their number is, logically, growing. The situation is evaluated in more detail in the next section focused on spatial patterns of suburbanisation. Finally, the number of rural municipalities decreased by 575 units between 2008 and 2016.

The population living in suburban municipalities (1st-3rd zones) increased from 1,314,000 in 2008 to 1,438,000 in 2016. This does not of course mean that all these people can be counted as newly in-migrated suburbanites. We can estimate approximately one third of the population in suburban municipalities as new incomers. i.e. roughly 5 per cent of the total population of Czechia, which is a surprisingly low number. This can be derived from the share of in-migrants per 100 permanently resident inhabitants (third rows in Tables 4 and 5). Moreover, the intensity of in-migration to suburbs is gradually increasing from 28 per mille in 1997–2008 to 37 per mille in the 2009–2016 period, and the intensity is very high especially within the first zone (more than 50 per mille). Thus, the suburbanisation process is far from ended and will no doubt play a significant role in the future.

Table 3 The structure of municipalities in zones of residential suburbanisation in 2008, 2010, 2013 and 2016

Type of settlement	Delimitation 2008	Delimitation 2010	Delimitation 2013	Delimitation 2016
Core cities	129	130	130	130
Zone 1	*83*	*112*	*141*	*216*
Zone 2	*179*	*241*	*333*	*469*
Zone 3	*632*	*771*	*745*	*497*
Zone 4	*163*	*NA*	*206*	*440*
Suburbs 1–3 altogether	894	1,124	1,219	1,182
Rural municipalities	5,073	4,996	4,695	4,498

Source: Ouředníček–Špačková–Klsák, 2018
Note: Total number of municipalities in each type and year.

Table 4 Basic characteristics of municipalities within the 1st, 2nd and 3rd zones of residential suburbanisation in 1997–2008

Indicator	Zone 1	Zone 2	Zone 3	Total
Number of municipalities	83	179	632	894
Number of population (2008)	96,000	190,000	1,028,000	1,314,000
Average share of in-migrated inhabitants during the whole period 1997–2008	60%	45%	33%	37%
Average annual intensity of in-migration per 1000 inhabitants (1997–2008)	46‰	35‰	25‰	28‰

Source: Ouředníček–Špačková–Novák, 2013

Table 5 Basic characteristics of municipalities within the 1st, 2nd and 3rd zones of residential suburbanisation in 2009–2016

Indicator	Zone 1	Zone 2	Zone 3	Total
Number of municipalities	216	469	497	1,182
Number of population (2016)	286,076	564,800	587,767	1,438,643
Average share of in-migrated inhabitants during the whole period 2009–2016	42%	29%	24%	30%
Average annual intensity of in-migration per 1000 inhabitants (2009–2016)	52‰	37‰	30‰	37‰

