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MORTALITY PATTERNS DURING THE TRANSFORMATION ERA IN CZECHIA 1989–2019

David Morávek[1] – Jitka Langhamrová[2]

Abstract

Mortality has decreased during the era of political and socio-economic changes in society since the Velvet Revolution in Czechia in 1989. A reduction in mortality was recorded in the period from 1989 to 2019 among infants and the share of middle and older age groups on the decline has increased. In Czechia, infant mortality has been reduced to one of the lowest at the level of European Union countries. The most common death of an infant occurs in the first days after birth. The reduction in mortality rates also meant an increase in life expectancy at birth. To study the impact of mortality of the different age groups on a change in life expectancy at birth, we used a decomposition method. Moreover, we showed the decrease in a mortality dispersion in life table distribution, nonetheless the greater degree of inequality among men compared to women persists, and deaths have shifted to higher ages. Mortality was further decomposed into senescent and background components based on the logistic model. Senescent mortality, which depends on age, decreased in Czechia during the period of 1989–2019, while background mortality did not show any trend, but rather fluctuations. Mortality from the most common causes of death from diseases of the circulatory system and malignant neoplasms decreased.

Keywords: Mortality, life expectancy, decomposition, cause of death

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INTRODUCTION

The mortality of the population of Czechia has improved since 1989, when the most political and socio-economic changes in society began. This process of transformation has generally had a favourable effect on mortality patterns (*Dzúrová*, 2000). The biggest decline in mortality by causes of death is visible in the case of circulatory diseases, where the reduction in cardiovascular mortality at adult and old ages was crucial for the increase in life expectancy after 1991 (*Fihel – Pechholdová*, 2017). The mortality decline was further influenced by political changes and a rapid transition to an open market economy, resulting in better conditions for improvement in population health (*Rychtaříková*, 2004; *Fiala et al.*, 2018). A healthcare reform took place, private health care was developed, and the availability of effective drugs, especially for the treatment of circulatory diseases, greatly improved. Modern medical technology became available, mainly in the field of non-invasive cardiac surgery (*Rychtaříková*, 2004; *Fiala et al.*, 2018),

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contributing to a profound reduction in cardiovascular mortality (*Fiala et al.*, 2018). Furthermore, one of the underlying reasons was significant change in nutritional habits as a result of the abolition of state subsidies and the liberalization of consumer prices (*Dzúrová*, 2000). Changes in the price system increased the demand for vegetable fats as opposed to animal fats, poultry as opposed to pork and beef, and resulted in more affordable prices of fruits and vegetables – all of which helped to advance a healthier dietary regimen (*Dzúrová*, 2000). Generally, the life expectancy has significantly increased since 1989, nonetheless compared to the developed countries of the European Union, Czechia still lags behind in the achieved level of mortality. The population projection until 2100 produced by the Czech Statistical Office (*CZSO*, 2018) expected a continuing growth in life expectancy based on the growth of life expectancy in Czechia and developed European countries[3)] over recent decades. However, as stated by (*CZSO*, 2018), the value currently reported by Czechia was reached in developed European countries on average 20 years ago. Nevertheless, due to the close connection of Czechia to the European area, it is assumed that future development will follow the trajectory of development observed so far in European countries with a high life expectancy (*CZSO*, 2018).

Deaths of infants under one year of age are given special attention. As is well known, infant mortality is one of the crucial characteristics of a country's level of development in connection with the assessment of the level of health care. The change in mortality is not the same in all ages (*CZSO*, 2018): one of the main features of current developments is the increasing influence of older age groups on the mortality decline (the so-called ageing of mortality decline). The decline in infant mortality has led to an increase in life expectancy in recent decades. Due to the currently relatively low values of infant mortality, no further significant reduction in the values can be expected that would have an impact on an increase in life expectancy at birth (*Arltová et al.*, 2013). In order to describe disparities in lifespan between males and females, we computed the median and modal ages at death, which are considered together with life expectancy as appropriate characteristics describing the distribution of life table deaths (*Cannudas-Romo*, 2010).

Decomposing the difference in life expectancy into age groups is useful in estimating how the mortality of a given age group contributes to the overall difference in life expectancy (*Preston et al.*, 2001). In order to evaluate the impact of mortality of the age group on a change in life expectancy at birth between two periods, we used the decomposition method according to Arriaga (1989). We also proposed a decomposition of mortality into senescent and background mortality based on Kannisto's logistic model. Senescent mortality was investigated as it depends on age (increases with age), while background mortality is constant with age, which allows to further assess the development of mortality separately by these two components. The first one, senescent mortality, is the result of biological aging; it can be postponed through medical intervention, but it cannot be avoided because death is inevitable (*Bongaarts*, 2009). The second one, non-senescent or background mortality, refers to deaths unrelated to aging (e.g. accidents, certain infections, etc.), which can be avoided by effective public health and safety measures and through medical intervention (*Bongaarts*, 2009). Senescent and background mortality are evaluated between 1989 and 2019. Furthermore, the development of estimated parameters based on the selected logistic model over the period of 1989–2019 in Czechia was examined. The selected model is based on a logistic curve, which takes into consideration the deceleration in mortality increase with age, and the model generally operates with a continuous definition of mortality, the so-called force of mortality (*CZSO*, 2018). In addition, the logistic model is also used, for example, for mortality modelling at high ages in the construction of life tables by the CZSO or by the Human Mortality Database (HMD). A logistic model including the Makeham parameter for

3) 15 European countries with good and quality mortality data were monitored: Austria, Belgium, Denmark, Finland, France, Great Britain, (former) West Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland.

background mortality was used for modelling mortality in several studies (see for example *Horiuchi – Wilmoth*, 1998; *Thatcher,* 1999; *Bongaarts*, 2005). Indeed, among the most common models assuming an exponential increase in mortality with age is the well-known model according to Benjamin Gompertz from 1825, later with the addition of constant expressing age-independent mortality to the formula by William Makeham in 1860.

To assess the development of mortality by cause of death in Czechia, a period was chosen from 1994 after the introduction of a revision of the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) in order to have consistent data for comparison over the period. In Czechia, the ICD-10 is introduced by CZSO Communication No. 495/2003 Coll., on the publication of the International Statistical Classification of Diseases and Related Health Problems (ICD-10), effective from 1 January 2004 with its subsequent updates in 2008, 2011, 2012, 2017 and the latest in 2020. Although the introduced classification complies with international standards, the results may be affected due to the methodological changes. Another reason for choosing this period is the availability of data in the Eurostat database since 1994, with the last available year being 2017. To evaluate the mortality of the population by causes of death in the given period, causes of death were selected that have long been among the most common causes in Czechia. The age-standardized death rates (per 100,000 people) based on the European standard population from 2013 were used for comparability of data on mortality by the selected causes of death according to ICD-10 in the given period. The decomposition method was used to assess the effect of the given group of the cause of death group according to ICD-10 on the change in life expectancy at birth between 1994 and 2017. We followed the procedure to evaluate the effect of changes in mortality by the cause of death on the overall change in life expectancy at birth according to Arriaga's proposal (*Arriaga*, 1984; *Arriaga*, 1989), where in the first step the difference between life expectancies at birth is decomposed by the contribution from each age group, and in the second step the contributions from each separate age group were divided into the contributions from each specific cause of death. Due to the fact that diseases of the circulatory system and neoplasms are among the most common groups of causes of death, specific groups of causes of death were also selected for a more detailed assessment of the mortality trend by cause of death for the period of 1994–2017 in Czechia.

DATA AND METHOD

The main data source was the life tables for Czechia for the period of 1989–2019 produced by the Czech Statistical Office. The Eurostat database containing data on mortality by cause of death for Czechia for the period of 1994–2017 was chosen as another data source. Life expectancy at birth, life expectancy at the age of 65 and the infant mortality rate were selected to examine the development of mortality in Czechia. To decompose the overall change in life expectancy at birth by age groups between two periods, Ponnapalli (2005) listed formulas in life table terms of l_x and e_x with regards to Arriaga's original proposal. The total effect *TE* of each age group on a change in life expectancy at birth can be written in the following form:

$$TE_x = l_x^1\left(e_x^2 - e_x^1\right) - l_{x+n}^1\left(e_{x+n}^2 - e_{x+n}^1\right),$$

where l_x^1 and l_{x+n}^1 is the number of surviving at age x and $x + n$ for period 1; e_x^1, e_x^2 and e_{x+n}^1, e_{x+n}^2 are life expectancies at age x and $x + n$ for periods 1 and 2.

For the open-ended age group, the total effect *TE* is calculated as follows (*Ponnapalli*, 2005):

$$TE_x = l_x^1(e_x^2 - e_x^1)\,.$$

In order to describe the disparities in lifespan among males and females, except for life expectancy representing a mean value, we computed the median and modal ages at death. To obtain median age at death *Md* in time *t*, we followed the formula (*Cannudas-Romo*, 2010) using values of the survival function at two contiguous ages $l(x)$ and $l(x+1)$ assuming a linearity in the interval where $l(Md) = 0.5$ is located.

$$Md(t) = x + \frac{\left[0.5 - l(x,t)\right]}{\left[l(x+1,t) - l(x,t)\right]}.$$

The modal age at death *M* expresses the age *x*, where the highest number of deaths occurs in the life table at time *t*. The number of deaths *d* at ages *x*, *x*–1

and $x + 1$ are used to fit a quadratic polynomial to the function describing the death distribution (*Canudas-Romo*, 2008).

$$M(t) = x + \frac{\left[d(x,t) - d(x-1,t)\right]}{\left[d(x,t) - d(x-1,t)\right] + \left[d(x,t) - d(x+1,t)\right]}$$

for x > 5.

For the decomposition of background mortality and senescent mortality, Kannisto's logistic model is considered using the continuous mortality rate μ_x, the so-called force of mortality. The model can be written in the following form (*Thatcher et al.*, 1998; *Thatcher*, 1999):

$$\mu_x = \frac{\alpha e^{\beta x}}{1 + \alpha e^{\beta x}} + c,$$

where x is age and α, β are the parameters of the model, c is a constant.

The sum of these two components equals the force of mortality (*Bongaarts*, 2005). For Kannisto's logistic model, the first term on the right-hand side is equal to the senescent force of mortality, and the background force of mortality corresponds to parameter c in the model (*Bongaarts*, 2005). The goodness of fit is tested using the coefficient of determination R^2. The age range of 20–90 years was chosen in order to estimate the values of model parameters due to the low numbers of deaths in old age and the lower reliability of data on the middle-year population in the oldest age. Makeham (1867), for instance, has neglected the ages under 20 and over 80, on account of the comparative insignificance of the numbers at risk at the excluded ages. Similarly, Bongaarts (2009) used as a threshold age a slightly higher age limit to avoid the "accident mortality hump" around age 20, namely the age of 25 years. With a monotonic increase in mortality with age, the following relationship between the force of mortality and mortality rate at a given age applies approximately (*Thatcher et al.*, 1998):

$$m_x \cong \mu_{x+0.5}.$$

According to Arriaga (1989) for calculating age-cause-specific decomposition we observe in the first step the proportion of change in the cause-specific mortality rates as a share of the total mortality change in the specific age interval. In the second step, we distribute the calculated total effect into specific cause contributions according to the proportions calculated in the first step. In formulas (*Auger et al.*, 2014) as follows:

$${}_nC_x^{(i)} = {}_nC_x \cdot \left[\frac{{}_nR_x^{(i,2)} \cdot {}_nm_x^{(2)} - {}_nR_x^{(i,1)} \cdot {}_nm_x^{(1)}}{{}_nm_x^{(2)} \cdot {}_nm_x^{(1)}} \right],$$

where ${}_nR_x^{(i)}$ is the proportion of deaths between ages x and $x + n$ due to cause i, and ${}_nm_x$ is the all-cause mortality rate between ages x and $x + n$.

MORTALITY DEVELOPMENT IN CZECHIA IN 1989–2019

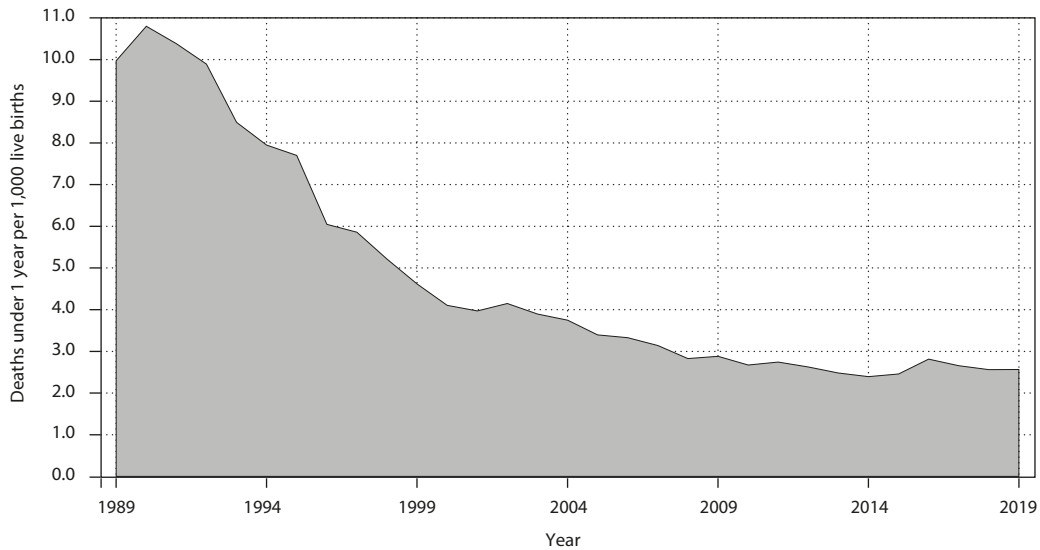
Infant mortality

The reduction in infant mortality has continued during the period of 1989–2019 in Czechia. Figure 1 presents the infant mortality rate in Czechia in 1989–2019. The highest number of infant deaths under one year of age per 1,000 live births was in 1990 (10.8‰). In the period of 1990–2019, infant mortality almost gradually decreased with some fluctuations to 2.6‰ in 2019. Infant deaths under the age of one year are not evenly distributed throughout the year; in general, the most deaths occur in the first days after birth.

Among infant deaths in Czechia in 1989–2019 (Figure 2), the highest share of deaths was from 28 days to one year of life (36.9%), then the share of deaths between the first and sixth day of life followed (26.2%). Deaths between the seventh to 27th day of life accounted for 22.0% and the remaining 14.9% were deaths within 24 hours. Given the range of the category over the 28th day of life to one year of life, it is not surprising that it represented the highest part of the total number of infant deaths. The majority of infant deaths occurred under 24 hours together with deaths between the first and sixth day after birth. The lowest value of share of deaths under one day in the given period was recorded in 2005 (10.1%) and, conversely, the highest value was registered in 2017 (20.4%). In 2014–2019, the share of children who died during the 24 hours after birth was slightly above average. The share of deaths between the first

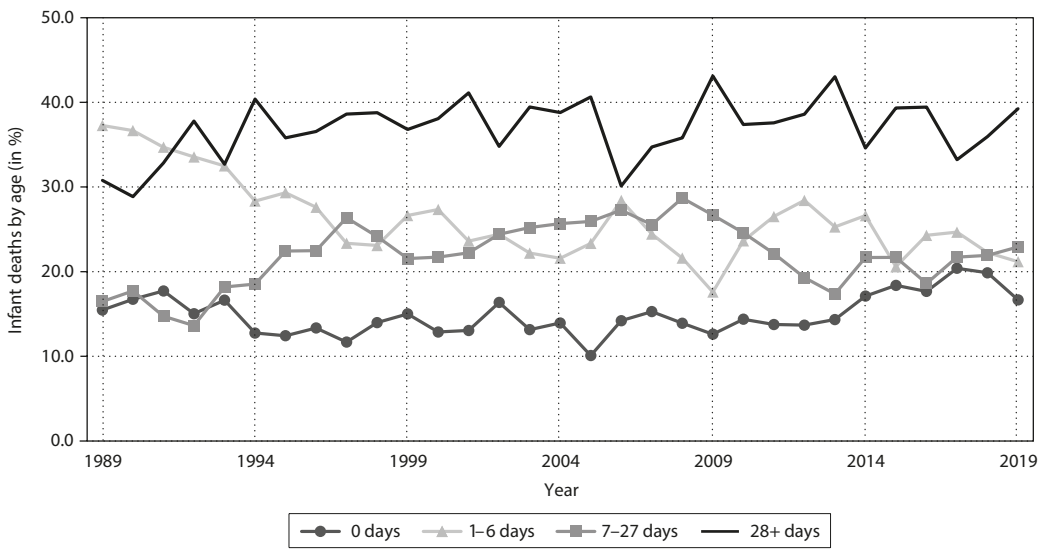
and sixth day of life decreased slightly in the period of 1989–2019. By 2019, the share of deaths between the first and sixth day after birth had fallen by 16.1 percentage points to 21.2% since the year 1989. By 2008, the share of deaths from the seventh to the 27th day of life had increased to 28.7% since the year 1989, followed by a decline to 17.4% (in 2013) and again a slight increase to 22.9% in 2019. Moreover, the share of deaths occurring from 28 days after birth increased from 30.8% in 1989 to 39.2% in 2019.

Figure 1 **Infant mortality rate in Czechia 1989–2019 (in ‰)**



Source: Czech Statistical Office (2020a), author's processing.

Figure 2 **Infant deaths by age in Czechia 1989–2019 (in %)**



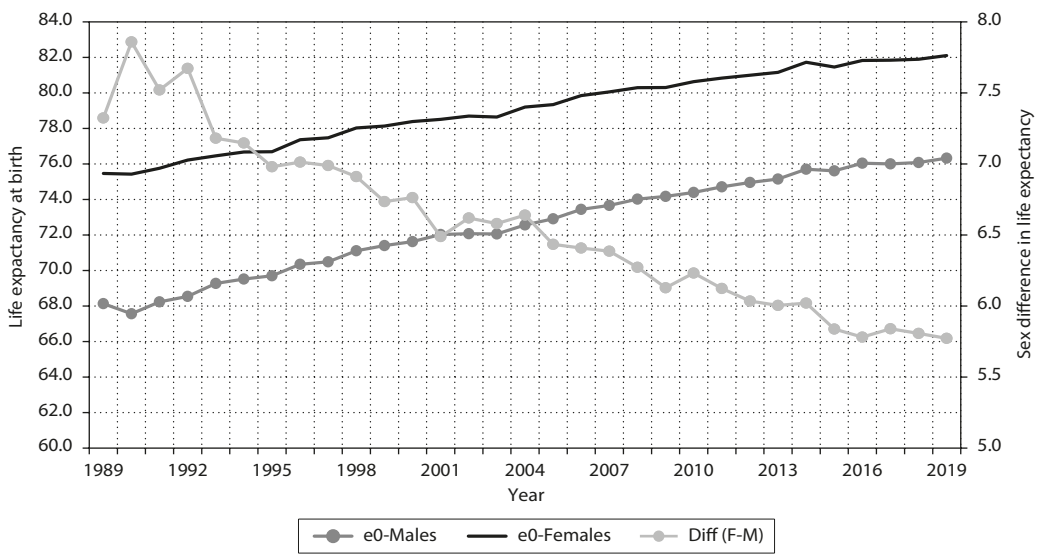
Source: Czech Statistical Office (2020a), author's processing.

Life expectancy

Life expectancy is one of the most used indicators in the study of mortality due to its comparability based on the model of a stationary population. The indicator reflects mortality in all age groups with no dependency on the age structure of the current population. As seen in Figure 3, the length of human life measured by life expectancy at birth increased during the period of 1989–2019 for both men and women in Czechia. Male life expectancy at birth has increased during 30 years by 8.2 to 76.3 years. Female life expectancy at birth increased less than for males, by 6.6 to 82.1 years in 2019. The male excess mortality decreased between the years 1989 and 2019. The highest value of the difference between the sexes was recorded in 1990 (7.9 years). On the other hand, the lowest difference in life expectancy at birth between men and women was in 2019 (5.8 years).

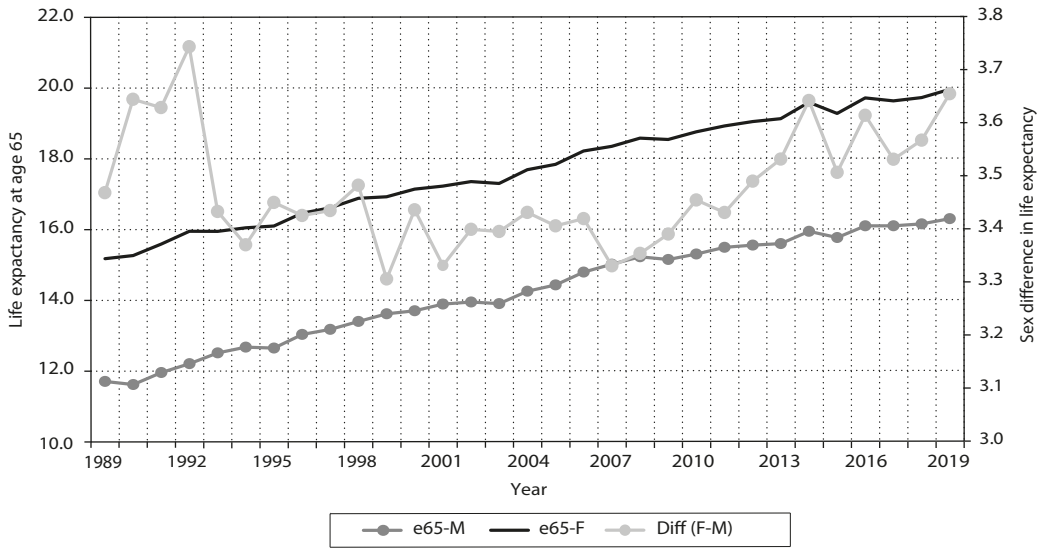
Compared to men, women tend to live longer, but on the other hand they suffer from greater morbidity, especially at an older age. This mortality-morbidity paradox is reported in connection with the longer life expectancy of women (*Austad – Fisher*, 2016). Male excess mortality is one of the recent demographic phenomena that have occurred in connection with the reduction of infections and the increase in mortality from neoplasms and cardiovascular diseases (*Beltrán-Sánchez et al.*, 2015). Male excess mortality has both biological and non-biological origins (*Sundberg et al.*, 2018). Given the generally higher mortality of men, it is interesting to observe the differences in mortality at older ages. Life expectancy at the age of 65 is most often stated, which expresses the length of a person's remaining life at a given age. The advantage of such an indicator is its better assessing of the mortality at a given age, because the person has already "survived" some causes of death occurring in younger ages, for example some of the external causes, and some of the infectious and chronic diseases, etc. Figure 4 shows that male life expectancy at the age of 65 increased between 1989 and 2019 by 4.6 years to 16.3 years. Female life expectancy at the age of 65 increased more compared to men, by 4.8 years to 19.9 years. At the beginning of the period in 1989, the difference in life expectancy between men and women at the age of 65 was around 3.5 years. It can be observed that the difference in the period fluctuated around this value. In particular, lower numbers of deaths at higher ages and the methodology used to model mortality rates may

Figure 3 **Life expectancy at birth by sex in Czechia, 1989–2019**



Note: Diff (F-M) – Female life expectancy minus male life expectancy (at birth).
Source: Czech Statistical Office (2020b), author's processing.

Figure 4 **Life expectancy at age 65 by sex in Czechia, 1989–2019**



Note: Diff (F-M) – Female life expectancy minus male life expectancy (at the age of 65).
Source: Czech Statistical Office (2020b), author's processing.

account for the fluctuations in the time series. The highest difference was recorded in 1992 (more than 3.7 years). On the contrary, the lowest difference was in 1999 (3.3 years). In 2019, the difference was equal to almost 3.7 years.

We calculated the contributions to the overall change in life expectancy at birth by age groups for males and females in the period from 1989 to 2019 (Table 1). The tempo of an increase in life expectancy gradually decreased mostly as a result of a reduction

Table 1 **Contributions to difference in life expectancy at birth by age group and sex, Czechia in 1989–2019**

Age Group	1989–1999		1999–2009		2009–2019		1989–2019	
	m	f	m	f	m	f	m	f
0	0.48	0.28	0.13	0.14	0.01	0.04	0.66	0.47
1–24	0.15	0.07	0.22	0.08	0.06	0.04	0.44	0.19
25–44	0.29	0.20	0.33	0.09	0.20	0.05	0.86	0.36
45–64	1.08	0.66	0.98	0.45	0.99	0.41	3.19	1.62
65–84	1.19	1.35	1.08	1.27	0.76	0.97	2.89	3.61
85+	0.07	0.11	0.03	0.14	0.14	0.30	0.14	0.38
Total	**3.26**	**2.67**	**2.77**	**2.17**	**2.16**	**1.80**	**8.19**	**6.64**
	%							
0	14.84	10.62	4.70	6.35	0.64	2.02	8.11	7.15
1–24	4.58	2.64	7.87	3.47	2.70	2.16	5.41	2.86
25–44	8.74	7.46	12.00	4.15	9.15	2.64	10.51	5.38
45–64	33.13	24.71	35.33	20.95	46.00	22.90	38.89	24.47
65–84	36.58	50.38	39.06	58.63	35.08	53.74	35.34	54.42
85+	2.13	4.19	1.04	6.45	6.43	16.55	1.73	5.73
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

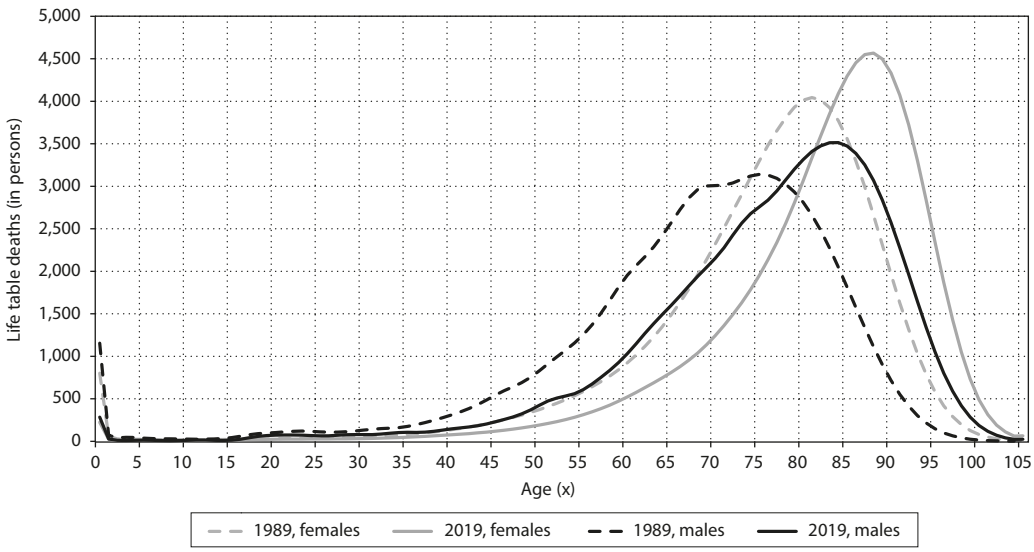
Source: Czech Statistical Office (2020b), author's calculations.

in the contribution of the age group 0 years to the overall change in life expectancy at birth. Since 1989, due to the decrease in infant mortality, life expectancy at birth has increased by 0.66 years for men and 0.47 years for women. The highest contribution was recorded for men in the age group 45–64 years (3.19) and 65–84 years (2.89). Female life expectancy at birth increased the most thanks to the contribution of the age group 65–84 years (3.61) and 45–64 years (1.62). Male life expectancy increased faster than female life expectancy between 1989 and 2019. The difference in life expectancy at birth between 1989 and 2019 equals the total contribution that was calculated at 8.19 years for men and 6.64 years for women. The contributions of the age groups of men exceeded the contributions of the age groups of women up to the age of 65, from which higher contributions were recorded for women. In relative terms, women had a significantly higher contribution of the age group 65–84 than contributions for the other age groups (higher than 50%). The value of contributions for women in the age group of 85 years and above gradually increased. On the contrary, male mortality improved in the younger and middle-aged groups. The contribution of men in the age group 45–64 years increased relatively.

Median and modal age at death

In general, mortality increases with age, which is also sometimes called the law of mortality. In addition, around the age of 20 a so-called "adult mortality hump", or increased mortality, can be observed especially due to external causes of death in young people, particularly for men compared to women. It is known that women have lower mortality compared to men and die at an older age. In Figure 5, we show a comparison of the distribution of male and female life table deaths for Czechia in 1989 and 2019. The change of mortality in the period of 1989 to 2019 showed that deaths shifted to higher ages, both in men and women. In 1989, the modal age at death was calculated at 75.7 years for males and 80.4 years for females. Over the 30 years in 2019, the modal ages are closer to each other (84.0 years for males and 88.2 for females); nonetheless, the greater number of female deaths persists at high ages. The further change of mortality refers to lower mortality dispersion in 2019 compared with 1989. The median age at death was calculated at 70.8 years for males and at 78.2 years for females in 1989. Then in 2019, the median age at death was slightly closer to the life expectancy at birth, with the values of 79.0 years for males and 84.8 years for females in 2019.

Figure 5 **Life table deaths, males and females, Czechia in 1989 and 2019**



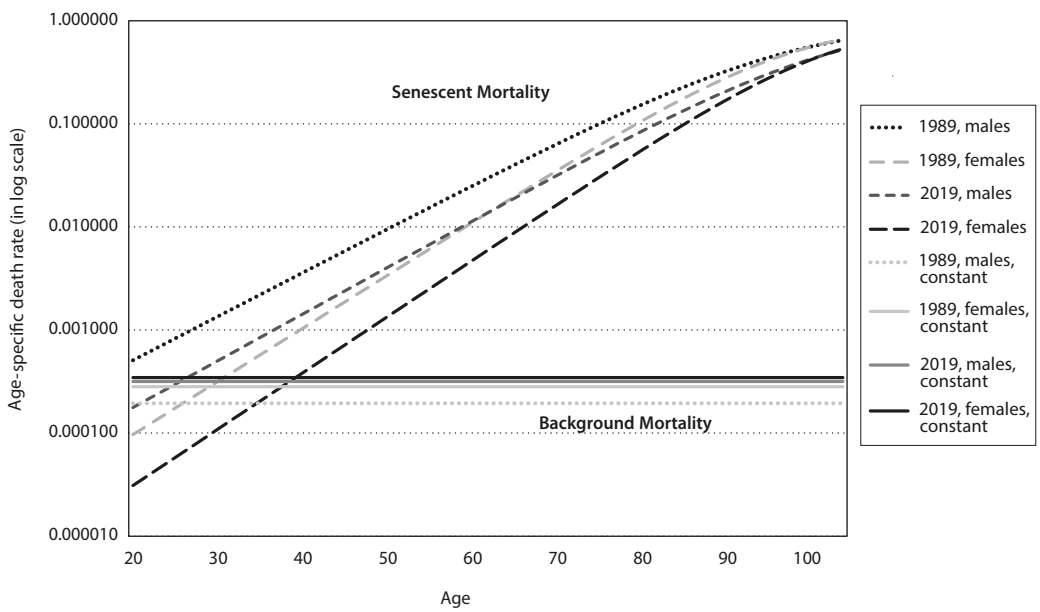
Source: Czech Statistical Office (2020b), author's processing.

Senescent and Background Mortality

The model estimates of senescent and background age-specific death rates in the age group 20–105 years for males and females in Czechia in 1989 and 2019 based on Kannisto's logistic model are shown in Figure 6. The goodness of fit of the model was tested using the R^2 statistic with the following results: 0.9961 (for males in 1989); 0.9988 (for females in 1989); 0.9945 (for males in 2019); and 0.9936 (for females in 2019). Based on the values of R^2, the model can be considered appropriate as the chosen model explained almost 100% of the variability. The estimate of senescent mortality decreased when comparing the years 1989 and 2019, both in men and women. The decrease of senescent mortality is more significant at lower ages as well. The shape of the curves of the estimated senescent mortality showed a slowing increase in the intensity of mortality towards the end of human life (so-called deceleration). The estimated background mortality slightly increased over the period, where the increase was higher for men compared to women.

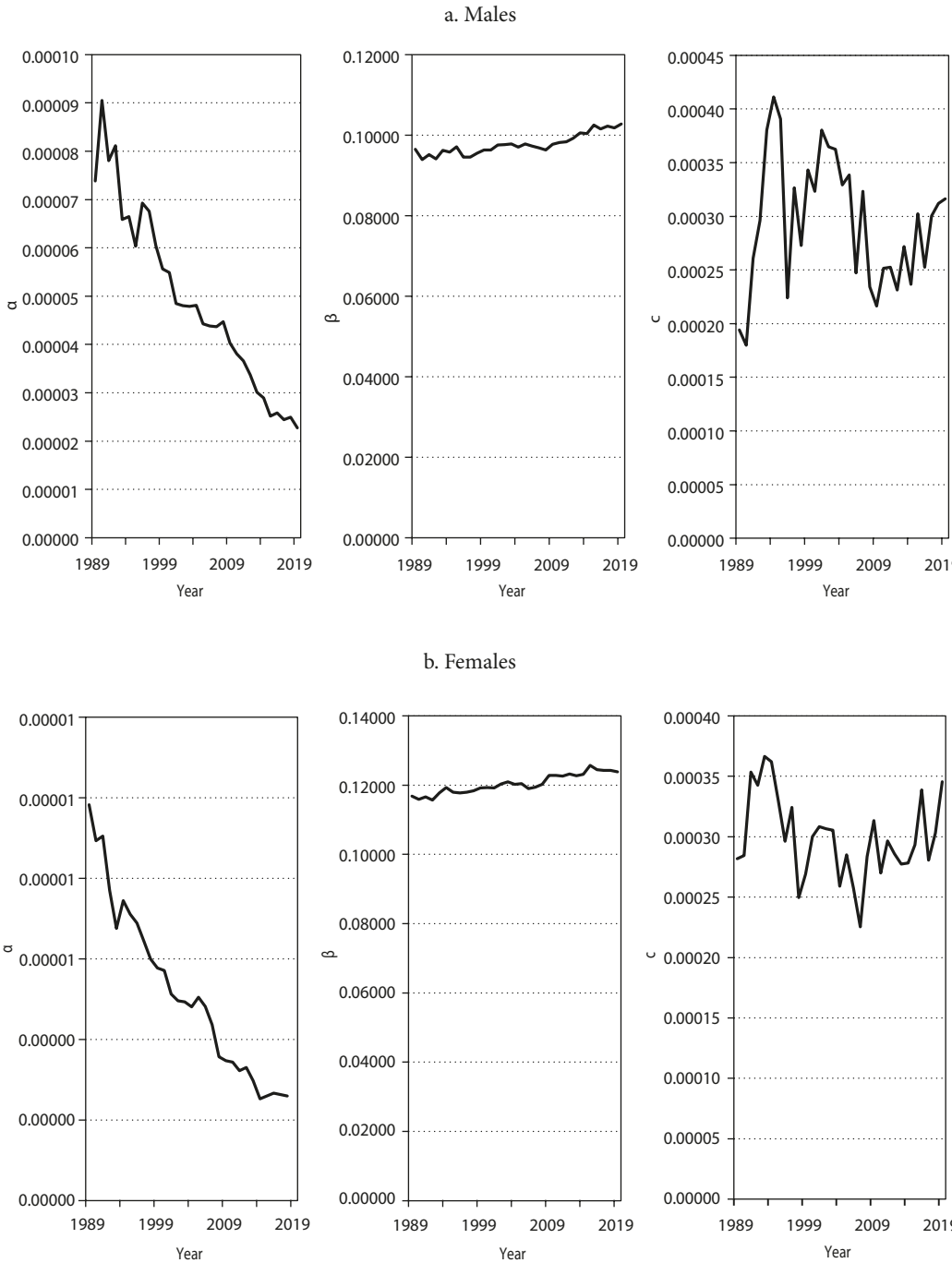
To show trends in mortality over the period of 1989–2019 for Czechia, we used the estimated parameters of Kannisto's logistic model within the age range from 20 to 90 years (Figure 7). The level parameter decreases during the period, both in men and women. As seen in Figure 7, the slope parameter seems to be nearly constant over time with a slightly upgoing trend. Similar findings were found in (*Bongaarts*, 2005; *Gavrilov – Gavrilova*, 1991; *Thatcher*, 1999). The decline in the value of the level parameter implies a decline in senescent mortality (*Bongaarts*, 2005). The constancy of the slope parameter implies that the senescent component of the force of mortality shifts to higher or lower ages as mortality conditions improve or deteriorate (*Bongaarts*, 2005). Although background mortality increased slightly between 1989 and 2019 (Figure 6), the estimated values of parameter for the period 1989–2019 (Figure 7) showed a higher variability of values over time, while no trend is shown except the fluctuations. Given the nature of background mortality, which is mainly related to external causes of death such as accidents, etc., fluctuations are not unexpected.

Figure 6 **Model estimates of senescent and background age-specific death rates in the age group 20–105 years, males and females, Czechia in 1989 and 2019**



Source: Czech Statistical Office (2020b), Bongaarts (2005), author's calculations.

Figure 7 **Estimates of parameters of the Kannisto logistic model for Czechia 1989–2019**

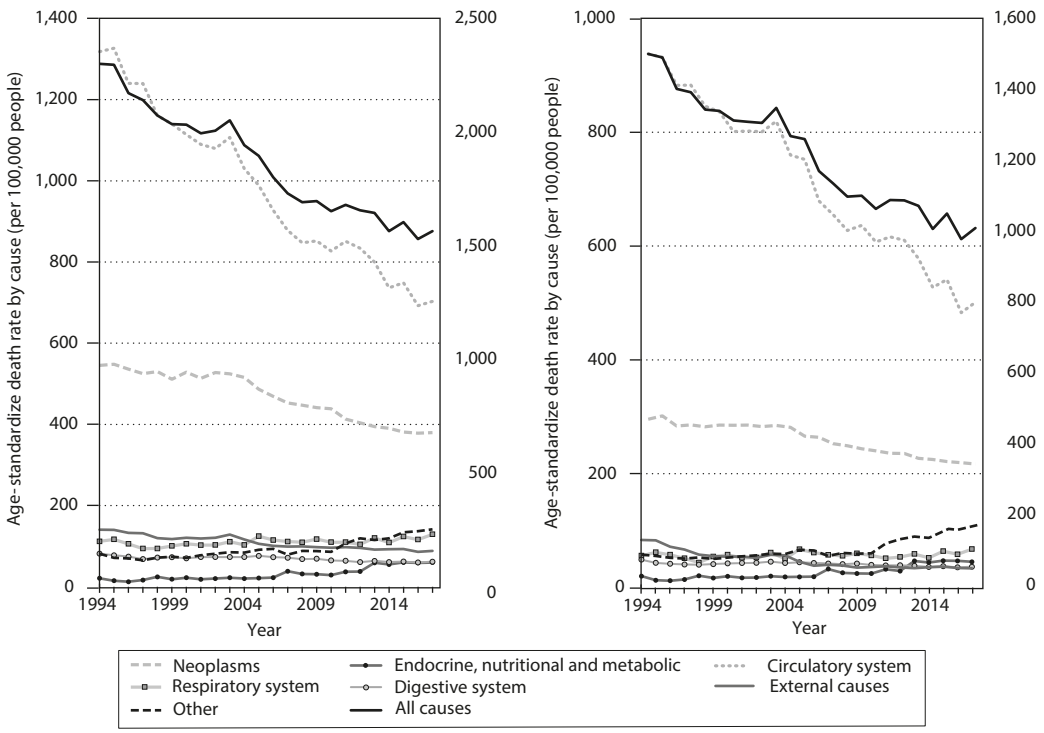


Source: Czech Statistical Office (2020b), Bongaarts (2005), author's calculations.

Mortality by Causes of Death

The following causes of death were selected according to ICD-10: Circulatory system (I00–I99); Neoplasms (C00–D48); Endocrine, nutritional and metabolic (E00–E90); Respiratory system (J00–J99); Digestive system (K00–K93) and External causes (V01–Y89). In Figure 8, we show the age-standardized death rate (per 100,000 people) based on the European standard population from 2013. The overall standardized mortality rate decreased in Czechia in the period of 1994–2017. Circulatory diseases and neoplasms predominate among the causes of death, both in men and women. However, in this period there was a reduction in mortality from the most common causes of death, which was also more significant in men compared to women. Mortality from diseases of the circulatory system as the most common cause of death has dropped from 1,318 deaths in 1994 to 703 deaths (per 100,000) in 2017 for males and from 938 to 501 deaths (per 100,000) for females. In 1994, mortality according to the second most common cause of death from neoplasms amounted to 546 deaths for males and 296 deaths for females per 100,000, while in 2017 a total of 380 male deaths and 217 female deaths were recorded. There was also a slight decrease in mortality due to diseases of the digestive system, both in men and women. In contrast, endocrine, nutritional and metabolic diseases slightly increased in mortality in the period of 1994–2017, in men from 21 to 60 deaths and in women from 20 to 45 deaths, per 100,000. Diseases of the respiratory system developed constantly in the given period with occasional fluctuations. Although the death of men from external causes of death was higher than that of women, the development of the mortality had a gradually declining trend in both sexes.

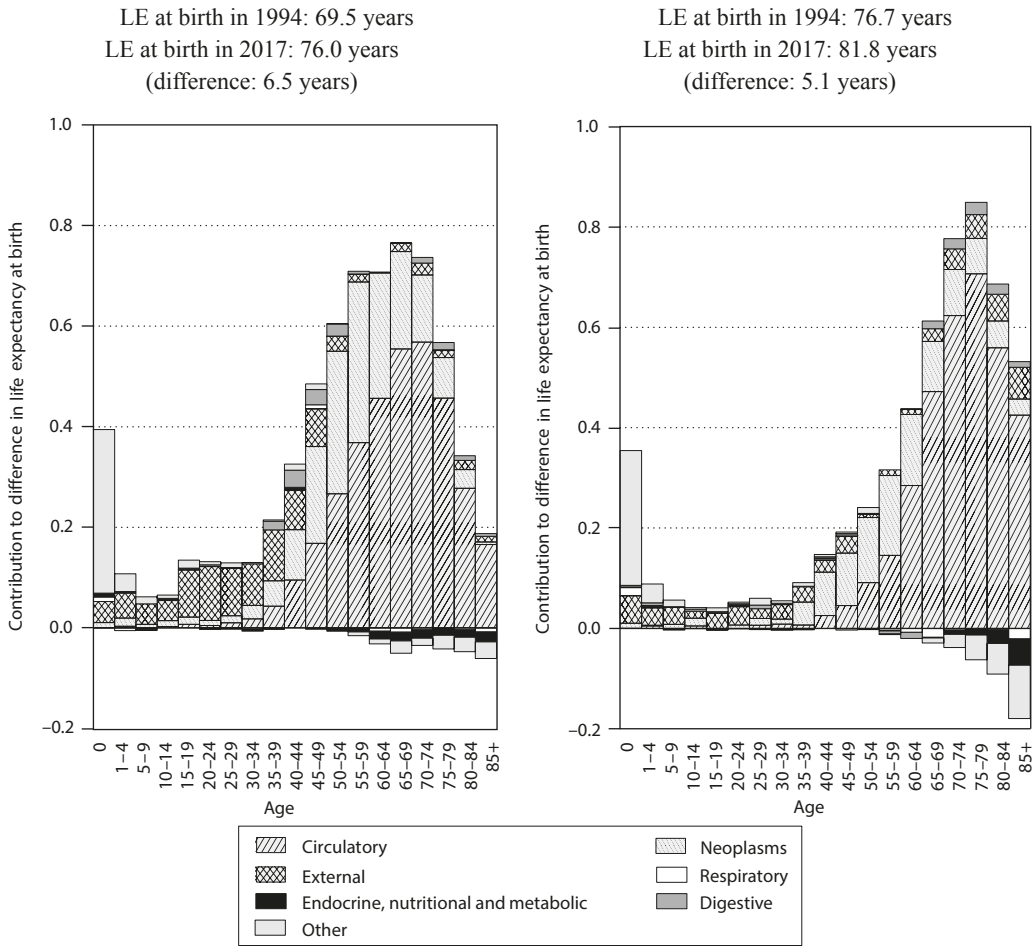
Figure 8 **Age-standardized death rate by selected cause* (per 100,000 people), males (left panel) and females (right panel), Czechia in 1994–2017**



Note: * Right axis: all causes of death (A00–Y89); Left axis: Neoplasms (C00–D48), Endocrine, nutritional and metabolic (E00–E90), Circulatory system (I00–I99), Respiratory system (J00–J99), Digestive system (K00–K93), External causes (V01–Y89), other causes of death.
Source: Eurostat (2020a and 2020b), author's processing.

As seen in Figure 9, a reduction in mortality from diseases of the circulatory system had a substantial impact on the increase of life expectancy at birth in Czechia in 1994–2017, both in men and women. In addition, life expectancy increased in this period due to the improvement in mortality from neoplasms, with this improvement being more noticeable for men. Male life expectancy has increased due to the improvement in mortality from external causes, especially in childhood and adulthood. Also, female life expectancy at birth has increased due to the reduction of mortality from external causes, but more at an older age compared to men. Diseases of the respiratory system, on the other hand, have contributed to a reduction in life expectancy at birth, both in men and women. Endocrine, nutritional and metabolic diseases have also contributed to a slight decrease in life expectancy at birth, in men and women, especially in older age groups. The reduction in mortality from digestive diseases has contributed to a slight increase in life expectancy at birth, in men in the middle and older age groups, and in women in the older age groups.

Figure 9 **Contributions to difference in life expectancy at birth by age group and by cause of death, males (left panel) and females (right panel), Czechia in 1994–2017**

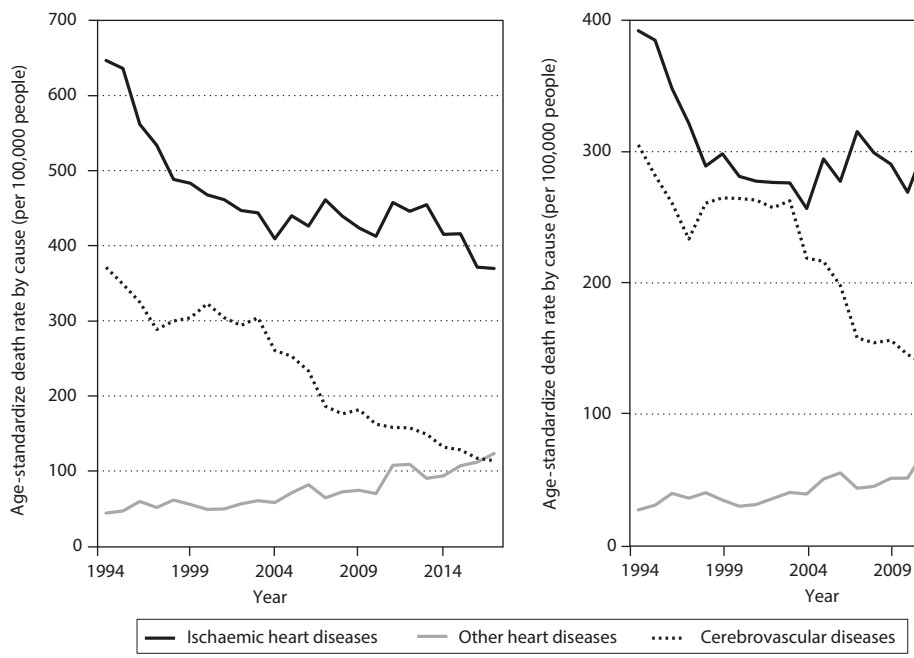


Source: Eurostat (2020c and 2020d), author's calculations.