Source: Ouředníček–Špačková–Klsák, 2018

SPATIAL DISTRIBUTION OF SUBURBS

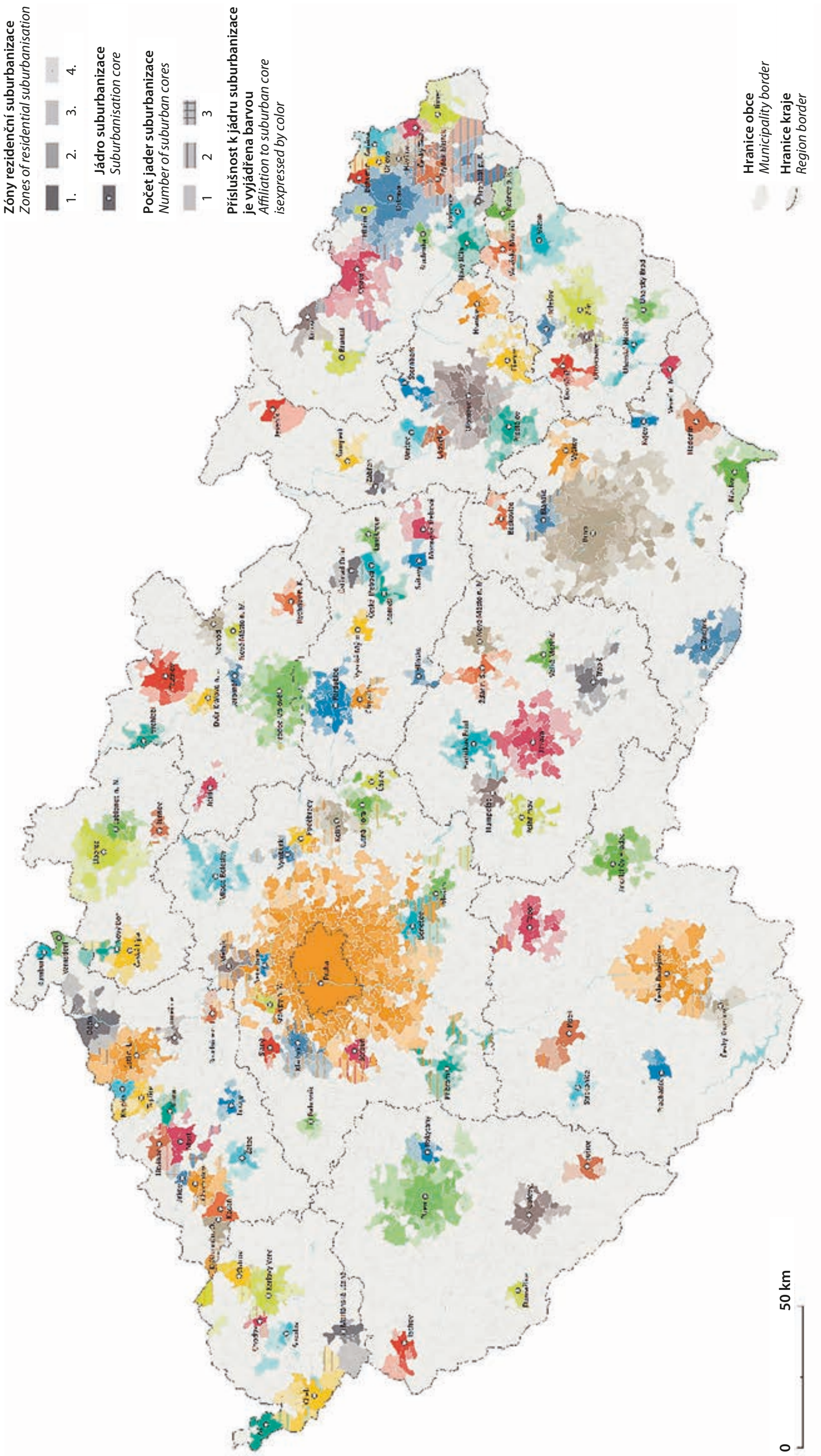
The general description of the scope can be extended by the evaluation of spatial patterns of suburban development. The map in Figure 1 depicts all suburban municipalities and core cities. The three shades of colour correspond to the different intensities of residential suburbanisation (zones 1–3), small crosses inside the choropleths mark the 4th zone of suburbanisation, i.e. 440 municipalities which did not meet the (even softer) criteria for actual delimitation but were recognised as residential suburbs in one or more past delimitations. The map therefore not only shows the actual extension of suburbanisation but also reflects past delimitations.

The interpretation of spatial patterns can be summarised in the following way: (i) suburbanisation is a widespread phenomenon in Czechia; (ii) there are considerable regional differences in the extent of suburban development around cities of similar size categories; and (iii) the spatial patterns have changed significantly between the 2000s and 2010s.

Ad (i) The map clearly shows that suburbanisation is a relatively widespread process, which hit not only capital city and regional centres, but literally every small town within Czechia. All 130 selected core centres of suburbanisation display a spatial connection to at least one suburban municipality which fulfilled the criteria of housing construction and share of in-coming population. This finding is very important because no literature was published on the suburbanisation around small cities until now. There is not enough space to thoroughly discuss the reasons for such extensive suburban development, which is relatively specific to Czechia. Fragmentation of the settlement system and especially the system of master planning with stricter control of housing construction inside administrative boundaries of cities and less control and knowledge about core planning principles within the smaller adjacent municipalities are definitely among the main factors in such development (*Feřtrová–Špačková–Ouředníček,* 2013).

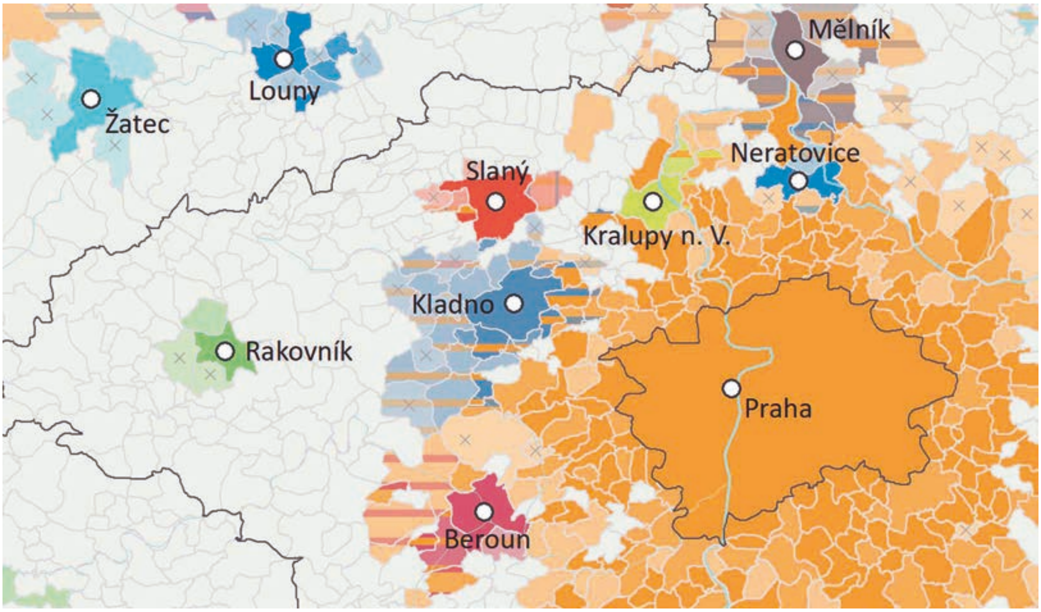
Ad (ii) However, the spatial distribution of suburbanisation is far from uniform in pattern. Economic development within the successful and unsuccessful urban regions significantly influences purchasing power, housing construction and deconcentration tendencies in cities of similar