From the most common group of causes of death from diseases of the circulatory system, more specific causes of death were selected, namely Ischaemic heart diseases (I20–I25), Other heart diseases (I30–I51) and Cerebrovascular diseases (I60–69). Figure 10 shows age-standardized death rate by selected Circulatory diseases (per 100,000 people) for males (left panel) and females (right panel) in Czechia in 1994–2017. Among the most common causes of death from Circulatory diseases were Ischaemic heart diseases, followed by Cerebrovascular diseases and Other heart diseases, both in men and women. Mortality from Ischaemic heart diseases decreased, especially from 1994 to 2004, with fluctuations and a slight decrease in the following years until 2017. While the decrease in mortality from Ischaemic heart diseases was more significant in men than in women, Cerebrovascular diseases showed a rapid decrease for women compared to men, where the mortality decreased gradually. Other heart diseases increased slightly in this period, in both men and women.

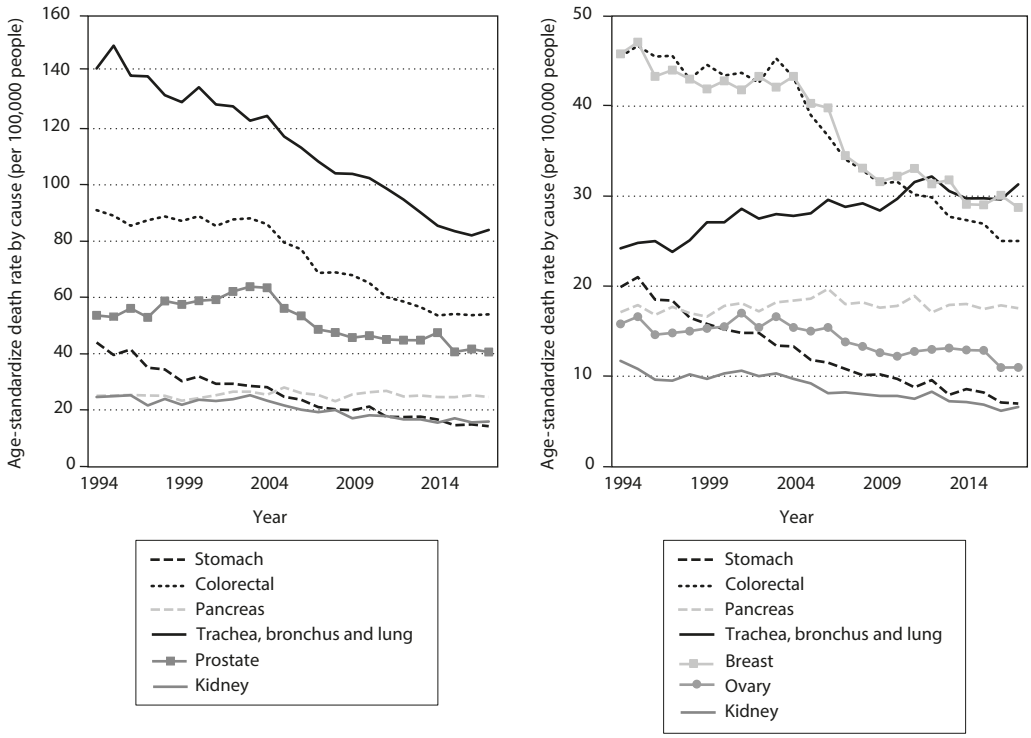
From the second largest group of the cause of death from neoplasms, more detailed causes of death were selected, namely Stomach (C16); Colorectal (C18C21); Pancreas (C25); Trachea, bronchus and lung (C33 and C34); Prostate – males (C61); Kidney, except renal pelvis (C64); Breast – females (C50); Ovary – females (C56). Figure 11 shows the age-standardized death rate by selected Neoplasms (per 100,000 people) for males (left panel) and females (right panel) in Czechia in 1994–2017. Among the most common cancer in men belonged trachea, bronchus and lung, prostate and colorectal. Male mortality from cancer related to trachea, bronchus and lung, and prostate has greatly decreased. However, mortality from prostate neoplasms in men increased slightly from 1994 to 2004, and subsequently decreased in the following years. The mortality of men from neoplasms of the stomach and kidney also decreased. The development of male mortality from neoplasms of the pancreas fluctuated during this period. Breast, colorectal and trachea, bronchus

Figure 10 **Age-standardized death rate by selected circulatory diseases* (per 100,000 people), males (left panel) and females (right panel), Czechia in 1994–2017**



Note: * Ischaemic heart diseases (I20–I25); Other heart diseases (I30–I51); Cerebrovascular diseases (I60–I69).
Source: Eurostat (2020a and 2020b), author's processing.

Figure 11 **Age-standardized death rate by selected neoplasms* (per 100,000 people), males (left panel) and females (right panel), Czechia in 1994–2017**



Note: * Stomach (C16); Colorectal (C18–C21); Pancreas (C25); Trachea, bronchus and lung (C33 and C34); Prostate – males (C61); Kidney, except renal pelvis (C64); Breast – females (C50); Ovary – females (C56).
Source: Eurostat (2020a and 2020b), author's processing.

and lung cancer were among the most common groups of neoplasms in women. Colorectal and trachea, bronchus and lung cancer slightly decreased with fluctuations in the years 1994–2004, in the following years there was a rapid decrease in mortality from these neoplasms in women by 2017. While mortality from trachea, bronchus and lung cancer dropped rapidly in men, there was a slight increase in mortality in women. There was also a reduction in women's mortality from the neoplasms of the ovary, kidney and stomach. As with men, the development of neoplasms of the pancreas fluctuated during this period.

CONCLUSION

To summarize, this study confirmed a mortality decline during the transformation era in Czechia in the period of 1989–2019. This conclusion was also confirmed in several studies examined for Czechia, see for example (*Fiala et al.*, 2018; *Lustigova et al.*, 2019; *Nepomuceno – Canudas-Romo*, 2019; *Fiala – Langhamrova*, 2020). Given that the mortality rate does not reach the level of mortality in developed European countries, we can expect a further reduction in mortality in the future in Czechia. However, no further significant reduction in infant mortality can be expected due to the fact that infant mortality has reached the level of one of the lowest at the European level. The reduction in mortality in Czechia in 1989–2019 also meant an increase in life expectancy. We showed also an increase in life expectancy for older men and women, namely at the age of 65. With regard to the reduction in mortality at age 65, the pressure on the social and pension systems in Czechia is expected to increase. The projection of the Czech Statistical Office from 2018 also expects to see further growth in life expectancy, both for men and women. In addition, we showed a decrease in mortality dispersion.

Despite the fact that a greater degree of inequality among men and women persists, the sex difference in life expectancy at birth declined over this period. In life table distribution, deaths move towards higher ages. Based on Kannisto's logistic model, we observed a decline in senescent mortality during this period, while background mortality remained almost unchanged. Given that background mortality can be influenced by the intervention of national policies in connection with prevention, mortality could decrease in the future due to this component, but as it turned out for Czechia in the period of 1989 to 2019, fluctuations can also be expected. In addition, the logistic model proved to be suitable for modelling mortality in Czechia on the basis of the share of explained variability, especially in the decomposition into components of mortality. Mortality from the most common causes of deadly diseases of the circulatory system and malignant neoplasms has decreased.

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CHANGES IN THE POPULATION AGE STRUCTURE OF CZECH DISTRICTS IN 1989–2019

Luděk Šídlo[1] – Branislav Šprocha[2]

Abstract

Changes in the reproductive behaviour of the Czech population occurring after 1989 have significantly affected the age structure. The more significant the changes at national level, the greater the regional change. The fall in the fertility rate, rising life expectancy, and new spatial patterns in migratory behaviour have significantl affected the population age structure in the Czech regions. This study focuses on Czech districts (LAU 1) and describes changes in the regional differentiation of three main age categories (pre-productive, productive, and post-productive) before presenting a district typology based on these categories. The results confirm the existence of territorial changes in the population age structure. Analyses of regional changes in age structure are an important resource when planning and ensuring accessibility to education, social services and health care, and other services.

Keywords: Age structure, regional differentiation, districts, Czechia, demographic ageing

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INTRODUCTION

The population of Czechia has undergone unprecedented change in the last thirty years and this has affected the rate and timing of fertility and the rate and structure of mortality (see e.g. *Burcin et al.*, 2010; *Fiala et al.*, 2018; *Šťastná et al.*, 2017; *Hašková et al.*, 2019, *Hašková – Pospíšilová*, 2020). Marked changes have occurred in the number and direction of both internal and external migration flows (e.g. *Čermák*, 2005; *Ouředníček – Sýkora*, 2002; *Ouředníček et al.*, 2019). Changes in key demographic processes are evident at the national level, but the greatest differences can be observed at the regional level. Some studies have analysed regional differences in the various components of demographic reproduction (e.g. *Bartoňová*, 1996; *Burcin et al.*, 1999; *Burcin – Kučera*, 2000; *Kašpar et al.*, 2017; *Šídlo*, 2008; *Šprocha – Šídlo*, 2016; *Šídlo – Šprocha*, 2018), but so far the only studies of regional differences in age structure affected by each of the basic components of population development – fertility, mortality, and migration – have been conducted using longer time intervals (e.g. *Bartoňová*, 1999) or different territorial units (e.g. *Grmanová*, 2017).

The main aim of this article is to present the basic trends in regional change affecting the population age structure of Czechia over the last thirty years. The regional units analysed are local administrative units (LAU 1) called districts. Various types of analysis can be used to study population age structure.

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In this study we focus primarily on changes in the basic population age categories defined in relation to economic activity: pre-productive (0–19 years), productive (20–64 years), and post-productive age (65+).

DATA AND METHODS

The data used in this article were provided by the Czech Statistical Office (*CZSO*, 2020) and relate to the population structure by sex and age for Czech districts (LAU 1) in the years 1989–2019 as of 31 December of each year. The data are for the territorial distribution of the district population in the given year and have not been adjusted to reflect boundary changes. Attempts were made to obtain data on the size and age of the population at the municipal level so adjustments could be made to reflect existing boundaries but these were unavailable. According to the CZSO estimates provided along with the data, the most extensive boundary changes took place in 2007 and affected 119 municipalities in 33 districts. Further boundary changes affecting the municipal composition of districts took place in 2000 (1 municipality), 2003 (2 municipalities), and 2005 (28 municipalities). Particular care has to be taken regarding the year 1996, as in that year (in addition to the reallocation of 10 municipalities to different districts) a new district was created – Jeseník (containing 22 municipalities) – consisting of part of the district of Šumperk and a municipality that had belonged to the district of Bruntál. Despite these boundary changes, it was decided that the data was sufficient for the purpose of this article, which is to present changes in the main age categories while focusing on the overall changes in regional differentiation. The assumption underpinning this article is that the addition or removal of one or two small municipalities has no significant effect on the proportion of each age category (in a region?). The district of Jeseník is taken into account throughout the analysis; it is analysed as belonging to one of the 76 districts that existed up to (and including) 1995 and as one of the 77 districts that have existed since 1996.

The method adopted in this study is to take the proportion of the population in each of the three age categories as a means of representing basic changes in the age structure of Czech districts over a thirty-year period. The last part of the article presents a visualisation of the changes in the structure of the three main components using a triangular diagram (also known as an Ossan triangle), a technique that is infrequently used in the Czech literature. In a triangular diagram each side serves as an axis in a system of coordinates and characterises one of the elements of the structure (*Voženílek – Kaňok,* 2011). This type of diagram can therefore be used to illustrate phenomena with a three-part structure, which makes it ideal for illustrating an age structure divided into three basic age categories. Triangular diagrams have been used to great success in, for example, the 'Atlas of the Slovak Population' (*Atlas obyvateľstva Slovenska*, 2006) and to illustrate changes in the age structure in the Visegrad Four countries (*Káčerová – Ondačková*, 2015), but its potential uses are much wider (e.g. to illustrate housing stock structure, see *Kladivo – Halás*, 2012, etc.). The method used in this article to automatically create a data typology using triangular diagrams was developed in a dissertation by S. Ganbaater (2013) at the Department of Geoinformatics, Faculty of Science, Palacky University in Olomouc. Details on the practical uses of this technique can be found in an article by the student's supervisor (*Dobešová*, 2014). This technique is freely available[3] as part of the ArcGIS toolbox, which automatically proceeds through each step of creating the typology on a triangular graph. In other words, it not only plots the relevant points on the graph but also attributes each point in relation to a triangle previously divided up to represent each section of the region or area.

MAIN RESULTS

Changes in the 0–19 age category

Comparing all three basic age categories we see that the most significant changes have taken place in the youngest category, the pre-productive population (0–19 years). This is primarily a consequence

[3] *<http://www.arcgis.com/home/item.html?id=661a8e7c463a4bd2b529f01221efa8f2>.*

Table 1 **Regional differences in the 0–19 age category as a share of the whole population and associated characteristics of the variation in Czech districts 1989–2019, data as of 31 December of the given year**

Interval (%) Indicator	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
34.01–35.00																															
33.01–34.00	5	3	2																												
32.01–33.00	2	4	5	2																											
31.01–32.00	14	12	6	8	5																										
30.01–31.00	21	19	15	11	9	7																									
29.01–30.00	19	22	26	21	14	8	7																								
28.01–29.00	10	8	11	21	25	18	10	8	1																						
27.01–28.00	4	7	10	11	14	27	19	13	8	3																					
26.01–27.00				1	8	10	26	21	16	9	5																				2
25.01–26.00	1	1	1	1		5	11	22	22	17	9	8	4															2	2	2	
24.01–25.00					1	1	2	10	17	27	21	15	10	9	4										1	2	2				
23.01–24.00							1	2	10	18	27	18	23	16	12	10	5	1		1	1	1	2	2	1						
22.01–23.00								1	2	1	12	29	29	33	28	22	18	14	10	5	4	1							1	3	3
21.01–22.00									1	1	1	4	8	16	27	36	34	29	25	27	20	18	11	6	3	2	4	6	8	8	9
20.01–21.00										1	1	2	1	0	3	6	17	28	34	34	32	36	37	34	26	26	28	31	32	33	38
19.01–20.00											1	1	1	2	2	1	0	2	5	7	17	18	23	30	33	31	31	30	28	27	21
18.01–19.00													1	1	1	1	2	2	2	1		1	1	2	10	15	12	8	6	4	4
17.00–18.00																1	1	1	1	2	3	2	3	3	3	1					
Number of districts	76	76	76	76	76	76	76	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
Czechia	29.7	29.5	29.2	28.8	28.2	27.4	26.6	25.7	24.9	24.1	23.4	22.9	22.5	22.1	21.7	21.4	21.0	20.7	20.5	20.2	20.1	20.0	19.8	19.7	19.6	19.6	19.7	19.9	20.1	20.3	20.5
Minimum	26.0	25.9	25.7	25.4	24.8	24.0	23.2	22.3	21.5	20.6	19.9	19.3	19.0	18.6	18.3	18.0	17.7	17.4	17.2	17.1	17.1	17.3	17.3	17.5	17.7	18.0	18.3	18.5	18.6	18.7	18.8
Maximum	34.0	33.7	33.2	32.7	32.0	31.0	29.9	29.0	28.1	27.2	26.3	25.8	25.4	24.9	24.3	23.9	23.4	23.0	22.7	23.1	23.5	23.7	23.9	24.0	24.0	24.3	24.7	25.1	25.4	25.8	26.0
Range	8.0	7.8	7.5	7.4	7.2	6.9	6.7	6.6	6.6	6.5	6.4	6.4	6.4	6.2	6.0	5.9	5.7	5.6	5.6	6.0	6.4	6.4	6.5	6.5	6.3	6.4	6.4	6.6	6.8	7.1	7.3
SD	1.5	1.5	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.2	1.2
CV (%)	5.1	5.0	4.8	4.8	4.8	4.8	4.9	5.0	5.1	5.1	5.2	5.1	5.1	5.0	4.9	4.7	4.7	4.6	4.7	4.8	4.8	4.6	4.8	4.9	5.0	5.2	5.4	5.5	5.6	5.7	5.8

Note: SD = Standard Deviation; CV = Coefficient of Variation.
Source: CZSO (2020).

of changes in the reproductive behaviour of the Czech population that led to falling fertility rates and changes in the timing of parenthood. These changes came to be subsequently reflected in the size of the pre-productive component as a proportion of the whole population, and this became evident over time in all the districts to varying degrees (see Table 1). At the beginning of the period, in 1989, the share of the population aged 0–19 ranged from 26.0 % (Hl. m. Praha, the capital of Czechia) to 34.0 % (Česká Lípa), and ten years later, in 1999, it was between 19.9% to 26.3% (the same districts as in 1989). In other words, the highest value was the same as the lowest value had been at the end of the 1980s. As Table 1 shows, the districts continued to shift towards the lower age category up until the first decade of the new millennium when the variation in this indicator became less distinct. This highlights the fact that nationally significant changes in the size and share of the child segment were taking place on a regional level.

At the end of the 1990s, however, migration processes began to affect the size of the pre-productive segment of the population. Specifically, internal migration, linked to suburbanisation, became increasingly evident in the populations of urban hinterlands, with Praha-západ and Praha-východ rapidly beginning to see a rise in the proportion of their population in this age category. For example, in 2004 Praha-západ had the lowest proportion of individuals aged 0–19 (22.1%), but that then rose to 26% at the end of 2019, thus gradually returning to its 1989 value (27.7%). However, it should be noted that, apart from these two districts, the share of the population aged 0–19 did not exceed 23% in any other district. The lowest proportion (in the period studied) of individuals aged 0–19 was recorded in the capital Hl. m. Praha in 2009, hovering around the 17% mark. However, over the decade this population segment rose slightly to 20%, reflecting the overall changes in the fertility rate seen in Czechia over the last ten years.

Turning to the districts that saw the biggest and smallest changes in the share of the pre-productive population between 1989 and 2019, we find that the biggest decline was in the district of Bruntál, with a fall of over 14 percentage points (from 33.8% to 19.5%). By contrast, the smallest decline was in Praha-západ (mentioned in the previous paragraph), with a decrease of only 1.7 percentage points. These results show that there were (and still are) large differences in the speed and duration of the changes at district level, as we saw with the changes in the proportion of the youngest age category. The migratory appeal of a region therefore has a marked impact on the age composition of the local population, especially in those areas that are attractive to families with children.

Changes in the 20–64 age category

The productive population, defined as people aged 20–64 for the purpose of this article, did not change within the observed timeframe as much as the youngest and oldest age categories did, but that does not mean there are no regional differences in the extent and duration of the change in the share of these segments compared to the population as a whole. As was the case with the youngest age category, the productive population underwent two stages of development, but in reverse to the changes affecting the pre-productive population (Table 2). This was primarily due to the age structure of the population in Czech districts, which had mainly been shaped by the post-war baby-boomer generation (at the beginning of the period studied these generations had yet to reach post-productive age) and the numerically strong 1970s generation. When combined with the falling numbers in the youngest age categories, these large generations initially increased the share of the productive population, which was around 57% of the population in 1989 and by the end of the first decade of the new millennium had risen to 65%. Over time, however, the variation declined, leaving a degree of heterogeneity. The migratory appeal of some districts/municipalities also played a role, with areas proving popular among the productive population recording high immigration levels (see e.g. *Křesťanová et al.*, 2019), and areas with high levels of emigration seeing falls in their share of the productive population. However, in the last decade or so greater heterogeneity was again seen in these areas, with the share of the productive segment falling in all districts to around the original level (58–59%), though the decline began at different times and developed at different speeds. The primary cause of this was the baby-boomer generation reaching post-productive age at the end of the monitored period.

Table 2 **Regional differences in the 20–64 age category as a share of the total population and associated characteristics of variation in Czech districts in 1989–2019, data as of 31 December of the given year**

Interval (%) Indicator	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
70.01–71.00																															
69.01–70.00																															
68.01–69.00																															
67.01–68.00																			1	1											
66.01–67.00																1	1	3	3	3	4	3	1								
65.01–66.00												1	1	4	11	17	24	22	24	18	11	7	4	2	1						
64.01–65.00											5	10	23	28	29	33	35	38	37	39	40	34	23	13	5	2	1				
63.01–64.00									4	12	22	29	27	30	29	20	15	14	12	16	20	29	36	36	29	14	4	1			
62.01–63.00								5	13	23	24	27	22	15	8	6	2				2	4	12	25	36	31	25	7	2	1	1
61.01–62.00						3	10	16	27	28	24	10	4										1	1	6	29	33	35	13	6	2
60.01–61.00	1	1	1	4	6	13	23	37	26	13	2															1	13	28	37	27	10
59.01–60.00	7	6	7	9	16	26	30	16	7	1																	1	6	23	32	34
58.01–59.00	13	17	21	25	36	24	12	3																					2	11	28
57.01–58.00	30	34	32	27	15	10	1																								2
56.01–57.00	20	15	14	11	3																										
55.01–56.00	5	3	1																												
54.01–55.00																															
53.00–54.00																															
Number of districts	76	76	76	76	76	76	76	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
Czechia	57.9	57.9	58.0	58.3	58.8	59.4	60.1	60.8	61.5	62.1	62.8	63.3	63.6	64.0	64.3	64.6	64.8	64.9	65.0	64.9	64.7	64.4	64.0	63.5	63.1	62.6	62.0	61.3	60.7	60.1	59.6
Minimum	55.4	55.5	55.6	56.0	56.5	57.1	57.9	58.5	59.1	59.9	60.6	61.2	61.6	62.1	62.4	62.6	62.9	63.1	63.1	63.0	62.7	62.3	62.0	61.5	61.1	60.6	60.0	59.4	58.8	58.3	57.7
Maximum	60.1	60.0	60.1	60.4	60.8	61.4	61.9	62.6	63.2	64.0	64.9	65.2	65.4	65.4	65.8	66.3	66.7	66.9	67.2	67.1	66.8	66.6	66.3	65.8	65.4	64.9	64.2	63.5	63.0	62.5	62.1
Range	4.7	4.6	4.5	4.4	4.4	4.3	4.1	4.2	4.0	4.1	4.2	4.0	3.8	3.3	3.4	3.7	3.9	3.8	4.1	4.1	4.2	4.3	4.3	4.3	4.2	4.3	4.2	4.1	4.2	4.1	4.4
SD	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.8	0.8	0.8	0.8
CV (%)	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.4

Note: SD = Standard Deviation; CV = Coefficient of Variation.
Source: CZSO (2020).

If we take the year 2007 (when Czechia had its highest proportion of individuals aged 20–64 [65%]) as our dividing line, we find that in the first half of the period the district of Mladá Boleslav changed the most, with the share of the productive population rising by 10 percentage points (from 56.9% to 66.7%). By contrast the smallest change can be seen in the district of Karviná, where the initial value was relatively high (59.9%) but by 2007 had risen by only 5.2 percentage points to 65.1%. In the second half of this period, 2007–2019, the largest change was seen in the district of Děčín, where the proportion of the population aged 20–64 fell by 7.5 percentage points from 65.2% to 57.7%. The smallest decrease was found in the district of Žďár nad Sázavou, from 63.1% to 59.3%, a decrease of 3.8 percentage points. Comparing the changes in these two periods it becomes clear that the most substantial changes taking place were those in the largest age categories, which means that we should assume, particularly when considering the economic implications, that there will be a futher decline in the relative size of the productive population across the country in connection with the transition of the numerically strongest generation from the 1970s into post-productive age.

Changes in the 65+ category

Changes in the size and share of the pre-productive and productive populations combined with the steady decline in the mortality rate and rising life expectancy among older individuals meant that the post-productive population was becoming proportionally larger. As Table 3 shows, the growth was gradual to start with, but in the last few decades it has accelerated and is now being manifested as demographic ageing. By the end of 2019 the 65+ population accounted for more than 20% of the population in 44 districts, although it it did not exceed 14% until 1994. This phenomenon is affecting all Czech districts and can be seen in the decrease in the variation of this indicator across districts over time. However, greater variation can be seen in the last two years, which may indicate dynamic ageing at the top of the age pyramid and larger district-to-district differences in the proportion of the elderly population.