Figure 1 Zones of residential suburbanisation in Czechia 2016



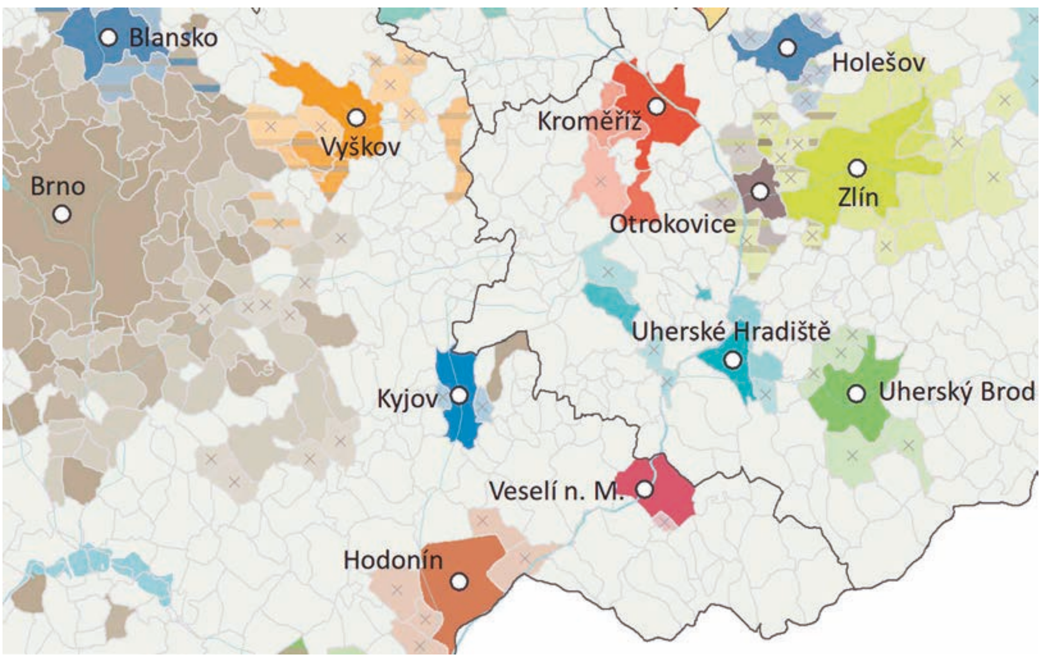
Source: Ouředníček–Špačková–Klsák, 2018

Figure 2 Zones of residential suburbanisation in Czechia 2016 – detailed view of west of Prague



Source: Ouředníček–Špačková–Klsák, 2018

Figure 3 Zones of residential suburbanisation in Czechia 2016 – detailed view of east of Brno



Source: Ouředníček–Špačková–Klsák, 2018 population size. This is very visible in a comparison of the suburban ring between Ústí nad Labem with only a number of suburban developments and České Budějovice or Mladá Boleslav with very intensive development.

Ad (iii) A relatively high number of crosses on the map can be interpreted as a shrinkage or contraction of suburban development during the second period after the economic crisis. During the 2000s all cities and towns had their own satellite settlement, whereas now many smaller cores are surrounded only by municipalities categorised as the 4th zone. While the suburbanisation during the 2000s could be described as a spread of suburbanisation due to hierarchical and neighbourhood diffusion, spatial development during the 2010s has the reverse character, i.e. contraction or concentration of suburban development to selected municipalities located closer to regional centres. Suburban construction and migration around smaller towns have almost disappeared (Rakovník, Žatec, Kyjov, Veselí na Moravě, Uherský Brod) and the edges of the Prague and Brno hinterlands also display a considerable number of municipalities belonging to the 4th zone of residential suburbanisation (see details in Figures 2 and 3). It seems that, at least currently, suburbanisation has reached spatial limits and new housing construction will not expand to more distant settlements. However, other processes of suburban development (transformation of second housing, migration to older houses) and also counterurbanisation processes are likely to increase in the near future.

DISCUSSION AND CONCLUSION

The dataset of residential suburbs provides a basis for determining the extent of residential suburbanisation in Czechia and an analytical tool for assessing settlement structure. In addition to the size categorisation of municipalities based on the number of residents, municipalities are also divided according to their geographic position and the dynamics of their migration growth. Three zones of suburban municipalities with different intensities of housing construction and the structure of in-migration were defined. The suburbanisation zones can be seen as one of the possible types of delimitation of metropolitan areas, in addition to traditional commuting ties (*Ouředníček et al.,* 2018). Compared to commuting regions, which are mainly based on the impact of the job function, zones of residential suburbanisation represent areas of urban population spread, indirect urbanisation and the lifestyle that new suburbanites bring from the urban environment (*Doležalová–Ouředníček,* 2006).

According to this methodology, a total number of 1,182 municipalities in Czechia were identified, whose development is significantly influenced by the process of suburbanisation. In 2016 1.4 million inhabitants lived in the suburbs most affected by the suburbanisation process. Approximately, one third of them have moved from the core city, therefore 5 per cent of the total population of Czechia could be classified as suburbanites. International comparison of this value is relatively obstructed due to a lack of information on the national levels and different measurements of suburbanisation, but we could roughly compare the situation in the USA. According to the American Housing Survey, more than 52 per cent of Americans categorise their household as suburban (AHS, 2017), when distinguishing between suburbs and exurbs it is 38.5 and, 17.8 per cent respectively (56.3 per cent; *Johnson–Shifferd,* 2016). Although no similar comparison with European countries is available, the scope of residential suburbanisation in this light is relatively low in Czechia.