When we compare the changes in the share of the population of post-productive age at the beginning and end of the period, we find that the greatest growth occurred in the district of Bruntál, rising by 12.3 percentage points (from 9.0% to 21.3%) while the lowest level of growth was in Praha-západ, where it increased from 14.6 % to 15.7%. These districts are the same ones we noted earlier as having the largest and smallest changes in the share of the population aged 0–19 between the beginning and the end of the period, and further underlines the fact that the changes in the age structure of Bruntál were significant overall, while those in Praha-západ were much less dramatic. Praha-západ is located in the Prague hinterland and the changes there are a consequence of its migratory appeal. The number of inhabitants almost doubled (98.4%) between 1989 and 2019. A similar pattern can be found in Praha-východ, where the same figure is 96.3%. The third-largest increase in population size was 43.5%, which was found in Brno-venkov and occurred later. It is worth noting that the migration largely occurred within the pre-productive and productive age categories and it offset the demographic ageing processes also in evidence. By contrast, in Bruntál by the end of the period the number of inhabitants had fallen by almost 17% from the initial level (one of the largest decreases of all the Czech districts, which may be partly connected with territorial changes that took place on the territory of the current district in the monitored period; see the methodological part). This shows that age structure is being affected by the basic natural components of demographic reproduction (birth and mortality rates) as well as by migration, and together these have had a significant impact in many districts

A district typology based on the share of the main age categories in the population

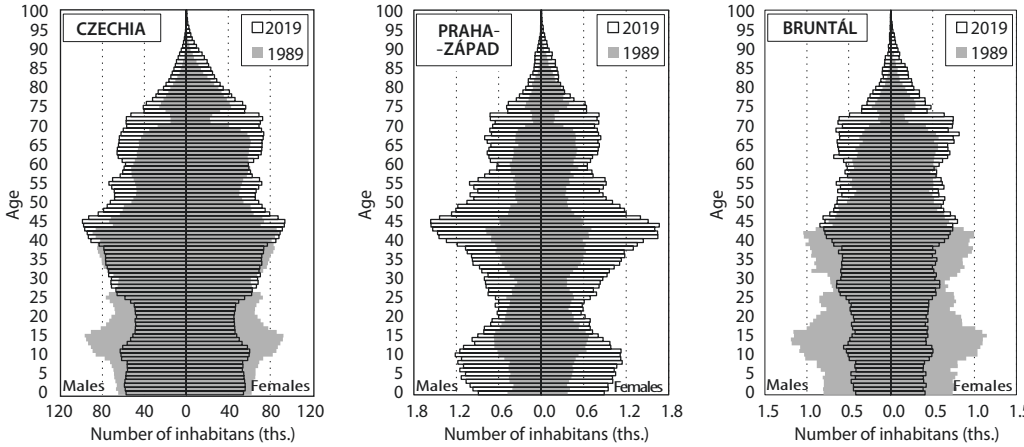
The age structure of the population in Czech districts has changed substantially over the last thirty years. Analysing and creating a typology of these changes that documents both the changes and the variation in the share of each of the three age categories over time is a difficult task. One way to do this is to use a triangular diagram (also known as Ossan triangle).

Table 3 **Regional differences in the 65+ category as a share of the total population and associated characteristics of variation in Czech districts in 1989–2019, data as of 31 December of the given year**

Interval (%) Indicator	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
23.01–24.00																															
22.01–23.00																															2
21.01–22.00																													4	10	18
20.01–21.00																											3	10	17	26	24
19.01–20.00																									5	9	18	30	30	24	22
18.01–19.00																							3	8	13	24	29	22	20	12	8
17.01–18.00																				1	2	5	13	21	30	29	20	10	4	3	1
16.01–17.00							1	1	1	1	1	1	1			1	2	3	5	6	15	18	25	29	22	10	4	3			
15.01–16.00	3	3	1	3	4	6	5	7	7	7	10	12	14	14	13	13	13	18	19	22	28	30	23	13	3	3	1		1	1	2
14.01–15.00	7	7	11	12	12	14	16	16	20	21	20	19	17	19	20	22	26	26	28	29	16	16	7	3	2	1	2	2	1	1	
13.01–14.00	16	16	15	13	16	19	20	25	24	25	23	23	24	25	27	24	21	16	15	11	10	2	5	3	2	1					
12.01–13.00	24	26	27	27	25	18	17	16	13	11	13	12	11	9	9	10	9	9	6	6	6	6	1								
11.01–12.00	12	12	10	10	10	11	10	6	6	6	4	5	5	5	4	5	5	5	4	2											
10.01–11.00	6	6	6	5	3	2	2	4	4	5	5	4	5	5	4	2	1														
9.01–10.00	3	4	5	5	5	5	4	1	2	1	1	1																			
8.01–9.00	4	1		1	1	1	1	1																							
7.01–8.00	1	1	1																												
6.00–7.00																															
Number of districts	76	76	76	76	76	76	76	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
Czechia	12.5	12.6	12.8	12.9	13.0	13.1	13.3	13.5	13.6	13.7	13.8	13.9	13.9	13.9	13.9	14.0	14.2	14.4	14.6	14.9	15.2	15.6	16.2	16.8	17.4	17.8	18.3	18.8	19.2	19.6	19.9
Minimum	7.3	7.5	7.8	8.0	8.2	8.4	8.7	8.9	9.1	9.3	9.6	9.9	10.2	10.4	10.6	10.7	11.0	11.3	11.4	11.7	12.1	12.5	13.0	13.4	13.8	14.0	14.2	14.5	14.7	14.8	15.0
Maximum	15.2	15.2	15.5	15.6	15.7	15.8	16.0	16.2	16.3	16.3	16.3	16.3	16.1	16.0	15.9	16.0	16.2	16.5	16.7	17.1	17.5	17.8	18.4	18.9	19.3	19.7	20.2	20.7	21.1	21.7	22.1
Range	7.9	7.8	7.7	7.6	7.5	7.4	7.3	7.2	7.2	7.0	6.7	6.5	6.0	5.6	5.3	5.3	5.2	5.3	5.3	5.4	5.4	5.3	5.4	5.5	5.6	5.7	6.0	6.2	6.4	6.8	7.1
SD	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.2	1.2	1.3
CV (%)	13.3	12.8	12.1	11.9	11.7	11.5	11.3	11.1	10.9	10.7	10.4	10.1	9.8	9.6	9.4	9.0	8.6	8.3	8.1	8.1	8.1	7.9	7.6	7.0	6.6	6.3	6.1	6.0	6.1	6.2	6.4

Note: SD = Standard Deviation; CV = Coefficient of Variation.
Source: CZSO (2020).

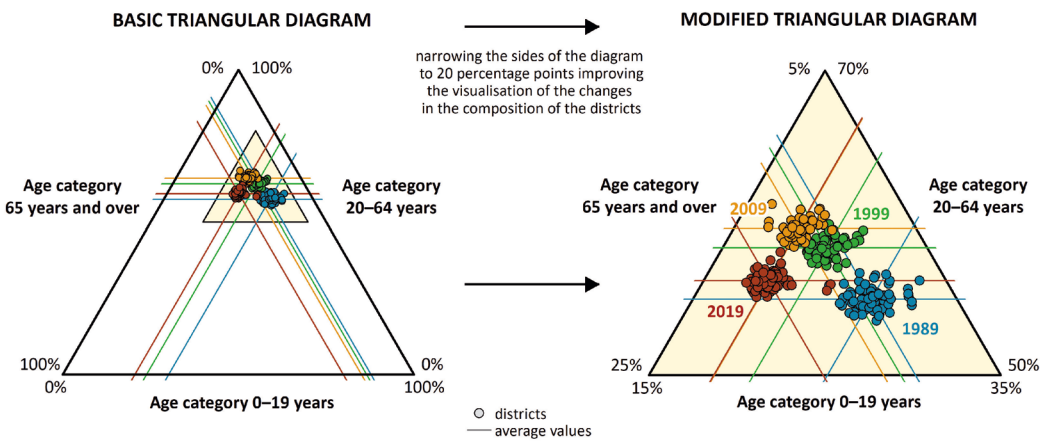
Figure 1 **Comparison of the population age structure between 1989 and 2019 for Czechia as a whole and for the districts of Praha-západ (with the smallest changes in population structure) and Bruntál (with the biggest changes), data as of 31 December of the given year**



Source: CZSO (2020).

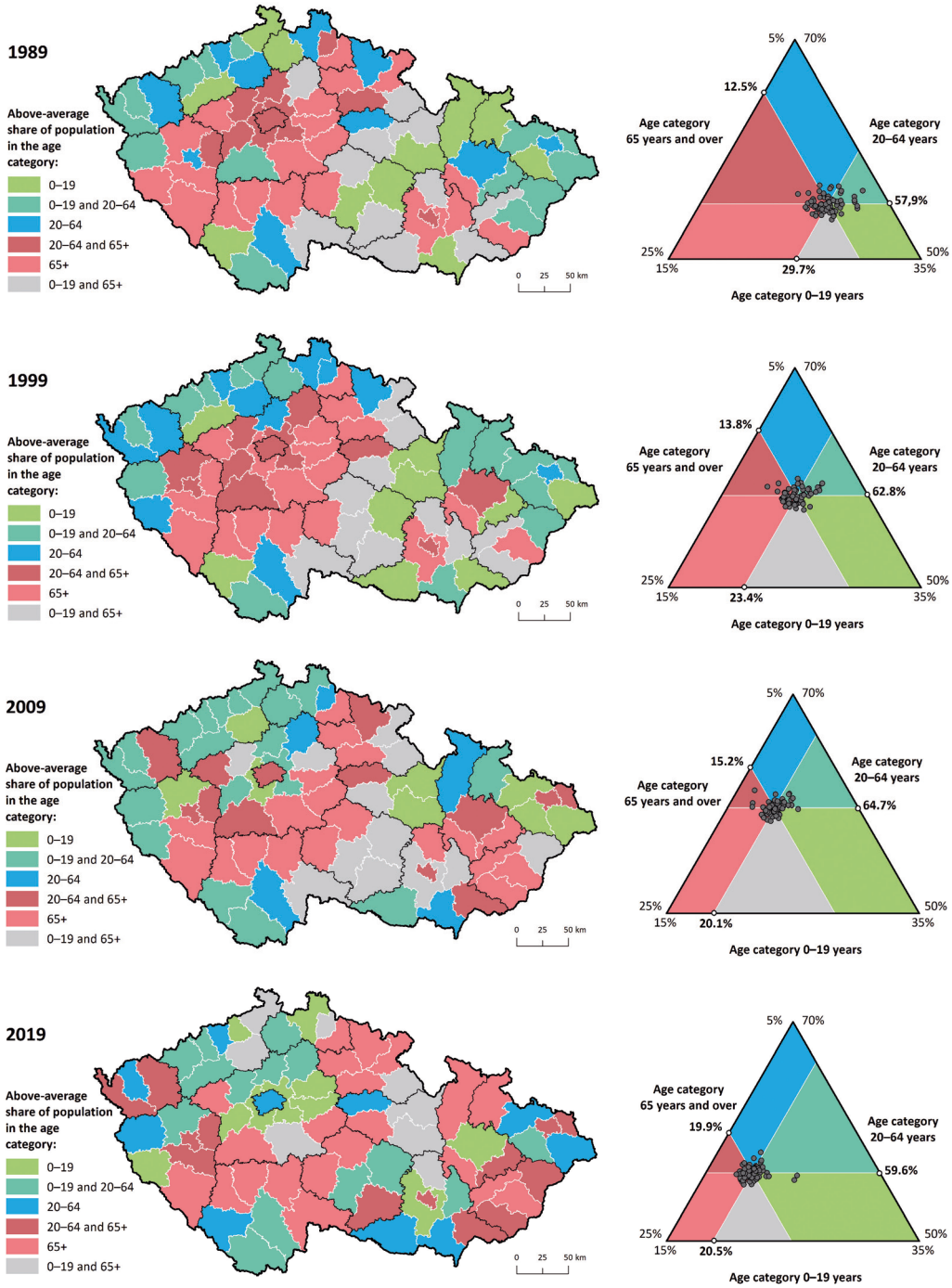
When we created the triangular diagrams for this article, some adjustments first had to be made to each side of the graph. This is because, despite the demographic significance of the changes in the population share of each age category, the changes were hard to identify when observed over a thirty-year period using a 0–100% interval, because the districts in the original triangular graph formed an indistinct cluster (see the left side of Figure 2). The sides of the triangle were therefore adjusted so that all three age categories were in the range of 20 percentage points, improving the visualisation of the changes in the composition of the districts and the overall trend over time. The modified version can be seen on the right side of Figure 2. The districts within the selected year range are clustered together in an upside down U shape. In other words, it shows the declining share of the pre-productive population and the growing

Figure 2 **Triangular diagram and modified version showing the number of persons in each age category for Czech districts in selected years**



Source: CZSO (2020).

Figure 3 **Typology of Czech districts by share of basic age categories based on the triangular graphs for the years 1989, 1999, 2009 and 2019, data as of 31 December of the given year**



Source: CZSO (2020).

share of the post-productive population. The curve is caused by the initial growth followed by a decrease in the share of the productive population.

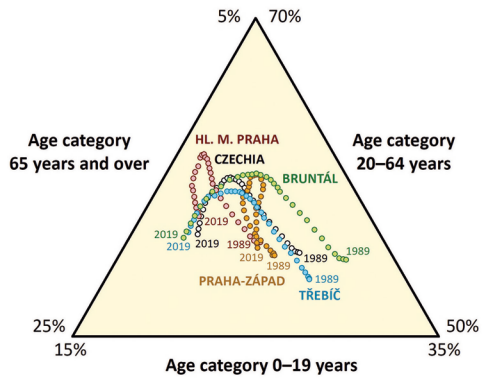
Using the toolbox the average values for each of the observed years can be added by generating straight lines. In Figure 2 the lines are shown in different colours corresponding to the dots indicating the year. These straight lines have the important function of defining the segments of the triangle for the given year, enabling the graph space to be divided up into six different areas showing the above-average proportion of the relevant age categories at the national level. The location of the dots/districts can then be used to create a district typology for each year representing each age category.

Figure 3 shows the changes in the district typologies in ten-year intervals for the duration of the period observed. The end state for the given year is illustrated by the triangular graph, which is divided into six sectors defined by the straight lines connecting the average values and determining the location of the districts on the graph. The cartogram method is then used to allocate the districts to the different sectors.

It is immediately clear that this typology substantially alters the territorial picture. The biggest change can be seen in the Central Bohemian and Moravian regions. In 1989 most of the Central Bohemian districts, as well as the capital Hl. m. Praha, had above-average shares of productive and post-productive inhabitants, but by the end of 2019 the opposite was true. Districts with above-average shares of inhabitants aged 0–19 and possibly also of inhabitants in the 20–64 age category predominated. On the other hand, the Moravian districts, mainly in the northern and south-eastern parts, tended to figure among the areas with above-average shares of productive and/or post-productive inhabitants. But there are also areas of the same type in all four cross-sectional years when compared across districts. Examples are the districts of Klatovy, Strakonice, Písek, and Tábor and Pelhřimov as well, which all have above-average shares of inhabitants aged 65+ in all four years. By contrast the districts in the north-west part (in NUTS 3 region called Ústecký kraj) have predominantly younger inhabitants throughout the period observed.

Changes in the age structure are visualised in the triangular graph for each administrative unit according to year, which allows us to follow any district 'movements' within the system of coordinates and compare them with other regions. Figure 4 shows the changes for Czechia and the capital Hl. m. Praha (the district with the smallest proportion of people at pre-productive age over the long term), Bruntál and Praha-západ (the districts with the smallest or largest changes in age structure, see above), and Třebíč (the district recording the biggest growth in the productive-age population between 1989 and 2019).

Figure 4 **Triangular graph showing the changes in the main age categories between 1989 and 2019, Czechia and selected districts**



Source: CZSO (2020).

The trajectory of the population structure of Bruntál is clearly marked out by the green dots on the graph, illustrating how the share of the pre-productive population fell while the post-productive population rose. By contrast the trajectory for Praha-západ is limited to the centre of the graph, indicating the similarity between the situation in 2019 and 1989. The capital Hl. m. Praha has its own specific developmental curve, which shows how in the second half of the period the proportion of inhabitants aged 65+ grew sharply while the youngest segment of the population increased The district of Třebíč copies the national picture to some degree, except at the beginning of the reference period, when it has a lower final value for the productive population and conversely a slightly higher share of the population of pre-productive age. The triangular graph therefore confirms, by means of visualisation, the different trends in the changes in the proportion of people in the basic age categories over time.

CONCLUSION

The aim of the article was to present regional differences in the age structure of the population in Czech districts over a period of thirty years as simply as possible and to create a district typology using triangular graphs. The conclusion is that two main trends were confirmed that relate to the overall changes in reproductive behaviour among the Czech population: a decline in the proportion of the youngest age category, despite the slight temporary growth recorded in recent years; and a gradual increase in the size and proportion of the elderly population, which has nevertheless accelerated in recent years and comes at the cost of a decline in the productive population. These changes, which are linked to demographic ageing, have dominated to the extent that they have affected all Czech districts to varying degrees. There are areas that exhibit specific characteristics and stand out from the remaining districts. These are mostly districts affected by the suburbanisation that began at the end of the 1990s: Praha-západ and Praha-východ, but also Brno-venkov and Plzeň-sever. The migratory appeal of these districts mainly attracts the younger segment of the productive-age group, who start families in their new location, and this then feeds through into growth in the child population. Consequently, demographic ageing has had less of an impact on these districts than in areas where there have been long-term fertility declines and population losses due to emigration – the northern Moravian districts are an example of the latter.

It is important to analyse regional differences in population age structure and to understand changes and trends in areas where the age composition has a greater effect on the supply and demand of various kinds of services. This applies particularly to education and social and health-care services, where different population structures can substantially affect the local accessibility of these services (see e.g. *Průša*, 2017; *Šídlo – Křesťanová*, 2018; *Maláková et al.*, 2020). These require careful, continual analysis and the information obtained could be used, for example, to link regional estimates to future population development, or when planning the number and size of the facilities that provide these services.

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THE DEMOGRAPHIC DIVIDEND AND ECONOMIC GROWTH: AN INTEGRATED THEORETICAL FRAMEWORK

Nusrat Jafrin[1] – Muhammad Mehedi Masud[2]

Abstract

The transition to sustainable development and equitable societies has become a major concern for population scientists and decision makers. This transformation is in some countries coinciding with the demographic transition, as the evolution of the age structure poses a new challenge for demographers and economists. At the same time, technological unemployment is becoming a burning issue across the world owing to the rapid digital revolution and globalisation. However, there is a lack of an integrated theoretical framework that can be used to achieve the demographic dividend by eliminating technological unemployment, which would ultimately help bring about sustainable development. This paper attempts to build an integrated theoretical framework based on the theories of demographic transition, comparative advantage, human capital theory, and the demographic dividend hypothesis in view of the developmental challenges of technological unemployment. This proposed integrated conceptual framework would foster the use of the demographic dividend to promote economic prosperity in a country whose population is largely economically active. This paper also makes some recommendations on how to prepare working-age people against the threat of technological unemployment in a bid to enhance economic growth.

Keywords: Demographic transition, demographic dividend, human capital, technological unemployment, comparative advantage, economic growth

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INTRODUCTION

The world is constantly experiencing changes in the age structure of the population over time, a process that is known as the demographic transition. This is a natural process that has already been observed in some countries, while others are either currently experiencing it or expect to do so in the future. Although the demographic transition takes place in various ways in society, it depends mainly on the historical, geographic, institutional, socio-economic, political, and cultural impacts of the society in question. And countries do not all go through

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this process at the same time (*Ahmad – Khan*, 2018). This demographic transition is of paramount importance for a country's economic performance, particularly during the transition's third phase, known as the 'demographic dividend'. This dividend is characterised by a larger proportion of young cohorts in the population and has a positive impact on per capita income as well as on savings and investments (*Lutz et al.*, 2019; *Cruz – Ahmed*, 2018).

However, the demographic transition provides a unique framework for studying many aspects of development in an integrated manner (*Dyson*, 2013). The transition is an integral part of modern development that has, however, yet to be conceptualised. For development studies, population is a paradoxical issue. On the one hand, the population clearly cannot be ignored in the discussion of the development process. On the other hand, the most established theories of development fail to properly address the challenge of population. This situation implies that demographic problems can neither be excluded nor easily integrated into a development context (*Malmberg*, 2014). Even the importance of the demographic transition for the growth in per capita income has been long neglected, mainly due to several inconsistent correlations that exist between population and economic growth (*Sánchez-Romero et al.*, 2018).

However, the transition to sustainable and equitable societies, a process fuelled by the demographic transition, has now become a major concern for governments, organisations, businesses, and intellectuals. Therefore, the evolution of the age structure poses a new challenge for demographers and economists. Although this evolution is happening in developing nations, there is a difference between the developed and developing countries in the process of demographic transition in terms of its pace and timing (*Ahmad – Khan*, 2019). Interestingly, the present transition in developing countries has helped them to manage the global crisis. For example, a number of economies, particularly those of the developed nations, were badly affected during the global economic crisis of 2007–2008 and struggled with the ensuing recession. However, populated countries such as China and India were not affected during this recession owing to the age structure dynamics. The demographic transition helped these countries to become resilient, because a positive correlation existed between the dynamics of age structure and economic growth. Consequently, the general standard of living was also influenced during the transition period. This phenomenon further inspired researchers to examine the effects of age structure on economic growth (*Ahmad – Khan*, 2018).

Although every country has to cope with a changing age structure as a result of the demographic changeover, there is no optimistic outlook for a country that fails to offer the essential conditions such as a skilled workforce, sufficient employment opportunities, etc., to adapt to the demographic transformation, which may vary across countries (*Singh*, 2016; *Guengant – May*, 2013). This is because less-skilled human capital has a negative effect on the demographic dividend as well as on the so-called digital dividends in this era of digital revolution and globalisation. This means that a structured scheme of instruction and training is needed to upgrade the skills of the labour force, as the lack of skills will prevent society from taking advantage of the window of opportunity. For instance, technological unemployment is becoming a serious issue across the world because of the increasing number of technological innovations, which make difficult tasks easier to perform and consequently it is possible to save on human labour. In addition, technology helps to reduce wage costs, resulting in capital accumulation and profit maximisation. In general, it expands human abilities with advanced techniques. Unemployment among young cohorts, however, can result in serious health issues, such as malnutrition, stress, depression, and even cardiac problems, etc. Moreover, deprived youth may resort to criminal activities. Youth unemployment also affects the well-being of the families as well as nations in the long run.

Sustainability programmes or policies that can lead to economic prosperity in countries that are currently witnessing or anticipating the onset of the demographic dividend offer several opportunities that are, however, accompanied by numerous challenges. Population, economics, and technology are interconnected and cannot be separated in implementing

sustainability. Also, there continues to be an enduring connection between key global sustainability challenges, which include the issues of economic growth, the reduction of poverty, youth unemployment, and technological adaptation etc. These issues are interconnected across different dimensions, but they are often studied and managed separately. There is a dearth of literature on an integrated approach that would also consider prominent economic growth determinants such as the demographic dividend, technological innovation, and human capital. To deeply understand the demographic transition and benefit from its advantages, an integrated approach is needed. Therefore, this paper aims to take a step forward in this direction by proposing an integrated framework approach that seeks to utilise the demographic dividend in development. This paper conceptualises the framework for economic growth using three theories – namely, the demographic transition theory of Thompson (1929), and Notestein (1945), Ricardo's theory of comparative advantage (1817), and Becker's human capital theory (1964), the demographic dividend hypothesis (*Bloom – Williamson*, 1998; *Bloom – Canning – Sevilla*, 2003; *Bloom et al.*, 2009; *Bloom*, 2011) and examining the challenge of development, such as technological or structural unemployment, as the following section explains.

METHODOLOGY

This study aims to develop an integrated theoretical framework based on a thorough review of the popular theory of demographic transition, the theory of comparative advantage, and the theory of human capital. It also examines the demographic dividend hypothesis and the developmental issue of technological unemployment. To achieve this objective, the study uses document analysis as a qualitative method. The documents for the analysis were collected from secondary sources, such as journal articles, books, book chapters, and reports.

DEMOGRAPHIC TRANSITION THEORY

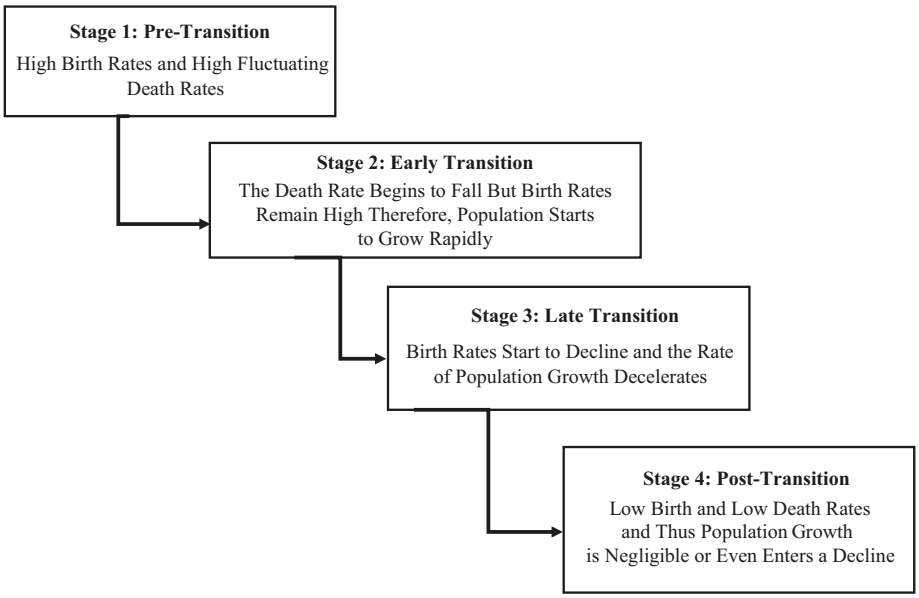
Demography emerged as an academic field after the Second World War and since then the demographic transition has received tremendous attention from researchers, particularly with respect to the reduction in the fertility and mortality rates (*Friedlander – Okun – Segal*, 1999). The demographic transition theory basically provides a theoretical foundation for explaining past population dynamics and producing demographic projections. The revolutionary efforts of both Thompson (1929) and Notestein (1945) provided the foundation for understanding transitional change in the population (*Loschky – Wilcox*, 1974).

Thomson's and Notestein's versions of the transition outline different stages in a society's transformation from a higher to a lower level of mortality and fertility (*Loschky – Wilcox*, 1974). For example, Thompson (1929) revealed the different types of changes that occur in population rates; his observations resulted in the renewed interest in demographic research that has occurred over the last three decades. However, his notion was politically influenced and more applicable in the United States than the rest of the world. This means that Thompson's article had little wider impact. On the other hand, Notestein views established a more formal structure for the theory of demographic transition (*Friedlander – Okun – Segal*, 1999).

A demographic rebellion began in the late 18th century in Europe that later spread to the rest of the world in the 19th and 20th centuries, and the process continues till today (*Fargues*, 2011). Generally, the demographic transition is a natural process that results from changing population characteristics and involves four main stages, as shown in Figure 1.

The first phase is characterised by both high birth and death rates (particularly among children) in pre-industrial society. During the pre-transition period, mortality rates start to decline slightly as a result of improvements in health, nutrition, and medical expertise, which is also known as the mortality or epidemiological transition (*Omran*, 1971). Gradually and with improved food production and sanitation, health and life spans are also enhanced, resulting in a lower death rate amidst a high birth rate, and this characterises the second stage of the transition. Also, a positive relationship begins to emerge between wealth and reproductive success, which promotes population momentum. The third phase is the late transition period and is indicated by lower fertility rates, leading to a plunge in the rate of population growth. Finally, after a period of time, both death and birth rates balance at truncated stages, resulting in little or no population growth (*Snopkowski – Kaplan*, 2018).

Figure 1 **The demographic transition theory**



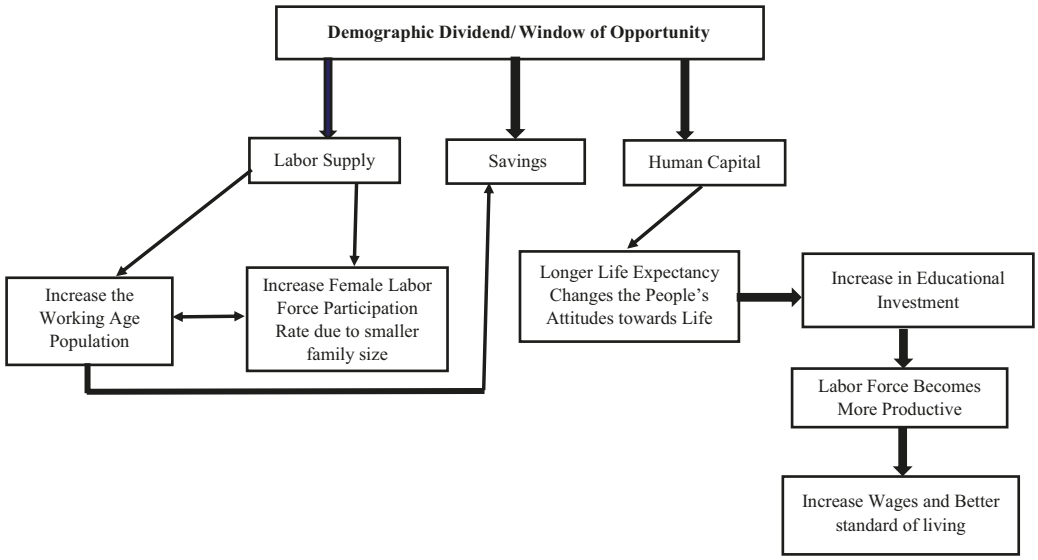
Source: Authors' compilation based on Thompson (1929), and Notestein (1945).

DEMOGRAPHIC DIVIDEND HYPOTHESIS

The idea of a demographic dividend has been discussed in the literature by researchers such as Bloom and Williamson (1998), Bloom, Canning and Sevilla (2003), Bloom et al. (2009), Bloom (2011), and Bloom et al. (2012). The developers of the demographic dividend hypothesis defined the demographic dividend as operating through a number of mechanisms such as labour supply, savings, and human capital (*Singh*, 2016). In general, each country has to go through the different phases of the demographic transition, but the third phase occurs when a country is approaching a low fertility and mortality rate while the size of the working masses is naturally increasing (*Joe – Kumar – Rajpal*, 2018). During this transition period, when a country welcomes a large proportion of young people owing to a rapid decline in fertility and mortality in the development process, a 'window of opportunity' opens, in which there will be low dependency ratio and the older cohort of the workforce has the ability to improve the country's economic prosperity (*Misra*, 2015). During this period of opportunity, the share of the population between the ages of 0 and 14 years falls definitively to 30%, while the proportion of senior citizens (60 years and over) drops to less than 15% (*Narayana*, 2018). This means that the working age population as the larger share can influence the nation's social and financial growth (*Bloom – Canning – Sevilla*, 2003). For example, per capita income increased by more than 6% between 1960 and 1995 in East Asia, as the region was able to take the advantage of the 'window of opportunity'. Moreover, the lower dependency ratio from 1970 to 1995 was responsible for one-fourth to one-third of the total growth of this region (*Fang*, 2016; *Sengupta*, 2015).

The demographic bonus is distributed via several mechanisms, and these are presented in Figure 2. The demographic shift affects the supply of labour in two main ways. First, there is a basic automatic effect that results from the steady and inexorable ageing of the baby boom cohort (*Bloom et al.*, 2009; *Bloom et al.*, 2012; *Bloom – Canning – Sevilla*, 2003). When this peer group is between the ages of 15 and 64, they are more likely to be working, which reduces the dependency ratio of the non-dependent population. Second, due to smaller family sizes, the likelihood of women participating in the labour market and obtaining an education will increase, since they will be less occupied with

Figure 2 **The demographic dividend hypothesis**



Source: Authors' compilation based on Bloom and Williamson (1998), Bloom, Canning and Sevilla (2003), Bloom et al. (2009), and Bloom (2011).

household chores. The demographic transition also helps to increase the growth of savings, which ultimately improves the investment and growth of a country. For instance, young people and the elderly consume more than they produce, whereas the active age population contributes more to economic output and savings (*Bloom et al.*, 2009; *Bloom et al.*, 2012; *Bloom – Canning – Sevilla*, 2003). Likewise, folks will only save if they have access to ample savings options and have confidence in national monetary markets (*Bloom – Williamson*, 1998). The evolution of the age structure generates an environment in which people are inclined to invest in their personal needs and in their children's well-being and education. This yields significant economic paybacks. Longer life expectancy causes fundamental changes in people's attitudes to education, the family, retirement, and the role of women. Therefore, as lifespan increases, parents are expected to prepare their offspring for subsequent stages in life. Healthier children are likely to benefit intellectually more from education and advances in education than their less healthy counterparts. Parents also focus on the quality of a child rather than the quantity of children, as they are able to devote more time and money to each child. The result of educational investment is that the labour force as a whole becomes more productive, promoting higher wages and a better standard of living (*Bloom et al.*, 2009; *Bloom – Canning – Sevilla*, 2003).

COMPARATIVE ADVANTAGE THEORY

Given the limited number of resources in the world, no one country can produce all types of products at a time. Even the level of technological knowledge varies between countries according to the physical and human resources that they possess. Every country has its own specific resources and by using them it becomes specialised in the production of particular products over others with lower opportunity costs. The county is therefore able to export these products because of their relative efficiency in producing them over other countries. This is known as a country's comparative advantage, which reflects the division of labour at an international level. The theory of comparative advantage was introduced by David Ricardo in 1817 in his famous book titled *On the Principles of Political Economy and Taxation* (*Gupta*, 2015; *Sampson*, 2017).

However, with the current technological innovations we see various types of new products and services emerging. This creates a dynamic demand for different products, the production of which requires

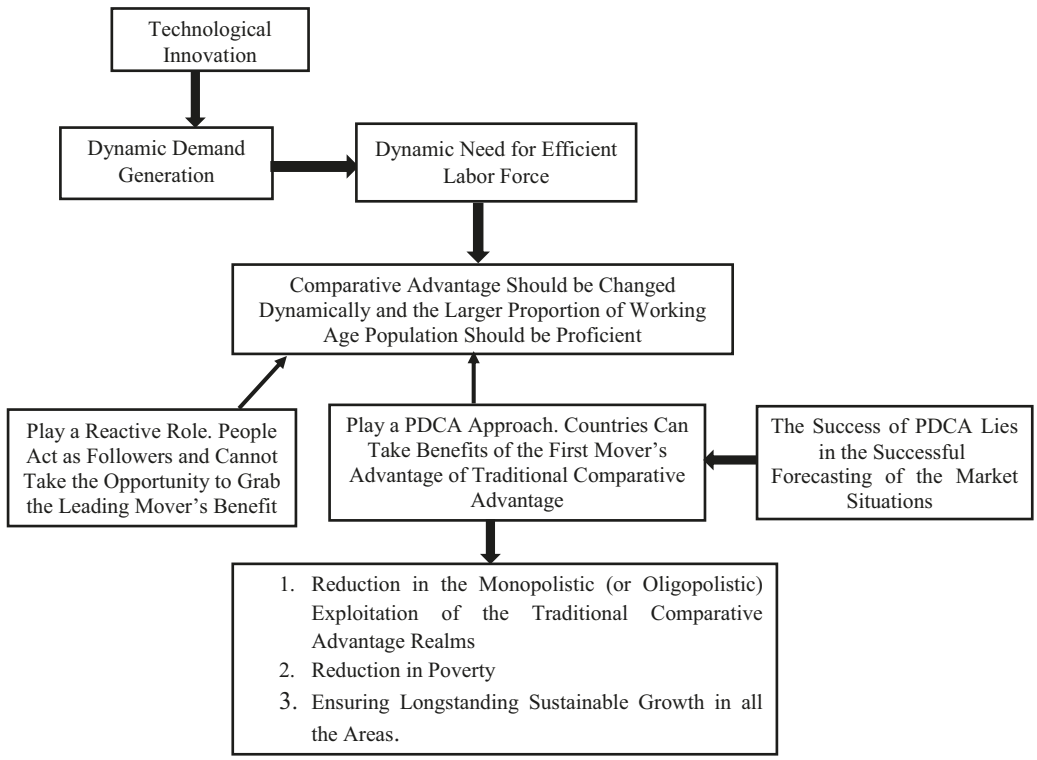
a dynamic skilled labour force in the labour market. Therefore, every county needs specialised knowledge to achieve a dynamic comparative advantage for all products in every sector. The dynamic Ricardian comparative advantage framework can be achieved through the continuous training of the workforce. Basically, a dynamic comparative advantage starts when the comparative advantage changes over time (*Sengupta*, 2015).

Sengupta (2015) has suggested that there are two ways to deal with the situation of comparative advantage in order benefit from a comparative advantage (Figure 3). First approach is that society can play a reactive role as a follower. But this approach has a limitation that due to act as a follower the county cannot take the opportunity of first mover's advantage. Thus, to overcome the first approach, society must be proactive, and this will have a significant impact on the overall development of the country. What this involves is adopting a proactive dynamic comparative advantage (PDCA) approach. Countries are facing a demographic shift towards the younger age group, so a proactive method of dynamic comparative advantage is crucial for ensuring sustainable progress in all sectors (*Sengupta*, 2015).

HUMAN CAPITAL THEORY

The world has become complex nowadays and because organisations are complex as well the people who run them need to solve many important issues; therefore, human capital has become central to the development of a society (*Hage*, 2017). Human capital is defined as the productive wealth that is embodied in the labour, skills, stock of knowledge, and health with which individuals can contribute to economic productivity. Skill sets can be acquired through on-the-job training, practical experience, and education (Figure 4). Further, practical experience allows individuals to develop

Figure 3 **The comparative advantage theory**

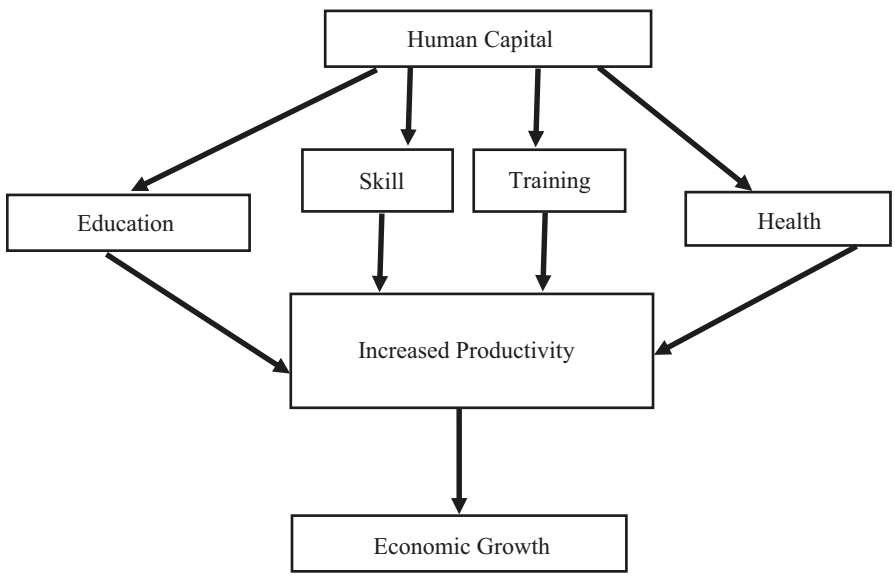


Source: Authors' compilation based on Ricardo (1817), and Sengupta (2015).

tacit knowledge that helps them in their performance of work activities (*Becker*, 1964; *Becker*, 1993; *Hage*, 2017). However, the term 'human capital' has a long and discontinuous history (*Tan*, 2014). Human capital theory was formally introduced in this century, but the concepts behind it emerged centuries ago (*Kiker*, 1966; *Sweetland*, 1996). For instance, Schultz (1961) formulated the idea of investment in human capacity for the purpose of core economic development. He incorporated five dimensions of human capital into his concept: health, on-the-job training, schooling, adult education, and migration. Therefore, he gave utmost importance to education, like Alfred Marshall and Johann Heinrich von Thünen and also supported the ideas of younger academics such as Jacob Mincer and Gary Becker. Subsequently, Becker (1964) played a major role in reviving the interest in human capital research through the interaction of Theodor Schultz and Jacob Mincer. He also emphasizes the idea of 'the economic approach to human behavior' (*Teixeira*, 2014). Basically, there are two views of the human capital model regarding returns on investment. According to the narrow view, income level increases with a higher level of knowledge and skills. This means that the returns are higher compared to the costs that are invested in an individual becoming knowledgeable and skilled (*Diebolt – Haupert – Goldin*, 2014). According to the wider view of the human capital model, however, the learning process not only influences market earnings but goes beyond the labour income in ways that are not reflected in market earnings (*Quiggin*, 1999).

Human capital theory is not only linked to economic perspectives, as it also relates to sociological and demographic aspects (*Quiggin*, 1999), and human capital is regarded as a key element of a nation's overall socio-economic well-being and development (*Tan*, 2014). For instance, the successful modernisation of economic growth, which started in the 19th century in different regions of Europe and the Western hemisphere, was influenced by technological advancement in conjunction with the fertility transition. However, both of these factors tie in with the idea of human capital, since technological development cannot be achieved without an educated population, and as knowledge levels rise in a population parents will favour child quality over quantity. For example, even a slight development in technological advances increases incomes, which encourages parents to spend some of their resources

Figure 4 **Human capital theory**



Source: Authors' compilation based on Becker (1964).

on their children's education. Their higher level of education then leads to further technological improvements, which in turn raise income levels in a continuous process (*Diebolt – Haupert – Goldin*, 2014).

TECHNOLOGICAL UNEMPLOYMENT

Unemployment has become a major global problem. For example, during the great recession of December 2007, many countries, including advanced societies and developing countries, suffered from very high unemployment rates. Unemployment rates were 9.2% and 19%, respectively, in the United States and Egypt in 2011. The Arab Spring uprising in Egypt, Tunisia, Syria, Libya, Iraq and Bahrain, and elsewhere, was caused by unemployment, poverty, inequality, and dictatorship (*Mouhammed*, 2011). The economic literature attributed the cause of unemployment to the situation in the economy, to the demographic structure, to (problems with/poorly functioning) institutions, and to technology. However, technological unemployment has recently become more worrying than these other factors.

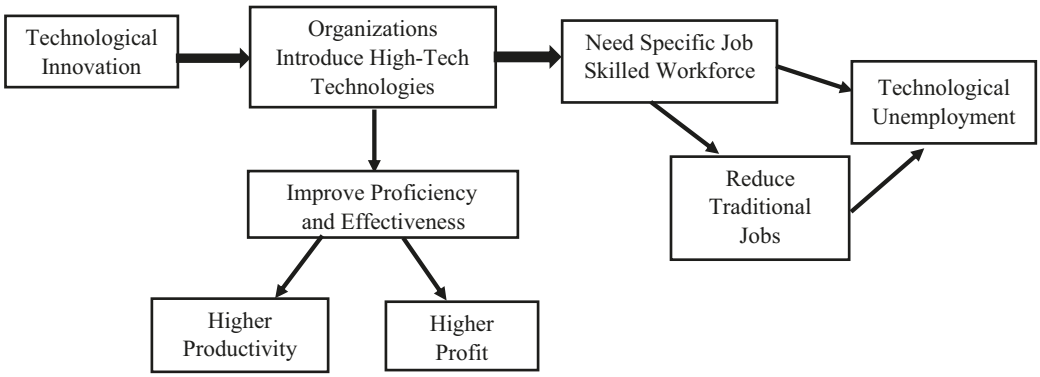
We cannot live nowadays without technology. Technological progress is one of the vital parameters of sustainable economic growth and human progress (*Broughel – Thierer*, 2019). Technological innovation makes it easier to perform difficult tasks and also to save on human labour. In addition, technology helps to reduce wage costs, resulting in capital accumulation and profit expansion. Therefore, most officials in different organisations are introducing advanced technologies in every segment of their commercial processes in order to expand effectiveness which will in turn lead to greater efficiency and a higher return on investment (*Martin – Leurent*, 2017). In general, human abilities are expanded with the aid of advanced techniques. Different techniques such as smart machines (advanced robots and machine learning) and smart devices (personal computers, laptops, mobile networking and smartphones) are considered as technologies. In addition, technologies are also defined by the smart techniques (cloud computing, big data and data analytics). Over a couple of decades, both the smart devices and techniques have significantly improved across the sphere (*World Bank Group*, 2015).

Technological unemployment has thus become a serious issue worldwide since the industrial period. Many people in society today are worried that technological advances will soon lead to unemployment. The incompatibility between the skills and abilities workers possess on the one hand and the skills and abilities organisations need from workers gives rise to structural unemployment in the labour market. This is due to technological innovations, which cause the structure of the economy and the organisational structure of companies to change frequently, and employers consequently need employees with specific job skills to fill the new types of jobs generated by these innovations (*Bennett*, 2016). If the labour force is unable to keep up with and adapt to these technological changes/innovations, structural unemployment is expected to occur (*Parker*, 2010). Owing to structural changes, employment in primary and secondary sectors has declined (Figure 5), as the acquisition of knowledge has become obsolete in these sectors. Construction, trading, retail, and graduate jobs are the sectors most harmed by technological advances. At the same time, new skills are needed to meet the needs of the service sector and new fields that are emerging as a result of advances in information technology, robotics, and other promising technologies. These new modern professions predominantly require advanced levels of qualifications with specific skills (*Bennett*, 2016; *Evangelista – Savona*, 2003).

DEVELOPING AN INTEGRATED CONCEPTUAL FRAMEWORK FOR UTILISING THE DEMOGRAPHIC DIVIDEND

There is a lack of literature on how to utilise the demographic dividend to achieve sustainable development. Rather, studies tend to discuss only the impact of young people on economic performance. Nowadays, population scientists have come to recognise the need for a sustainable society with more employment opportunities for the young cohort. However, to attain such a prosperous society, there is a need for an integrated conceptual framework to aid in the utilisation of the demographic dividend for economic growth.

Figure 5 **Technological unemployment**



Source: Authors' compilation based on literature review.

The association between working-age population and economic growth was examined in several studies by Lutz et al. (2019), Sánchez-Romero et al. (2018), Rizk (2018), Cruz and Ahmed (2018), Misra (2015), and Navaneetham and Dharmalingam (2012). These studies were conducted from the perspectives of both emerging and advanced countries. There are also a number of works (*Cavallo – Sánchez – Valenzuela*, 2018; *Bloom – Williamson*, 1998; *Modigliani – Ando*, 1957; *Ando – Modigliani*, 1963; *Modigliani*, 1966) that have highlighted the favourable impact of demographic factors on savings and investment behaviour. Other studies, such as those by Ahmad and Khan (2019), Song (2013), Bloom et al. (2012), Navaneetham (2002), and Bloom and Williamson (1998), have demonstrated the impact of human capital on the economic performance of a society. Yet other studies (e.g. *Fiorelli*, 2018; *Schumpeter*, 2017; *De Liso – Leoncini*, 2011) have provided many explanations for technological unemployment. However, there is a lack of studies showing how the demographic dividend can be utilised to improve the economy by eliminating technological unemployment.