The descriptive statistics and cartographic analysis of residential suburbanisation during the two selected periods – 1997–2008 and 2009–2016 – show relatively significant changes in spatial patterns of suburban development. Generally, this can be explained as a shift from an extensive to an intensive form of residential suburbanisation. Although housing construction did not extend significantly to other parts of metropolitan regions, the intensities of migration and housing construction are even higher, thus creating more concentrated development closer to regional centres. Suburbs located around small towns and at the edges of larger metropolitan areas have at least temporarily halted suburban development.

This intensive residential suburbanisation described during the 2010s confirms that suburban municipalities are more and more integrated into daily urban systems of wider metropolitan regions with intensive commuting to core cities but also dispersion of specific activities important for the complex functioning of metropolitan region, i.e. logistics, shopping, entertainment and recreational activities. Today, a typical feature is the appearance of new suburban nodes which serve as centres of regional and local commuting and create new micro-regions with a concentration of administrative functions, retail, primary and secondary education and a wide spectrum of services. This development has subsequently led to creation of new jobs, many of them tightly connected to (induced by) the growing demand of the new suburban population. The impacts of suburbanisation on functional differentiation of the Czech metropolitan regions is beyond the scope of this article.

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Population and vital statistics of the Czech Republic 2018: cohesion regions and regions

Cohesion region (NUTS 2), region (NUTS 3)	Population 1 July	Population 31 December	Marriages	Divorces	Live births	Abortions	Deaths			Increase (decrease)			Marriages	Divorces	Live births	Deaths	Total increase
							Total	Within 1 year	Within 28 days	Natural	Net migration	Total	per 1,000 inhabitants				
Czech Republic	10,626,430	10,649,800	54,470	24,313	114,036	32,952	112,920	292	187	1,116	38,629	39,745	5.1	2.3	10.7	10.6	3.7
Praha	1,301,135	1,308,632	6,549	2,798	15,460	4,104	12,417	31	20	3,043	11,076	14,119	5.0	2.2	11.9	9.5	10.9
Střední Čechy	1,360,998	1,369,332	6,656	3,397	14,776	4,232	13,687	24	13	1,089	15,448	16,537	4.9	2.5	10.9	10.1	12.2
Jihozápad	1,223,510	1,226,805	6,441	2,825	12,830	3,826	12,972	31	18	-142	5,935	5,793	5.3	2.3	10.5	10.6	4.7
Severozápad	1,115,865	1,115,685	5,930	2,784	10,854	4,296	12,829	41	23	-1,975	894	-1,081	5.3	2.5	9.7	11.5	-1.0
Severovýchod	1,511,421	1,513,693	7,704	3,393	15,928	4,682	16,257	44	30	-329	3,296	2,967	5.1	2.2	10.5	10.8	2.0
Jihovýchod	1,693,748	1,696,941	8,845	3,748	19,024	4,553	17,819	43	33	1,205	3,613	4,818	5.2	2.2	11.2	10.5	2.8
Střední Morava	1,215,407	1,215,413	6,060	2,702	12,777	3,579	13,290	36	23	-513	-308	-821	5.0	2.2	10.5	10.9	-0.7
Moravskoslezsko	1,204,346	1,203,299	6,285	2,666	12,387	3,680	13,649	42	27	-1,262	-1,325	-2,587	5.2	2.2	10.3	11.3	-2.1
Hlavní město Praha	1,301,135	1,308,632	6,549	2,798	15,460	4,104	12,417	31	20	3,043	11,076	14,119	5.0	2.2	11.9	9.5	10.9
Středočeský kraj	1,360,998	1,369,332	6,656	3,397	14,776	4,232	13,687	24	13	1,089	15,448	16,537	4.9	2.5	10.9	10.1	12.2
Jihočeský kraj	640,909	642,133	3,407	1,439	6,748	2,163	6,696	21	12	52	1,885	1,937	5.3	2.2	10.5	10.4	3.0
Plzeňský kraj	582,601	584,672	3,034	1,386	6,082	1,663	6,276	10	6	-194	4,050	3,856	5.2	2.4	10.4	10.8	6.6
Karlovarský kraj	295,285	294,896	1,631	678	2,755	975	3,491	13	9	-736	-54	-790	5.5	2.3	9.3	11.8	-2.7
Ústecký kraj	820,580	820,789	4,299	2,106	8,099	3,321	9,338	28	14	-1,239	948	-291	5.2	2.6	9.9	11.4	-0.4
Liberecký kraj	441,608	442,356	2,265	1,000	4,725	1,702	4,705	18	12	20	1,036	1,056	5.1	2.3	10.7	10.7	2.4
Královéhradecký kraj	550,688	551,021	2,791	1,273	5,677	1,641	6,024	12	8	-347	279	-68	5.1	2.3	10.3	10.9	-0.1
Pardubický kraj	519,125	520,316	2,648	1,120	5,526	1,339	5,528	14	10	-2	1,981	1,979	5.1	2.2	10.6	10.6	3.8
Kraj Vysočina	509,019	509,274	2,689	1,064	5,430	1,335	5,277	15	11	153	205	358	5.3	2.1	10.7	10.4	0.7
Jihomoravský kraj	1,184,729	1,187,667	6,156	2,684	13,594	3,218	12,542	28	22	1,052	3,408	4,460	5.2	2.3	11.5	10.6	3.8
Olomoucký kraj	632,547	632,492	3,204	1,417	6,699	1,896	6,952	24	17	-253	-433	-686	5.1	2.2	10.6	11.0	-1.1
Zlínský kraj	582,860	582,921	2,856	1,285	6,078	1,683	6,338	12	6	-260	125	-135	4.9	2.2	10.4	10.9	-0.2
Moravskoslezský kraj	1,204,346	1,203,299	6,285	2,666	12,387	3,680	13,649	42	27	-1,262	-1,325	-2,587	5.2	2.2	10.3	11.3	-2.1