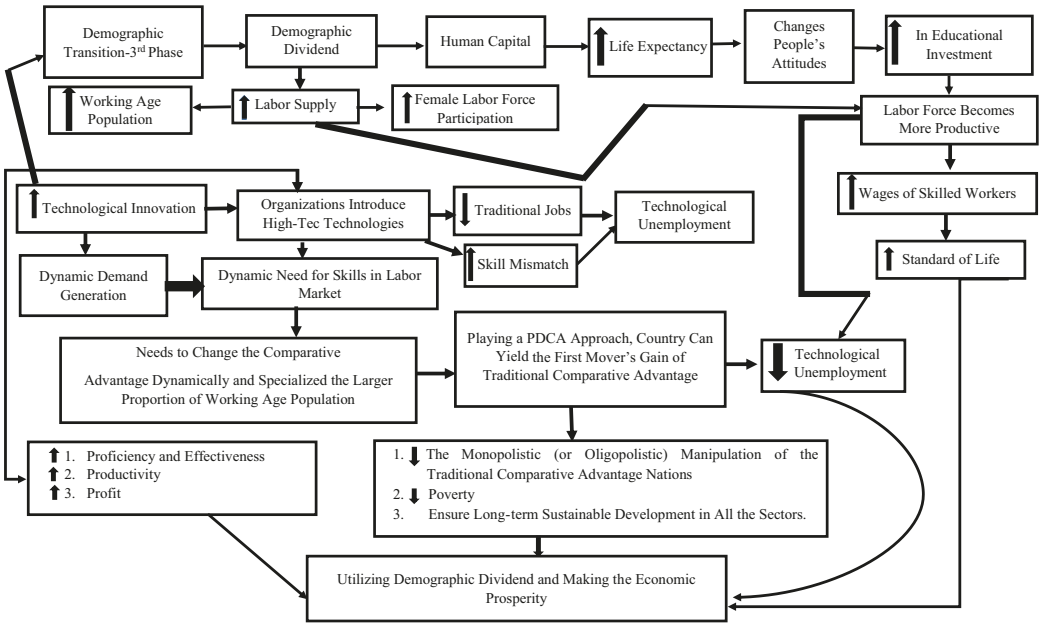
This paper therefore proposes an integrated conceptual framework for utilising the demographic dividend (see Figure 6) based on the demographic transition theory of Thompson (1929), and Notestein (1945), the comparative advantage theory of Ricardo (1817), the human capital theory of Becker (1964), and the demographic dividend hypothesis of Bloom and Williamson (1998), Bloom, Canning and Sevilla (2003), Bloom et al. (2009), and Bloom (2011), while considering along with developmental issues such as technological unemployment or structural unemployment.

When a country is entering into the demographic dividend stage, it has a comparative advantage over other countries in terms of its working-age cohort. To make improve the productivity of this large cohort, market-oriented education with effective training is needed. At the same time, technological innovations create a dynamic need and demand in companies for a technologically well-trained labour force and diminishes the rate of traditional job offerings. This adapted labour force can enhance the profits of organisations. Countries can utilise the first-mover advantage of a traditional comparative advantage by adopting a proactive dynamic approach that will/can ultimately undermine/break down the monopolistic attitudes of developed countries, success in which will also reduce poverty in these countries. This will also ensure sustainable development in every sector of the country. These integrated procedures can facilitate the utilization of the demographic dividend, which can bring long-term economic prosperity to the nation (Figure 6).

CONCLUSION AND RECOMMENDATIONS

De Silva (1997) found that many countries are neglecting to make the continuous investment in human capital that is necessary to achieve and maintain an effective and progressive economy. If a country's economic conditions are such that it is unable to offer what is required to build a trained

Figure 6 **Demographic dividend and economic growth: an Integrated theoretical framework**



Source: Authors.

and skilled labour force and ample employment prospects, that country may not be able to benefit from the positive effects of the demographic dividend. Insufficiently trained human capital negatively affects the demographic dividend as well as the so-called digital dividends that exist in the era of the digital revolution and globalisation. Thus, if the workforce does not keep up with technological trends, technological or structural unemployment may ensue.

To overcome this situation, developing countries that are experiencing the demographic dividend must play a proactive, dynamic role in combating structural unemployment. In fact, human capital is the most important resource that contributes significantly to a nation's economic growth. Therefore, a larger proportion of working-age adults must be taken into account as the primary boosters of development in order for a country to take advantage of/benefit from the demographic dividend or the 'window of opportunity'.

First, the education system must be reorganised and improved in order to accommodate the needs of high-quality/highly skilled employment, industry, investment, and trade so that the future working-age population will be prepared for innovations and development. Second, educational institutions should introduce certain initiatives such as structured teaching and training workshops through a memorandum of understanding with companies and businesses so that students can improve their practical knowledge and be prepared for the job market when they graduate.

Third, working-age adults and especially young people are courageous and dynamic, and continuous training in the workplace and lifelong learning will allow companies to retain the talented workforce that can adapt to rapid changes and technological improvements. Fourth, in order to benefit from the comparative advantage that the demographic dividend offers, systematic human resource management practices should be developed in the public and private sectors.

Fifth, decent work is at the heart of a sustainable and dynamic system of development. Therefore, promoting decent work will increase the employability of the working-age population. In addition, a culture of decent work for the working-age population should be adopted, an effect of which will be to strengthen rural communities. Last but not least, the government, employers, educational institutions,

and training associations can adopt the proposed comprehensive and integrated framework in this paper, which involves utilising the demographic dividend to reduce unemployment and create job opportunities, which in turn will facilitate sustainable development.

The integrated framework proposed in this study has been developed on the basis of a thorough review of theoretical literature. However, future researchers can consider this framework for empirical study.

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TRENDS IN MARRIAGE AND DIVORCE RATE IN THE PAST 30 YEARS (1989–2019)

Jana Křesťanová[1)]

Abstract

The marriage rate, divorce rate, and the associated population structure by marital status significantly changed after 1989. The model of frequent and early marriage has turned into a model in which people postpone marriage and marry less often. Although the divorce rate was growing even before 1989, its structure changed. Changes in marriage and divorce rates were reflected in the structure of the population by marital status, where there was an increase in the proportion of single and divorced people and, conversely, a decrease in the share of persons living in marriage and slightly also in the share of widowed persons.

Keywords: Nuptiality, divorce rate, marital status, transition to a democratic system, Czechia

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INTRODUCTION

Towards the end of 1989, major changes began to occur in society in connection with the fall of the communist regime and the transition from a totalitarian to a democratic system. The transition ushered in a number of economic and social changes and was reflected in demographic developments. Fertility rates have fallen well below the replacement threshold. Mortality conditions have been improving and life expectancy increasing. A dramatic decrease has been observed in nuptiality, while divorce rates have continued to rise. The share of live births outside marriage has increased significantly and the number of unmarried cohabitations has grown. Foreign migration rates have begun to increase significantly (*Fiala et al.*, 2018).

The present study focuses on the development of marriage and divorce rates and the associated change in population by marital status between 1989 and 2019. Newly emerging opportunities for individual choices and lifestyles have brought about changes in marital behaviour and supported the continued growth of divorce rates. At the same time, the generation of the 1990s created new forms of cohabitation as alternatives to marriage (*Rabušic*, 1996). The aim of the article is to capture the key effects of these changes.

CHANGES IN NUPTIALITY AND IN MARRIAGE BEHAVIOUR

The marriage behaviour of the population in Czechia has undergone a significant transformation in the past 30 years. The year 1989 can be described as the last year in which marriage rates were characterised by high intensity and early timing (*Fialová – Kalibová*, 2010). In absolute numbers, 81.3 thousand marriages were concluded in 1989, the mean age of a single groom was 24.6 years and 21.8 years in the case of a single bride. The years 1990 and 1991 were

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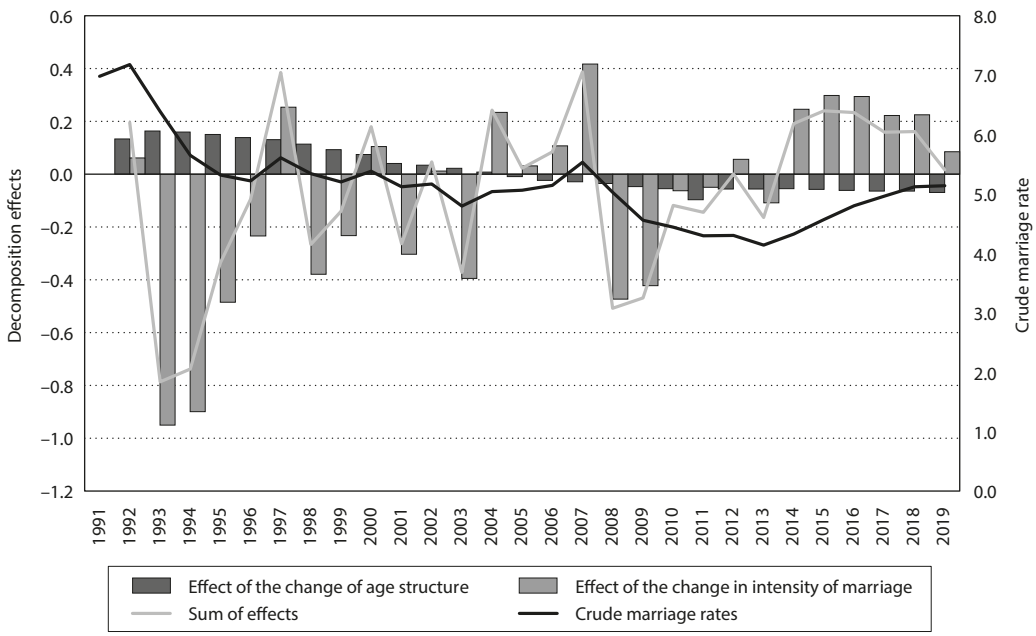
strongly affected by the significant reduction in marriage loans (in effect from 1 January 1991), which led to early entry into a first marriage in 1990, increasing the number of marriages (in absolute numbers 91.0 thousand) and reducing the mean age (to 24.0 years for men and 21.4 years for women). This also resulted in a decrease in the number of marriages in 1991 to 72.0 thousand (*Rychtaříková*, 2007). Since 1992, the number of marriages has shown a long-term declining trend and marriage behaviour has shifted to the model of postponing marriage to a higher age or not getting married at all. The number of marriages reached a local maximum in 2007 when it was at a level of 57.2 thousand (a relative year-on-year increase of 8 percentage points; the next year the number decreased by 8 percentage points). This increase was influenced by particularly attractive data for this year (4.4 thousand marriages were concluded on 7 July 2007). A historical low in the number of marriages was recorded in 2013 (43.5 thousand). The number of marriages has been growing every year for the last six years; in the last year observed 54.9 thousand new marriages were registered.

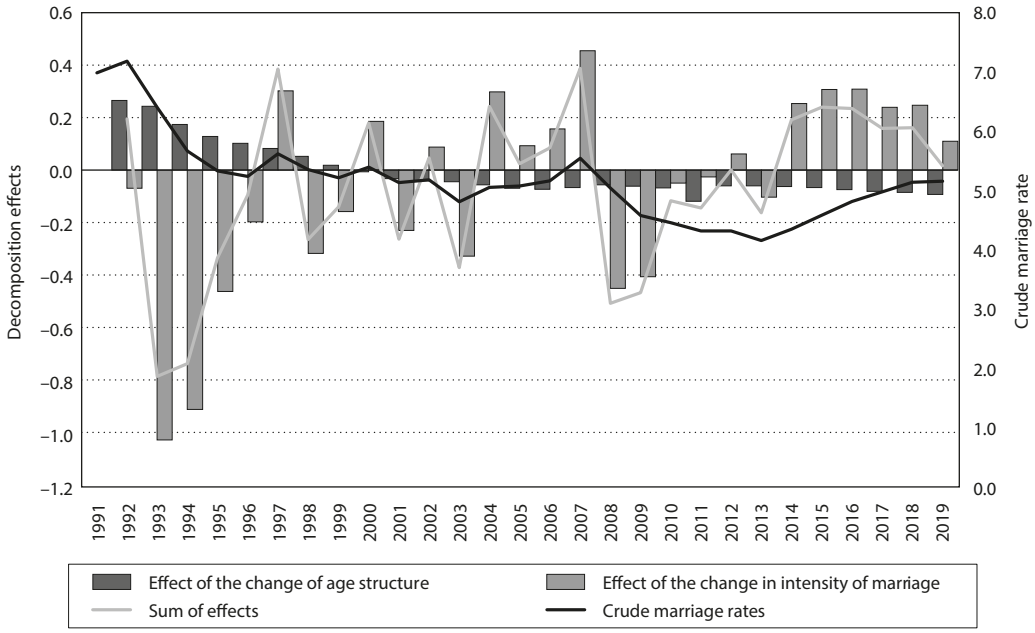
The development of the crude marriage rate indicates the trend in the number of marriages. Overall, the indicator fell from 7.8 marriages per 1,000 inhabitants in 1989 to 5.1‰ in 2019. The lowest level of 4.1‰ was recorded in 2013. Using the decomposition method as described by *Kitagawa* (1955), the year-on-year change in the crude marriage rate indicator can be decomposed into the effect of age structure (i.e. number of persons by age units) and the effect of intensity (i.e. number of marriages by the age of the man/the woman). According to the available data for 1991–2019, it is clear that the change in intensity played a much more significant role in the year-on-year changes of the indicator for both sexes (Figure 1a and Figure 1b). In the 1990s, the effect of age structure counteracted the total decline in the crude marriage rate. The effect of the age structure has been in negative values since 2004 for men and since 2000 for women, i.e. it has thus been offsetting the total year-on-year change. The increase in the crude marriage rate since 2013 is thus due to a change in intensity, where the effect of the age structure acts against the total increase.

Figure 1a **Decomposition of the year-on-year changes in crude marriage rates, males, 1991–2019**



Note: This is the decomposition of the difference between two crude marriage rates in two consecutive years.
Source: Czech Statistical Office; author's calculations.

Figure 1b **Decomposition of the year-on-year changes in crude marriage rates, females, 1991–2019**



Note: This is the decomposition of the difference between two crude marriage rates in two consecutive years.
Source: Czech Statistical Office; author's calculations.

With respect to the marital status of the couple, there have been no significant changes in the distribution, which has been the case for the past 30 years (Table 1). About three-quarters of couples are marrying for the first time. The highest share of first marriages was in 1990, when the figure approached 80% for both men and women. The share of protogamous (when both fiancés are single) was also highest that year (72%). The share of protogamous marriages in the years 1989–2019 ranged from 63% to 72%. The number of marriages of a higher order, compared with the first marriages, is about one-third and thus includes approximately one-quarter of the total number of marriages. That repeated marriages in most cases concern divorced persons who get married again is something that did not change throughout the observed period. Widowed persons rarely remarry. While in the case of divorced persons the second fiancé in the couple is usually also divorced, in the case of widowed fiancés it is more often a marriage with a divorced person.

Conversely, what has changed significantly in the 1989–2019 period is the distribution of weddings over the calendar year (Figure 2). While previously weddings were more evenly distributed throughout the year (except for the month of May), over time they began to accumulate mainly in the summer months. Until the mid-1990s, about 40% of all weddings took place in the months from June to September, but since 2006 more than 60% do (65% in 2019). By contrast, at the start of the observed period 17–20% of all marriages occurred in the winter months (December to February); by 2019, their share had fallen to 6%. It is also worth mentioning the long-term change in the position of the month of May, which was one of the least popular months in the past (this was due to a superstition about May weddings). Measured by the value of the monthly index,[2] wed-

2) Monthly index eliminates the effect of different number of days in a month and indicates the relationship of the monthly number of marriages (when converted to the same number of days) to their number in the average month of the year.

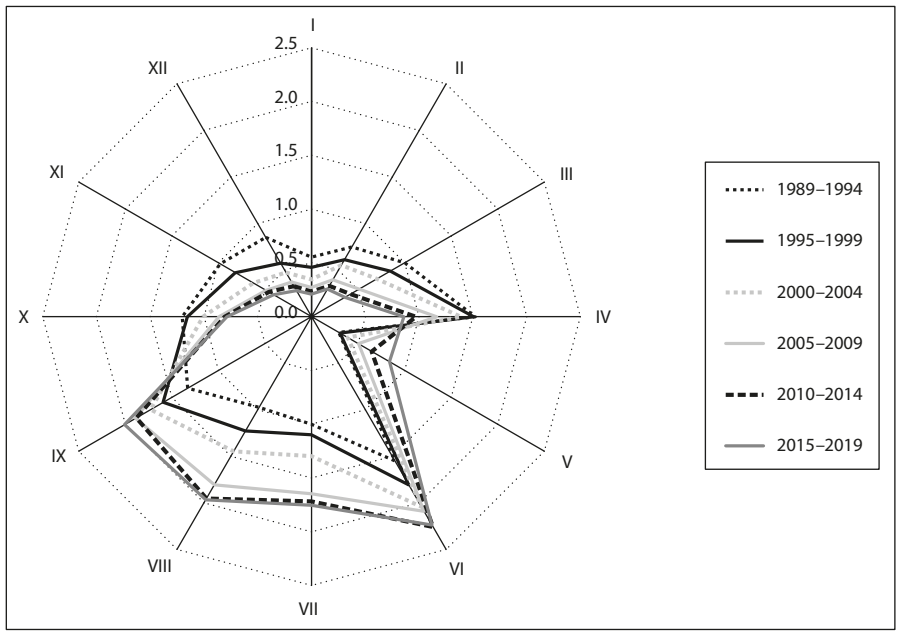
Table 1 **Marriages by marital status and by order, 1989–2019 (selected years)**

	1989	1994	1999	2004	2009	2014	2019
Total marriages	81,262	58,440	53,523	51,447	47,862	45,575	54,870
Marital status of male: single	62,545	44,374	39,819	37,940	34,865	34,691	41,606
divorced	17,396	13,122	12,961	12,857	12,454	10,466	12,802
widowed	1,321	944	743	650	543	418	462
Marital status of female: single	62,737	44,641	40,116	38,147	35,203	35,155	41,724
divorced	17,347	12,840	12,641	12,552	12,001	9,949	12,443
widowed	1,178	959	766	748	658	471	703
Marriages of singles (protogamous)	55,958	39,538	34,927	33,022	30,315	30,785	36,690
Remarriages (for both)	10,539	8,963	8,515	8,382	8,109	6,514	8,230
Protogamous marriages (%):	68.9	67.7	65.3	64.2	63.3	67.5	66.9
Remarriages (%): males	23.0	24.1	25.6	26.3	27.2	23.9	24.2
females	22.8	23.6	25.0	25.9	26.4	22.9	24.0

Source: Czech Statistical Office; author's calculations.

dings in May amounted to less than 30% of the number in an average month until the mid-1990s, but gradually its monthly index grew. In 2019, it was 0.98 (i.e. it was almost an average month), which is historically the highest value ever observed for May. It seems that nowadays, rather than tradition, the choice of a wedding day is influenced by the probability of nice weather (*Tesárková – Karousová, 2009*). The deviation of monthly indexes compared to the surrounding years was also influenced by numerically interesting dates – for example, the value of the monthly index increased for February 2002, July 2007, August 2008, November 2011, July 2017, and August 2018. If a numerically interesting date also falls on a Saturday or Friday (the most common days in the week for a weddings), there is usually

Figure 2 **Seasonality of marriage (monthly indexes), 1989–2019**



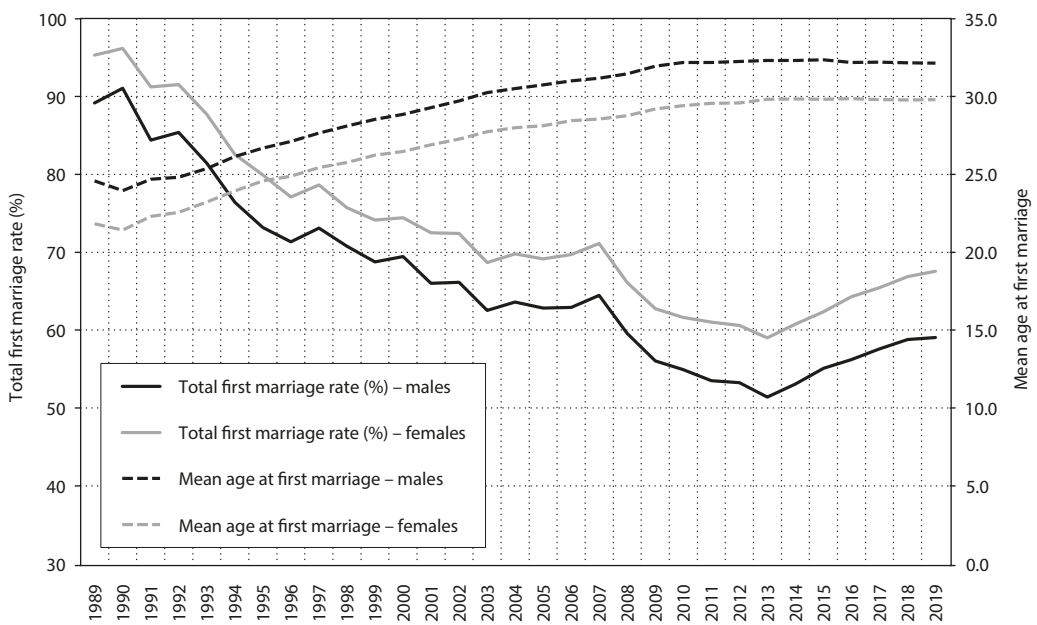
Source: Czech Statistical Office; author's calculations.

even more interest in the date. This is evidenced by the richest day in the number of marriages in the entire period under review, which was Saturday, July 7, 2007, when there were 4,406 marriages. Other examples of numerically attractive days are Friday, August 8, 2008, when there were 2,226 marriages, and Saturday, August 18, 2018, with 3,259 marriages.

The development of the total marriage rate of singles and the mean age at the time of first marriage indicate that marriage behaviour changed in the years 1989–2019 (Figure 3). At the beginning of the observed period, in 1989, 89.2% of single men and 95.3% of single women entered their first marriage before reaching the age of 50, while marriage order, mortality, and the foreign migration of singles remained unchanged. In the following year, 1990, the values were even slightly higher (91.1% for men and 96.2% for women) and were also the highest values recorded throughout the observed period In the following years, the first-marriage rate fluctuated, reaching a local maximum in 2007 (64.5% for men and 71.1% for women), but it eventually decreased to a historically low level in 2013 (51.4% for men and 59.0% for women, i.e. 37.8 percentage points and 36.3 percentage points less, respectively, than in 1989). Conversely, since 2014, the values of the indicator have been growing every year, and by 2019 the values had reached 59.0% for men and 67.5% for women. The mean age at which men and women entered their first marriage in 1989 was 24.6 years for men and 21.8 years for women. In 1990, due to early marriages, it decreased even further – to 24.0 years for men and 21.4 years for women. Since 1991, however, it has been growing every year. Significant year-on-year changes in the indicator for both sexes mainly occurred in the period up to the beginning of the 21st century, after which they decreased, and since 2012 the mean age at first marriage for both sexes has basically stagnated. In 2019, men entered their first marriage on average at the age of 32.1 years and women at the age of 29.8 years. This was an increase of 7.6 years for men 8.0 years for women compared to the start of the observed period.

Evidence of these changes is also provided by changes in the share of singles marrying (based

Figure 3 **Total first marriage rates and mean age at first marriage, 1989–2019**



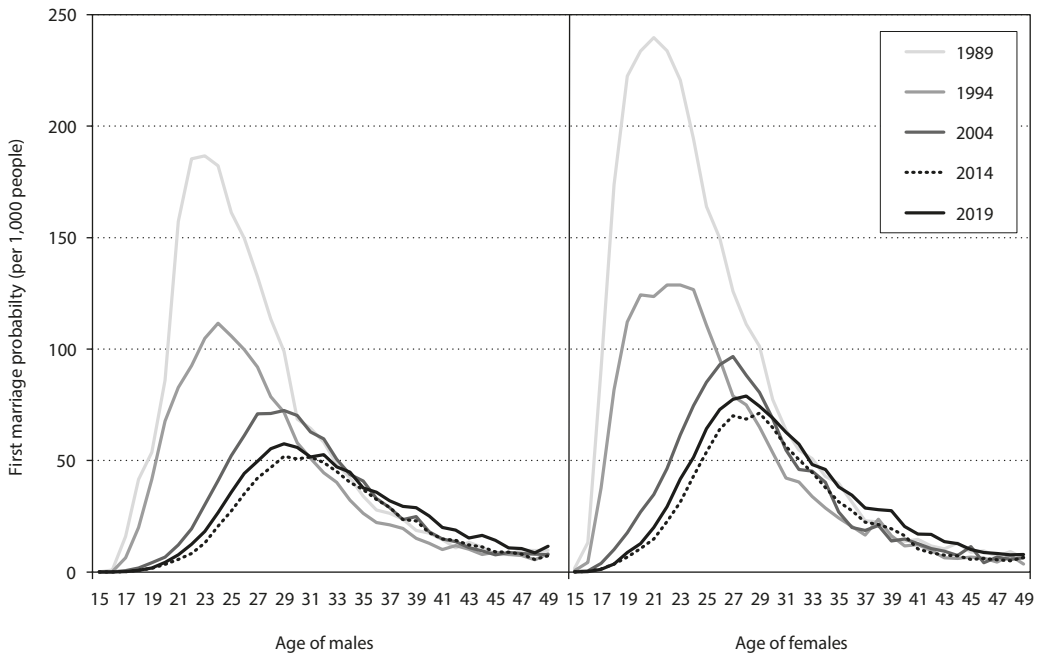
Note: First marriage indicators are based on the single decrement primo-nuptiality tables.
Source: Czech Statistical Office; author's calculations.

on the single decrement primo-nuptiality tables). Compared to 1989, the share of singles marrying increased significantly until 2019. While, for example, only 37.2% of men aged 25 were single in 1989 and only 16.1% of women, by 1989 the share of singles at that age had risen to 93.0% for men and 84.2% for women. Conversely, 10.8% of men and 4.7% of women were still single at age 50 at the beginning of the observed period, while in 2019, 41.0% of men and 32.5% of women were single at that age. These changes reflect the shift in the age of people at first marriage to a higher age and the total lower intensity of the first marriage at the end of the observed period compared to the beginning. However, the shares of singles did not change smoothly. In general, there was a slight increase in the share of singles among older people over time, i.e. previously postponed marriages were later compensated for in both sexes at an older age. From 2014 to 2019, the share of single people decreased (except in the youngest age groups), owing to an increase in the total intensity of marriage in this time period.

In 2019, men of the age of 29 entered into their first marriage with the highest intensity, when more than 57 out of a thousand single men got married. For women, the highest intensity was at the age of 28, when 79 out of a thousand single women got married (Figure 4). The age at which the marriage of singles peaked changed during the observed period, as it moved to an older age, and the maximum intensity also decreased. For comparison, in 1989 the intensity peaked at the age of 23 for men, when marriage intensity reached 187‰ and at the age of 21 for women (240‰). Within the age spectrum, the marriage rate decreased significantly in younger ages compared to the 1990s and did so up until recent years, while it increased slightly in the older ages. The increase in the total intensity of first marriage in the 2014–2019 period was reflected in growth in all age groups, not only as a result of previously postponed marriages, but also as a reflection of a general increase in the marriage rate of singles.

Although changes in the first marriage rate are key to evaluating the development of marriage, about a quarter of all marriages are of a higher order,

Figure 4 **First marriage probabilities by sex and age, selected years**

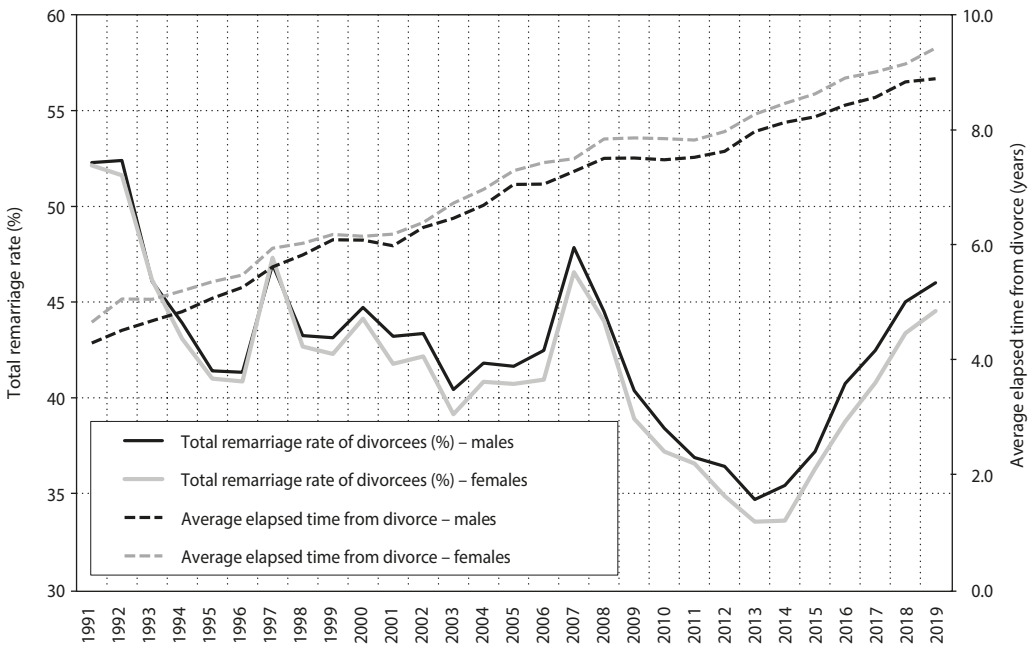


Note: Based on the single decrement primo-nuptiality tables.
Source: Czech Statistical Office; author's calculations.

so repeated marriage plays a role in evaluating marriage behaviour. Given that it is almost always divorced persons who enter repeated marriages, the total intensity of repeated marriages is usually assessed by the total remarriage rate of divorcees. In 1991 (data are not available for previous years), 52.3% of divorced men and 52.1% of divorced women would remarry if the remarriage rates of divorcees by length of marriage remained unchanged (Figure 5). In the following years, the total remarriage rate of divorced people fluctuated, reaching its lowest level in 2013, when it was 34.7% for men and 33.5% for women. In the last six years, it has been growing alongside first marriage rates. In 2019, if the remarriage rates of divorcees by the length of marriage remained unchanged, 46.0% of divorced men and 44.5% of divorced women would enter into another marriage (these figures are 6.3 percentage points and 7.6 percentage points, respectively, less than in 1991).

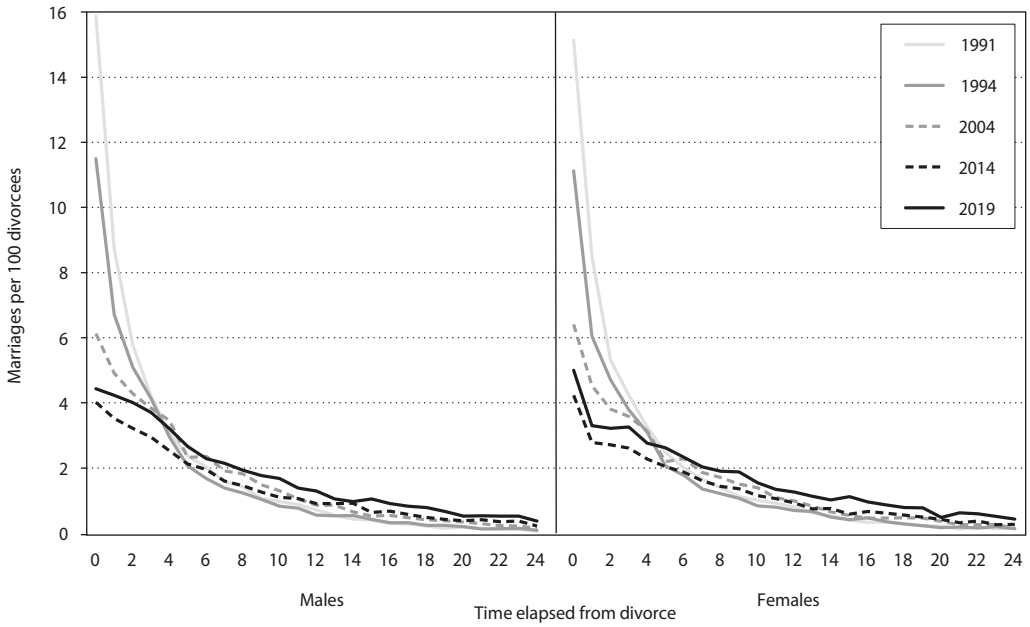
The total remarriage rate of divorcees is slightly higher among men than women. The difference arises within the shorter period after a divorce (up to and including 5 years), when divorced men remarry slightly more often than women (Figure 6). In the case of other lengths of time since divorce (after 6 or more years), the remarriage rate of divorced men and women is almost the same. The remarriage rate of divorced persons is also highest within the period shortly after a divorce, and the remarriage rate of divorcees gradually decreases as the time that has elapsed since the divorce increases. The average length of time from a divorce to a next marriage increased relatively smoothly during the observed period. In 1991 it was 4.3 years for men and 4.8 years for women, while by 2019 it had increased to 8.9 years for men and 9.4 years for women (i.e. a total increase of 4.6 years and 4.8 years, respectively). The increasing interval between a divorce and a next marriage was caused mainly by a decline in the rates of marriage occurring within in the shorter period of time since a divorce and the increase in the remarriage rate after 15 or more years since a divorce.

Figure 5 **Total remarriage rate of divorcees and the average length of time after a divorce before remarriage, 1991–2019**



Note: The remarriage rates of divorcees are constructed from the distribution of remarriage rates by the length of time elapsed after a divorce.
Source: Czech Statistical Office; author's calculations.

Figure 6 **The remarriage rates of divorcees by sex and the average length of time after a divorce before remarriage, selected years**



Source: Czech Statistical Office; author's calculations.

CHANGES IN THE DIVORCE RATE

Along with changes in marriage behaviour over the past 30 years, the character of divorce has also changed. Development in the 1990s did not bring about any dramatic changes in the divorce regime, but rather changed the external circumstances that affected the level of divorce. The divorce rate was gradually rising before 1989, which had to do with women being able to gain a certain degree of economic independence and to establish contacts at the workplace, and with the poor housing situation, problems with childcare given that women were working full time, and the limited availability of necessary services, etc. (*Rychtaříková*, 2018). After 1989, the continuing growth of divorce rates was mainly influenced by the rise of individualism and new possibilities for self-realisation (*Kocová et al.*, 2015).

At the beginning of the observed period, a total of 31.4 thousand marriages ended in a divorce (Table 2). In the following years, the number of divorces had a fluctuating trend, but by 2019 the number had fallen to 24.1 thousand, while the declining trend in the number of divorces had been steadier since 2013. The lowest number of divorces was recorded in 1999 (23.7 thousand), which was connected to the Family Act amendments (e.g. which made it more difficult for marriages with minor children to divorce). Leaving aside 1999, the number of divorces in 2019 was the lowest since 1973. The declining number of divorce was connected to the declining number of marriages in previous decades (until 2013) and to changes in the divorce structure.

Most men and women who divorce are doing so for the first time. The share of repeated divorces in the 1989–2019 period ranged from 17% to 20%. In 85–90% of the cases of repeated divorces, the man or the woman was divorcing for the second time. Until 2014, it was predominantly women who were the ones who filed for a divorce (in 64–68% of cases in 1989–2014), while the man filed for the divorce in 32–36% of cases. Since the beginning of 2014, it has also been possible to file a joint petition for a divorce, but statistical records of this type of divorce exist only since 2015. Gradually, joint petitions for divorce have become the main type, as in 2019 were 51% of divorce petitions filed jointly.

Table 2 **Divorces by order, 1989–2019 (selected years)**

	1989	1994	1999	2004	2009	2014	2019
Total divorces	31,376	30,939	23,657	33,060	29,133	26,764	24,141
Male order of divorce: first order	25,521	25,551	18,825	26,607	23,488	21,391	19,506
second order	4,987	4,648	4,163	5,714	4,973	4,792	4,098
third and higher order	868	740	669	739	672	581	537
Female order of divorce: first order	25,272	25,463	18,878	26,793	23,593	21,582	19,797
second order	5,246	4,748	4,126	5,562	4,944	4,602	3,840
third and higher order	858	728	653	705	596	580	504
Percentage of repeated divorces: males	18.7	17.4	20.4	19.5	19.4	20.1	19.2
females	19.5	17.7	20.2	19.0	19.0	19.4	18.0

Source: Czech Statistical Office; author's calculations.

The age structure of people who divorce has changed with the changes that have occurred in the age structure, with the shift of entry into marriage to an older age, and with the increasing length of marriage before a divorce (*Fialová – Kalibová*, 2010). In the 1989–2019 period, the number of divorces among couples under the age of 30 significantly decreased (from 29.4% to 4.8% for men, from 40.8% to 9.2% for women). Between 1989 and 2019, the proportion of divorced men and women increased the most among people aged 50 and over (from 8.4% to 27.1% for men and from 4.8% to 17.7% for women). In the terms of five-year age groups, 25–29-year-olds predominated among divorced men until 1995, 30–34-year-olds until 2007, 35–39-year-olds until 2013, and 40–44-year-olds since 2013. In the case of divorced women, a slightly younger age structure is evident, because they generally marry at a younger age than men. Until 2002, women aged 25–29 were the most represented in the five-year age groups, in 2003–2008 it was women aged 30–34, by 2015 it was women aged 35–39, and in the last four years, as in the case of men, it is women aged 40–44 years.

One of the key factors in a court's decision on a divorce is the number of minor children a couple has, and statistics in 1989–2019 monitored this (Table 3). In the past 30 years, the proportion of divorces without minors has increased (from 27.9% to 41.0%), while, conversely, the proportion of divorces with minor children has decreased (from 72.1% to 59.0%), reflecting both the lower birth rate and the increased proportion of divorces of couples married for a longer time (by which time the children have reached the age of majority). Another reason may be that there has been a change in social attitudes resulting in a decrease in marriages concluded solely because

Table 3 **Divorces by number of minor children, 1989–2019 (selected years)**

	1989	1994	1999	2004	2009	2014	2019
Divorces without minor children	8,754	8,650	9,480	12,255	12,282	11,557	9,905
Divorces with minor children	22,622	22,289	14,177	20,805	16,851	15,207	14,236
including 1 minor child	12,319	12,902	8,199	11,802	9,533	8,265	6,866
2 minor children	8,766	8,124	5,248	7,993	6,538	6,133	6,489
3 and more minor children	1,537	1,263	730	1,010	780	809	881
Number of minor children in divorced marriages	x	33,143	21,005	31,008	25,094	23,119	22,644
Average number of minor children per divorce with minor children	x	1.49	1.48	1.49	1.49	1.52	1.59
Divorcees with minor children (%)	72.1	72.0	59.9	62.9	57.8	56.8	59.0
including 1 minor child (%)	54.5	57.9	57.8	56.7	56.6	54.3	48.2
2 minor children (%)	38.7	36.4	37.0	38.4	38.8	40.3	45.6
3 and more minor children (%)	6.8	5.7	5.1	4.9	4.6	5.3	6.2

Source: Czech Statistical Office; author's calculations.

a woman becomes pregnant (*Langhamrová – Vaňo*, 2014). Available data indicate that 32.0 thousand children were affected by divorce in 1991, while in 1999 the number had decreased to 21.0 thousand due to a change in legislation, and in 2019 the number of minor children registered in the divorce proceedings of their parents was 22.6 thousand. In most divorced families with minor children, there was one child at the time of the divorce. The average number of children per divorced marriage with children increased from 1.52 to 1.59 children in the observed period.

The distribution of divorces according to the duration of the marriage changed significantly. In previous periods, people divorced mainly within the first five years of marriage, but since the 1990s this trend has changed, and divorces are growing also among long-lasting marriages. When considering the length of a marriage before a divorce in five-year intervals, every year since the mid-1990s the most divorces have been found to occur after 5–9 years of marriage (Table 4). In 2019, 19.9% of all divorces occurred after this length of marriage; while in 1989 it was 24.1% (divorces within the first five years represented 32.1% of divorces in 1989). Since 1989, there has also been a steadily increasing trend in divorces occurring after 25–29 years of marriage and after 30 years. In 1989, 3.3% of marriages were divorced after 25–29 years and 2.0% after 30 or more years; by 2019 their shares had risen to 8.7% and 9.2%, respectively.

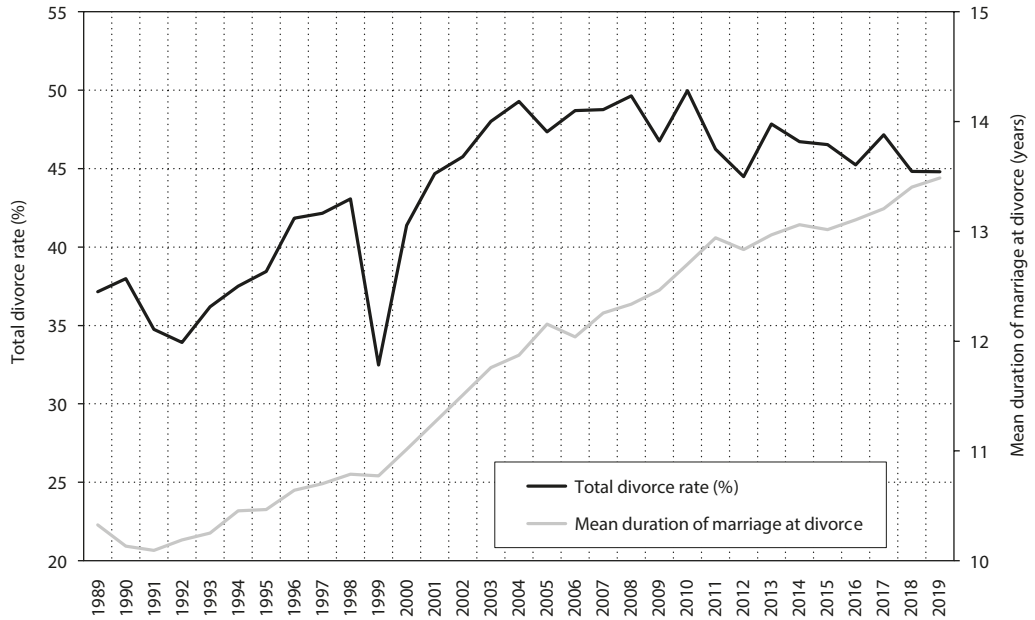
Since the mid-1990s, the intensity of divorce has also been found to peak in the interval of 5–9 years of marriage, with the length of marriage then decreasing (Figure 8). During the years observed here, the divorce rate decreased among the marriages of the shortest lengths, the peak divorce rate widened (within one-year lengths, the divorce interval extended to the usual 2 to 6 years after marriage), and the divorce rate increased in long-lasting marriages. Between 1989 and 2019, the number of divorces per 100 marriages contracted before the respective number of years for the 25–29 year marriage group increased from 0.28 to 0.56 divorces per 100 marriages (reaching a peak of 0.61 in 2017). In the case of divorces that occurred after 30 years or more of marriage there was an increase from 0.08 to 0.28 divorces per 100 marriages (Table 4).

Table 4 **Divorces and divorce rates by duration of marriage, 1989–2019 (selected years)**

Time elapsed (years)	1989	1994	1999	2004	2009	2014	2019
	Divorces by time elapsed since entering into marriage						
0–4	10,076	8,998	5,371	6,019	5,760	4,523	4,450
5–9	7,550	8,375	6,589	7,396	5,925	6,153	4,800
10–14	5,561	4,935	4,418	6,994	4,771	4,298	4,534
15–19	4,142	4,029	2,759	5,439	4,933	3,682	3,444
20–24	2,373	2,749	2,343	3,609	3,899	3,659	2,590
25–29	1,050	1,240	1,407	2,127	2,101	2,343	2,097
30+	624	613	770	1,476	1,744	2,106	2,226
	Divorce rates by time elapsed since entering into marriage						
0–4	2.46	2.41	1.93	2.30	2.18	1.99	1.74
5–9	1.91	2.05	1.77	2.66	2.26	2.33	2.11
10–14	1.19	1.25	1.08	1.88	1.72	1.64	1.72
15–19	0.88	0.86	0.70	1.33	1.32	1.33	1.32
20–24	0.55	0.58	0.50	0.91	0.95	0.98	0.93
25–29	0.28	0.29	0.30	0.46	0.53	0.57	0.56
30+	0.08	0.08	0.10	0.16	0.19	0.24	0.28

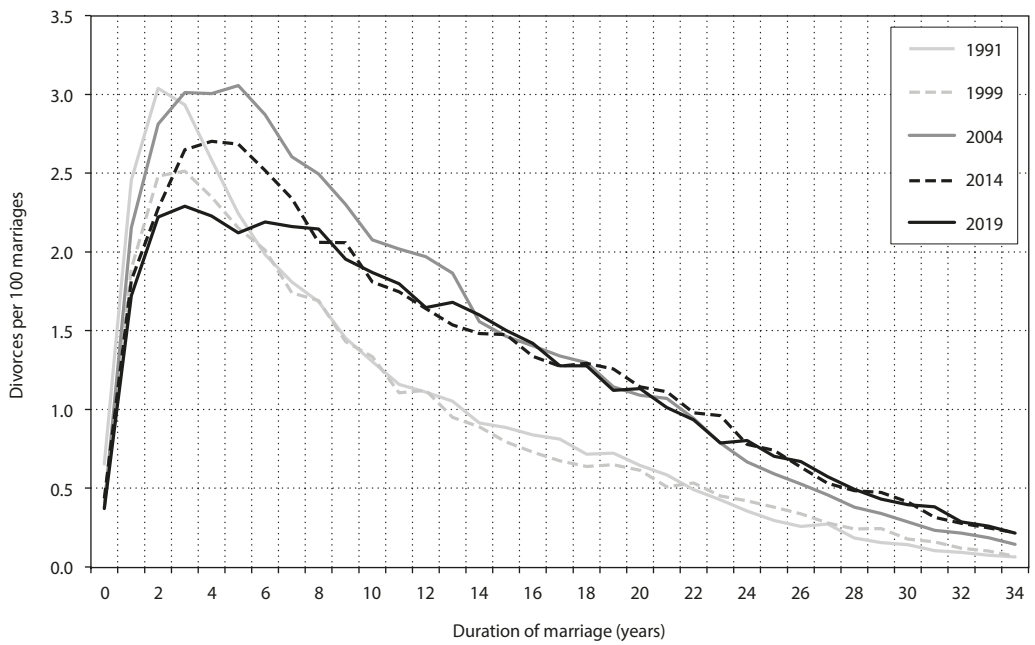
Source: Czech Statistical Office; author's calculations.

Figure 7 **Total divorce rate and mean duration of marriage at divorce, 1989–2019**



Note: Total divorce rate and mean duration of marriage at divorce based on the distribution of reduced divorce rates by time elapsed since entering into marriage.
Source: Czech Statistical Office; author's calculations.

Figure 8 **Divorce by duration of marriage, selected years**



Source: Czech Statistical Office; author's calculations.

The increase in the divorce rate of long-term marriages is also related to the increase in the mean duration of marriages. It has been growing since the 1990s with smaller fluctuations. While in 1989 it was 10.3 years, by 2019 it was already 13.5 years, and thus it was 3.2 years longer than at the beginning of the period (Figure 7). If the intensities of divorce by length of marriage remained at the level of 1989, 37.1% of marriages would end in divorce. Up to 2001, the total divorce rate grew irregularly, except for a significant decrease to 32.5% in 1999. Since 2001, the total divorce rate in the Czech Republic has been in the range of 45–50% and reached its highest level at 50.0% in 2010, while its lowest level was in 2012 at 44.5%. In 2019, 44.8% of marriages would end in divorce, which is 7.7 percentage points higher than in 1989.

CHANGES IN POPULATION STRUCTURE BY MARITAL STATUS

The structure of the population by marital status reflects changes in age structure, marriage, divorce, and mortality. The change in family behaviour since the 1990s, which led to a decline in marriage and a high level of divorce, and the change in age structure and decrease in mortality have together led to an increase in the proportion of single and divorced people and slightly also in the share of widowed persons in the past 30 years.