Radek Havel

Population and vital statistics of the Czech Republic 2018: towns with more than 50,000 inhabitants

Town	Population 1 July	Population 31 December	Marriages	Divorces	Live births	Abortions	Deaths	Increase (decrease)			Marriages	Divorces	Live births	Deaths	Total increase
								Natural	Net migration	Total	per 1,000 inhabitants				
Praha	1,301,135	1,308,632	6,549	2,798	15,460	4,104	12,417	3,043	11,076	14,119	5.0	2.2	11.9	9.5	10.9
Brno	379,526	380,681	2,018	868	4,749	1,102	4,236	513	641	1,154	5.3	2.3	12.5	11.2	3.0
Ostrava	289,629	289,128	1,509	639	3,163	951	3,491	-328	-994	-1,322	5.2	2.2	10.9	12.1	-4.6
Plzeň	171,707	172,441	871	402	1,860	452	1,859	1	1,504	1,505	5.1	2.3	10.8	10.8	8.8
Liberec	104,163	104,445	563	252	1,181	407	1,043	138	328	466	5.4	2.4	11.3	10.0	4.5
Olomouc	100,408	100,523	517	224	1,262	342	1,054	208	-179	29	5.1	2.2	12.6	10.5	0.3
České Budějovice	93,984	94,014	546	252	1,071	375	1,004	67	84	151	5.8	2.7	11.4	10.7	1.6
Ústí nad Labem	93,020	92,952	508	251	1,047	377	983	64	-152	-88	5.5	2.7	11.3	10.6	-0.9
Hradec Králové	92,763	92,742	485	240	991	231	1,046	-55	-120	-175	5.2	2.6	10.7	11.3	-1.9
Pardubice	90,458	90,688	431	216	957	236	952	5	348	353	4.8	2.4	10.6	10.5	3.9
Zlín	74,835	74,997	356	175	772	255	784	-12	62	50	4.8	2.3	10.3	10.5	0.7
Havířov	72,146	71,903	389	191	681	268	919	-238	-241	-479	5.4	2.6	9.4	12.7	-6.6
Kladno	68,971	69,054	355	191	743	307	804	-61	311	250	5.1	2.8	10.8	11.7	3.6
Most	66,401	66,186	345	149	648	287	751	-103	-355	-458	5.2	2.2	9.8	11.3	-6.9
Opava	56,834	56,638	313	130	577	161	650	-73	-308	-381	5.5	2.3	10.2	11.4	-6.7
Frýdek-Místek	56,066	55,931	266	132	591	205	563	28	-431	-403	4.7	2.4	10.5	10.0	-7.2
Karviná	53,209	52,824	239	115	466	188	741	-275	-423	-698	4.5	2.2	8.8	13.9	-13.1
Jihlava	50,891	50,845	247	150	520	150	540	-20	141	121	4.9	2.9	10.2	10.6	2.4

Radek Havel

Abstracts of Articles Published in the Journal Demografie in 2019 (Nos. 1–3)

Ladislav Průša

WHO CARES FOR OUR SENIORS?

Population ageing is exerting a direct effect on all EU countries. Population structures are changing significantly, and the demands placed on individual social systems are increasing. In expert discussions, continuous attention is being devoted to issues surrounding long-term pension-system sustainability and, in recent years, attention has also focused on social services and health-care issues. The lessons learned so far have revealed that the social services system is not prepared for the consequences of an ageing population. Many social services providers are already facing a shortage of social workers and in most regions waiting times for placement in residential facilities are increasing, field social services are not being further developed, and the support provided by carers is insufficient. The aim of this paper is to attempt to quantify the expected increase in the need for skilled workers in the social services sector so that these services will continue to be provided at a high-quality level.

Keywords: social services, population ageing, international comparisons, care allowance

Demografie, 2019, **61: 5–18**

Katarína Rožeková – Michala Lustigová

THE IMPACT OF OVERWEIGHT AND OBESITY ON THE RISK OF DEATH FROM CANCER IN THE CZECH POPULATION

The article analyses the population's attributable mortality risk on selected malignant neoplasms in 2016 that could be attributed to excessive BMI in the Czech population, taking into account the eight-year gap between exposure and cancer mortality by gender. In Czechia there were 1,902 deaths in 2016 (7% of all malignant neoplasm cases) diagnosed as due to one of the selected types of neoplasms as a result of a long-term high BMI.

Keywords: Czechia, Body Mass Index, cancer, mortality

Demografie, 2019, **61: 19–27**

Jana Křesťanová – Luděk Šídlo – Branislav Šprocha

POPULATION CHANGE IN CZECHIA AND SLOVAKIA ON THE MUNICIPAL LEVEL IN 1996–2015 EXAMINED USING THE WEBB DIAGRAM

The Webb diagram is a method that can be used to compare how much natural change and net migration in a region population contribute to the increase or decrease in the total population. The aim of the article is to evaluate the dynamics of population development in Czechia and Slovakia at the municipal level between 1996 and 2015. By using the Webb diagram, it is possible to clearly compare how natural and migration change

is reflected in the populations in the smallest regional units in both countries. In Czechia the development was more dynamic than in Slovakia, especially in 2006–2010, when there was a bigger change in the spatial pattern of population movement. Population growth in the municipalities was found to be more the result of migration growth and the process of suburbanisation. Population declines were caused by several factors, such as the attractiveness of the given area or the status of the municipality in the hierarchy of municipalities (core vs periphery).

Keywords: Webb diagram, municipalities, natural population change, migration population change, Czechia, Slovakia

Demografie, 2019, **61: 28–41**

Anna Šťastná – Jitka Slabá – Jiřina Kocourková

REASONS FOR THE UNPLANNED POSTPONEMENT AND TIMING OF THE BIRTH OF A SECOND CHILD

The two-child family continues to constitute the most common family model in the Czech Republic. However, the postponement of family formation and childbearing means that second births are being shifted to an older age. Employing data from the 'Women 2016' survey, we analyse both the reasons behind women postponing second childbirth to a later age than originally planned and the effect of fertility postponement on the length of the birth interval between the first and second child.

Keywords: Second birth, fertility postponement, fertility timing, birth interval, the Czech Republic

Demografie, 2019, **61: 77–92**

Hana Hašková – Radka Dudová – Kristýna Pospíšilová

WHY AN ONLY CHILD? FACTORS CONNECTED WITH HAVING A SINGLE CHILD IN THE CR

The article discusses the phenomenon of having a single child in the Czech Republic and summarises the existing knowledge on this topic. Based on Census data from 2011 and representative survey data from the Life Course 2010, it analyses the factors connected with having and intending to have one child. The findings indicate that there is a larger share of mothers with a single child among divorced women than among single and married women of the same age, and that there are associations between being the mother of a single child and living in a larger city and certain professional orientations and occupations. The findings also support the thesis of the effect of values, external conditions and sequential decision-making on the intention to have a single child.

Keywords: one-child families, small families, fertility intentions, low fertility, Czech Republic

Demografie, 2019, **61: 93–110**

Ondřej Nývlt

DIFFERENTIAL FERTILITY IN CZECHIA BASED ON DATA FROM THE HOUSEHOLD PANEL STUDY

The basic aim of the article is to analyse which characteristics are related to the number of children in Czech families. In demography, this subject is referred to as differential fertility. The overall level of fertility is further broken down according to basic demographic, educational, occupational, value, and geographical variables. Unlike standard demographic fertility outputs, the level of fertility is also analysed in relation to men. Historically, the population census has always been the basic source of data on differential fertility. However, this study is mainly based on data from the Czech Household Panel Survey (CHPS)], which allows a more detailed breakdown. In addition, individual characteristics do not relate only to an exact point in time but are derived from the respondents' life course. The results of differential fertility can also take the form of conclusions about a successful or unsuccessful life strategy of the total number of children in Czech families.

Keywords: differential fertility, household survey, number of children in families

Demografie, 2019, **61: 111–128**

Luděk Šídlo – Anna Šťastná – Jiřina Kocourková – Tomáš Fait

IMPACT OF THE MOTHER'S AGE AT CHILDBIRTH ON THE HEALTH OF NEW-BORN CHILDREN IN CZECHIA

The postponement of the fertility of women to higher ages is reflected in increased health risks that may pose a threat to both the mother and the new-born child. The aim of the article is to assess the impact of the age of women at childbirth on the health of the child and the risk of the occurrence of complications during hospitalisation following the delivery. We assume that the health of new-born children can be determined from the course of the hospitalisation. Complications during the hospitalisation of the child or longer hospitalisation periods may be related to the increased need for health care as a result of a weakened state of health following the delivery. The analysis makes use of individual anonymised data obtained from the General Health Insurance Company of the Czech Republic (GHIC CZ) on reported health care for children born in 2014. Using the descriptive statistics and binary logistic regression methods we identify the influence of the mother's age on the incidence of complications with new-born children so as to control other influences that are closely associated with such complications. The results revealed that the advancing age of the mother is related to an increase in the chances of complications during the hospitalisation of the new-born child.

Keywords: mother's age at childbirth, new-born child, health condition, birth weight, IVF, Czechia

Demografie, 2019, **61: 155–174**

Radek Zdeněk – Jana Lososová

OBJECTIVE AND SUBJECTIVE POVERTY OF HOUSEHOLDS IN CZECH REGIONS

This article is focused on the actual and required incomes of Czech households and their differences among regions (NUTS 3). The source data is taken from the SILC survey from 2005 to 2015. Equalised net annual income is selected as the income indicator. For the characteristics of poverty, the poverty rate, the poverty gap ratio and the depth of poverty are used. The required minimum subjective household income is modelled as a function of actual income, household size and region by a regression model with random effects. In addition, the objective and subjective conceptions of poverty and the degree of their compliance in regions are confronted.

Keywords: objective poverty, subjective poverty, regions, random effects

Demografie, 2019, **61: 175–185**

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Articles in periodicals

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Syrovátka, A. 1962b. 'Child Mortality from Automobile Accidents in the Czech Lands.' *Czech Medical Journal*, 101, pp. 1513–1517.

In-text references

(*Srb*, 2004); (*Srb*, 2004: pp. 36–37); (*Syrovátka et al.*, 1984).

Table and figure headings

Table 1: Population and vital statistics, 1990–2010

Figure 1: Relative age distribution of foreigners and total population of CR, 31 Dec 2009

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