At the end of 1989, a total of 19.8% of the population aged 15 and over were single de jure (Table 5). During the observed period, their share grew steadily every year and reached 31.7% in 2019, which was 11.9 percentage points more than in 1989. The difference in the share of singles among men and among women has long hovered around nine to ten percentage points. In 1989, 24.6% of men were single and 15.4% of women were single, and by 2019 their shares had increased by 12.4 percentage points for men and 11.2 percentage points for women. However, married men and women still make up the majority group in the population of the Czech Republic. Their share has, however, been declining (more significantly since the early 1990s). In 1989, 63.5% of the total population aged 15 and over were married, 66.3% in the case of men and 61.0% in the case of women. The share of married people in the total population fell below 50% for the first time in 2010 (for men only in 2013, for women earlier, already in 2007). In the last year observed here, 47.8% of men, 45.3% of women, and 46.5% of the total population aged 15 and over were married. The share of divorced persons has shown a steadily growing trend since the 1960s. Between 1989 and 2019, the share of divorced persons increased from 7.0% to 13.6%, and the share increased by 6.1 percentage points to 12.3% for men and by 7.3 percentage points to 15.0% for women. What lies behind the higher proportion of divorced women (compared to men) is the fact that men are slightly more likely to marry after divorce (*Fialová – Kalibová*, 2010). The share of widowed persons in the population changed the least during the observed period, decreasing from 9.7% to 8.2%. The decrease was mainly the result of a decrease in the share of widows among women (from 16.0% to 13.2%), thanks to a faster improvement in male mortality. There tend to be significantly fewer widowers among men, and during the observed period there were around 3%.

The population structure by marital status has changed over time not only in terms of the total population aged 15+ years, but also in terms of age, and the changes have occurred with different degrees of intensity and in different directions. If we look at the years 1989 and 2019, the largest changes occurred among men aged 25–34 and women aged 20–29. In these age categories, the shares of single people increased the most, while the shares of married people decreased the most. Between 1989 and 2019, the proportion of single men increased by 57 percentage points to 85.0% in the 25–29 age group and by 51 percentage points to 60.0% in the 30–34 age group; the proportion of single women increased by 62 percentage points to 73.1% in the 25–29 age group and by 59 percentage points to 94.0% in the 20–24 age group. Between 1989 and 2019, the share of married men decreased the most in the 25–29 age group (by 54 percentage points to 14.2%) and in the 30–34 age group (by 47 percentage points to 31.1%). The biggest decrease in the number of married women was in the 25–29 age group, where it fell by 57 percentage points to 25.1%, and in the 20–24 age group, declining by 56 percentage points to 5.8% in 2019.

Table 5 **Population 15+ years by sex and marital status, 1989–2019 (selected years) (31 Dec.)**

Sex, marital status	Population (thousands)			Percentage of the population 15+ years						
	1989	2004	2019	1989	1994	1999	2004	2009	2014	2019
Total - single	1,606.9	2,368.9	2,849.0	19.8	22.4	24.9	27.2	29.6	30.8	31.7
- married	5,153.1	4,638.0	4,176.2	63.5	60.2	57.1	53.3	50.5	47.8	46.5
- divorced	563.6	922.2	1,225.5	7.0	7.8	9.1	10.6	11.6	13.0	13.6
- widowed	785.8	764.6	733.1	9.7	9.6	8.9	8.8	8.3	8.4	8.2
Males - single	957.1	1,355.9	1,628.1	24.6	27.2	29.8	32.3	34.7	36.0	37.0
- married	2,573.6	2,317.2	2,099.6	66.3	62.8	59.3	55.2	52.0	49.2	47.8
- divorced	240.7	404.7	539.0	6.2	7.0	8.2	9.6	10.5	11.8	12.3
- widowed	111.7	118.9	129.0	2.9	3.0	2.7	2.8	2.7	3.0	2.9
Females - single	649.8	1,012.9	1,220.9	15.4	17.8	20.3	22.5	24.8	25.7	26.6
- married	2,579.5	2,320.8	2,076.5	61.0	57.9	55.0	51.6	49.0	46.5	45.3
- divorced	322.9	517.5	686.5	7.6	8.6	10.0	11.5	12.7	14.2	15.0
- widowed	674.1	645.7	604.1	16.0	15.6	14.8	14.4	13.6	13.6	13.2

Source: Czech Statistical Office; author's calculations.

These changes are due to a reduction in the intensity of nuptiality and the postponement of entry into marriage. Owing to the rising level of divorce, the increasing average length of marriages at divorce, and the postponement of marriage to a higher age, the proportion of divorced persons increased over time, especially among people over the age of 45. In 2019, the largest share of divorcees by five-year age groups was in the 50–54 age group, both for men (25.3%) and for women (29.2%). In 1989, by contrast, the maximum shares were significantly lower and were recorded for both men and women in the 40–44 age group (10.8% for men and 12.5% for women). The proportion of widows was affected by the improving mortality rate, and there was a significant decrease in the number of widows among women (decreasing by as much as 24 percentage points to 32.0% in the 70–74 age group).

SUMMARY AND CONCLUSION

The marriage rate, divorce rate, and the associated population structure by marital status significantly changed after 1989. Until the early 1990s, marital behaviour was dominated by a model of frequent and early marriage. The new opportunities ushered in by the democratic system have transformed this model into one in which people marry at a later age and less often. The links between marriage and family have weakened. The number of long-term unmarried cohabitations has increased and more and more children are being born out of wedlock. There are more and more young people who do not favour marriage at all (*Langhamrová – Vaňo*, 2014).

The mean age at first (and therefore also the next) marriage shifted to a higher age, and the proportion of those who never entered into a marriage increased. Marriage has lost its former significance and, unlike the family, does not have as firm a place in the value ladder of today's society as it used to (*Kuchařová et al.*, 2019). Conversely, more and more unmarried cohabitation changes from marriage to trial to a lasting relationship (*Šťastná – Paloncyová*, 2012). For example, in the 2017 CVVM survey, almost three-fifths of respondents believed that it is alright to live together without planning to marry (*CVVM*, 2017). There are various factors that may lead people to just postpone getting married, such as economic insecurity, (relative) poverty, and / or a precarious position in the labour market (*Hašková – Rabušic*, 2008). Another important factor is the increasing share of the population who have higher education, which can lead to marriage being postponed to a later age (*Hamplová*, 2006).

The intensity of the marriage rate decreased sharply for singles and even fluctuated for divorced

persons. The average time between divorce and remarriage has increased, both because people do not remarry soon after a divorce or after being divorced for more than 15 years. The seasonality of weddings also changed; marriages began to be concentrated more in the summer months, and the month of May also became more popular as the influence of the May superstition weakened. In the last six years, marriage has experienced a revival, and marriages are increasing among both singles and divorcees. This is mainly due to the influence of intensity, i.e. people enter into marriage more often.

The divorce rate did not change dramatically after 1989, but rather continued the trends that had begun before the transition to a democratic system. However, it was affected by new factors; the rise in the divorce rate was no longer driven by the high economic activity of women, but rather by individualism and a general openness to divorce. In the observed period, the number of divorces was most affected by the Family Act amendments of 1998, which led to a decline in the number of divorces in 1999. With changes in the age structure, the postponement of marriage altered the age structure of divorcees. There has been a significant decrease in divorces among couples under the age of 30, and there has been an increase in divorces among older people. At the end of the observed period, persons aged 40–44 predominated among divorced men and women. Because of lower birth rates fewer marriages taking place due to an unplanned pregnancy, there has been a reduction in divorces among couples with minor children. Divorce rates also increased for long-term marriages and the mean duration of marriages increased. Divorce rates reached their highest level in 2010, when half of all marriages divorced.

Changes in the marriage and divorce rates were reflected in the structure of the population by marital status. In the past 30 years, there has been an increase in the share of single and divorced people and, conversely, a decrease in the proportion of people living in a marriage and also, slightly, in the share of widowed persons.

Demographic developments after the transition to a democratic system have resulted in the fact that families today are less stable than they were before 1989. At the same time, the increase in life expectancy has led to the possibility of people starting a second family and living more years with a chosen partner (*Rychtaříková*, 2007). The increase in marriage rates and the moderation in the growth [the slower rise] in divorce rates in recent years suggest a revival of interest in entering into marriage and a possible reversal of the negative developments in previous years.

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CHANGES IN THE AGE STRUCTURE AND THE AGEING OF THE POPULATION OF CZECHIA AFTER THE YEAR 1989

Tomáš Fiala[1] – Jitka Langhamrová[2]

Abstract

The aim of this paper is to present a brief analysis of population ageing in Czechia in the last three decades, a time when very important political and socio-economic changes occurred in the aftermath of the Velvet Revolution in 1989. Population ageing accelerated owing to a rapid increase in life expectancy and a deep decline in fertility caused by the postponement of maternity to a later age. The ageing process was partly slowed by a relatively high rate of immigration. The paper shows the development of mean age and changes in the age structure of the population using broad age groups defined by reproductive age and by productive age. It also presents the ageing indexes and old-age dependency ratio. Besides these standard indicators the trends in alternative indicators based on remaining life expectancy and the concept of prospective age are also analysed.

Keywords: Czechia, population ageing, prospective age

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INTRODUCTION

Population ageing is a logical consequence of the demographic trends of previous decades in which there is a decrease in mortality (i.e. an increase in the length of life) usually accompanied by a decrease in fertility. Almost every country in the world is facing population ageing now or will face it in the near future. The main consequence of this phenomenon is the rising cost of old-age pensions and health and social care. For this reason, population ageing is being observed and analysed by the United Nations, the European Union, and other international institutions as well as by the governments of many countries.

Demographic development in Czechia after WW II was considerably influenced by the Communist regime. The increase in life expectancy in the 1950s was followed by a period of stagnation in mortality during the 1960s, 1970s, and 1980s. At the same time the post-war period was characterised by a relatively high level of fertility due to the pro-natality measures of the communist regime, especially in the early 1970s. The pace of population ageing was relatively slow at that time (*Rychtaříková*, 2018).

After 1989, rapid changes occurred in the political and economic system in Czechia, which also resulted in changes in demographic behaviour. Life expectancy began to increase quickly. At the same time, there

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was a sharp decline in fertility, mainly owing to the fact that many young women who had not yet had children postponed starting a family until an older age, a trend that had already been observed in previous years in Southern, Western and Northern European countries. This led to an acceleration of population ageing. Unlike some other post-Communist countries, Czechia attracted immigrants, which partly slowed the ageing process.

The standard indicators of population ageing usually suppose a constant old-age threshold of 65 years. This assumption is more and more problematic given the continuing increase in life expectancy and the improvement of the health of the population. Almost 50 years ago, Ryder (1975) suggested an alternative approach: to measure old age according to the number of years remaining until death. Sanderson and Scherbov (2005, 2007, 2010, 2013) further developed the idea of measuring the old-age threshold based on remaining life expectancy.

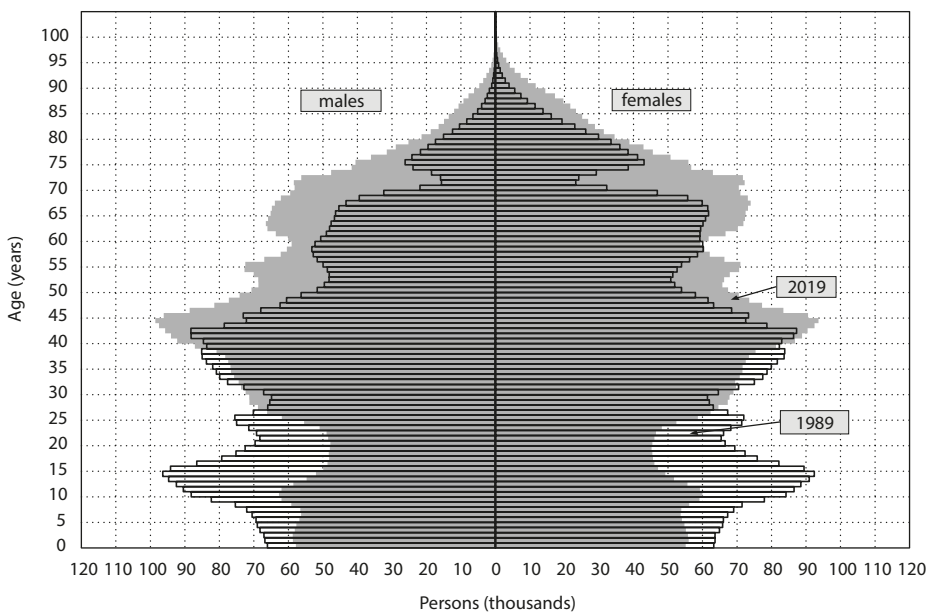
This paper contains a simple analysis of population ageing in Czechia in the 1989–2019 period using standard and alternative indicators of ageing.

GENERAL CHANGES IN POPULATION SIZE AND STRUCTURE

Czechia had more than 10,360,000 inhabitants in 1989. The age structure was very significantly influenced by the alternating periods of higher and lower birth rates in previous decades because international migration in the Communist era was relatively low. The most numerous age groups were people around the age of 15, born in the 1970s at the time of a major pro-natalist policy, and people around the age of 45 born right after World War II. On the other hand, the number of persons between the ages of 70 and 74 was significantly lower (owing to the very low birth rate during World War I) and so was the number of persons between the ages of 50 and 54 (owing to a drop in the birth rate during the economic crisis in the 1930s). The lower number of persons between the ages of 20 and 29 and children under 10 reflects the drop in the birth rate that occurred during the 1960s and 1980s (Figure 1).

In the period between 1989 and 2019 the total population of Czechia increased by more than 300,000, mainly as a result of a relatively high level of international migration. Since there were

Figure 1 **Age and sex structure of population 1989 and 2019 (mid-year)**



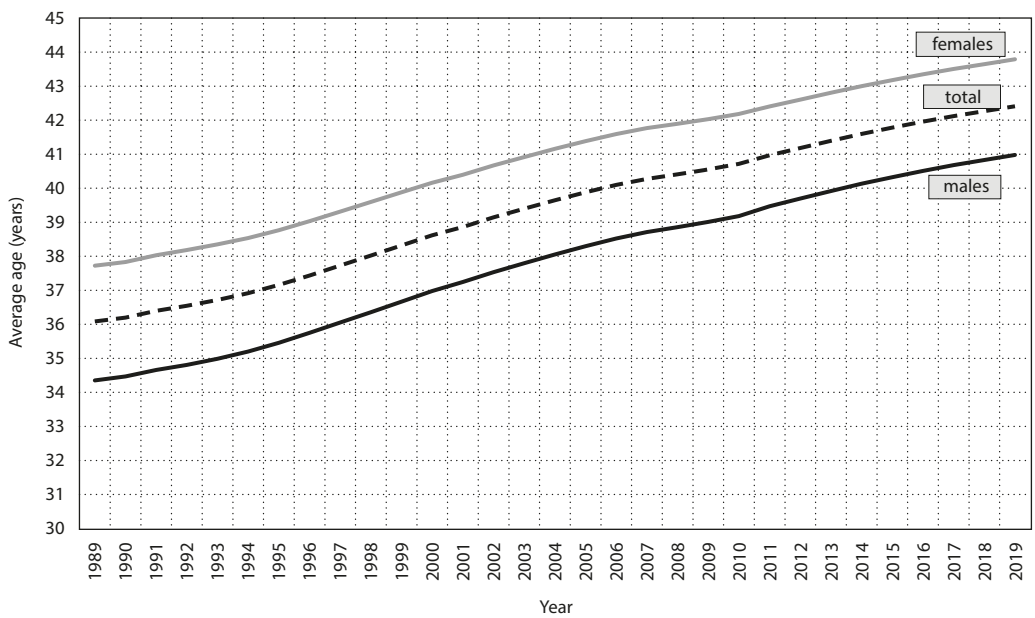
Source: Czech Statistical Office (2020a).

considerably more male immigrants, the increase in the number of men was over 220,000, while the number of women increased by only around 85,000. The age structure changed very significantly. The size of the population increased in all the older age units, starting at age 39 and over in the case of men and starting at age 40 and over in the case of women (with the exception of a slight decrease in the number of those aged 59). The number of persons aged 40 and over increased by about 1.5 million. On the other hand, there was a decrease in the number of younger persons, with the exception of a slight increase in the number of men aged 27–31 and women aged 27–30. The total number of persons under the age of 40 decreased by almost 1.2 million, within which category the number of persons under the age of 20 decreased by more than 900,000.

During the analysed period the average age of the population began to increase at a much faster rate than in the previous decades. While the average age of the Czech population between 1979 and 1989 increased by only 0.68 years (from 35.40 to 36.08), it went up to 38.32 years in 1999, to 40.55 years in 2009, and to 42.41 years in 2019. The increase in the average age after 1989 was thus about three times higher than what it was in the 1980s. The average age of men increased slightly faster than the average age of women owing to a faster increase in life expectancy. The difference between the average age of women and men diminished by more than 0.5 a year (from 3.37 to 2.81) – see Figure 2.

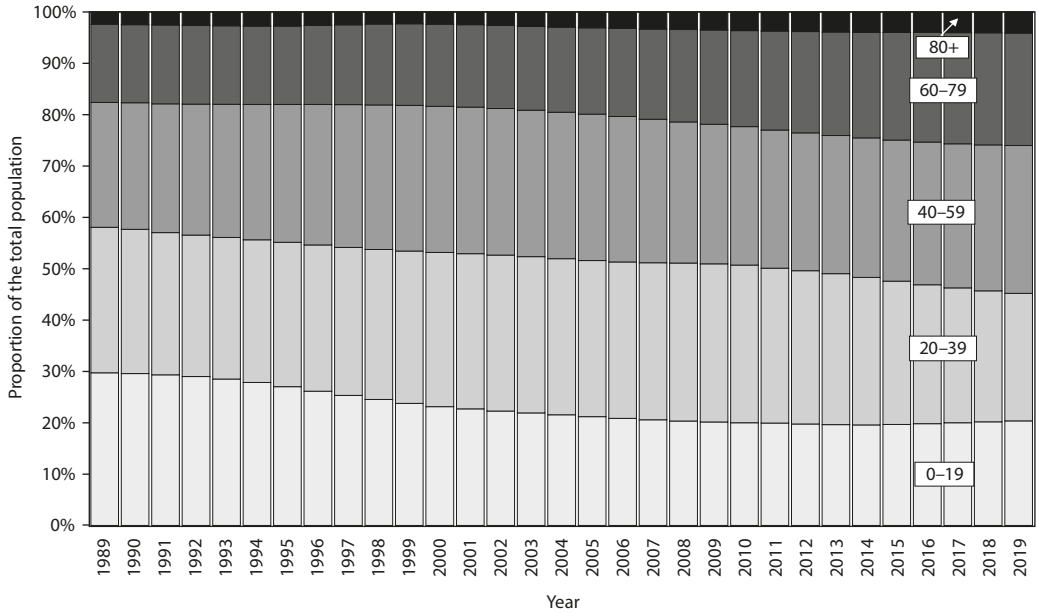
The share of persons under the age of 20, which until 1989 had accounted for around 30% of the total population for a long time, kept dropping over the next 20 years until it reached 20%. The number of young people thus dropped by almost one-third. The main reason for this, besides low fertility, was the fact that the numerically large generation born in the 1970s gradually transitioned out of this age group. The share of persons aged 20–39 decreased from 28.3% to 24.8% over the same time period, i.e. by only 3.5 percentage points. On the other hand, the share of the population represented by the 40–59 age group, which the above-mentioned numerically strong generation gradually entered, increased by 4.5 percentage points, from 24.3% to 28.8%. The share of persons aged 60–79 increased quite significantly (from 15.2% to 21.9%) because the large generation(s)

Figure 2 **Average age of the population**



Source: Czech Statistical Office (2020a), authors' calculations.

Figure 3 **Age structure of the population**



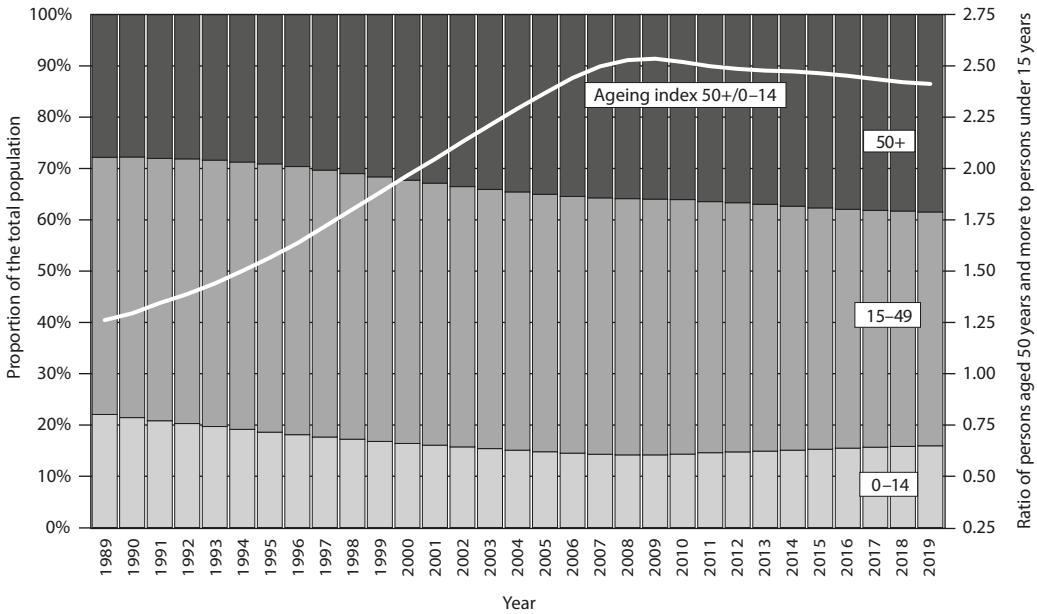
Source: Czech Statistical Office (2020a), authors' calculations.

born after World War II gradually entered this age group. The number of persons in this age group increased by almost half. The share of the oldest age group (80+) also increased, from 2.4% to 4.1%. Although this increase represents only 1.7 percentage points, it means that the number of people in the oldest age group increased by more than three-fourths during the observed period (Figure 3).

The trend in the shares of the population represented by broad age groups defined by reproductive age (0–14, 15–49, 50+) after 1989 was very significantly influenced by the coincidence of a sharp decline in birth rates and the fact that the numerically strong generations born in 1974 and later gradually entered the parental age group. The child age group (0–14 years) saw a decrease in the share of the population from 22% to 14% over 20 years. During the last 10 years of the analysed time period, the percentage of the child age group slightly increased thanks to a rise in the birth rate – when postponed reproduction later took place. In 2019, the child age group represented almost 16% of the population. The number of children in the population thus decreased by more than one-fourth during the entire analysed time period. The share of the parental generation (15–49 years old) slightly increased during the first years of the analysed period from 50% to over 52% because, as mentioned above, the numerically strong generation born in the 1970s entered this age group. Over the following years, however, the influence of the gradual transition of the numerically strong post-war generation from the parental to the grandparent age group (50+) began to prevail. By 2019, the share of the parental age group gradually decreased all the way to 45.6%. The share of the grandparent group during the analysed period increased more or less evenly from 27.8% to 38.5%, i.e. by more than 10 percentage points. The number of grandparents increased by more than 40% (Figure 4).

This trend, of course, resulted in a significant increase in the biological age index (the ratio of the number of persons aged 50 and over to the number of children under 15). The index increased from the initial 1.26 (1989) to 1.88 in 1999 and to 2.54 in 2009. Over the next 10 years, the index continued to gradually decrease because of higher birth rates, and by 2019 it had dropped to 2.41.

Figure 4 **Broad age groups defined by reproductive age**



Source: Czech Statistical Office (2020a), authors' calculations.

The trend in the shares of the population represented by broad age groups defined by productive age (0–19, 20–64, 65+) was of course similar, but with certain differences. We considered the age of 20, and not the previously used age of 15, to be the lower limit of productive age. This is consistent with the fact that most youth, after finishing primary school at the age of about 15, go on to high school or vocational school. Based on the last census, the share of economically active persons in the 15–19 age group represented only around 10% of the total number of persons in this age group. We will consider the age of 65 as the upper limit of productive age, although the retirement age in Czechia will not reach this upper limit until 2031.

The coincidence of a sharp decline in birth rates and the gradual transition of the numerically strong generations born in 1974 and later into the productive age population had a very significant impact on lowering the percentage of the pre-productive age population. While in 1989 persons of pre-productive age represented almost 30% of the total population, in 2014 they amounted to only 20%, which is a decrease of 10 percentage points. Thanks to higher birth rates during the last years of the analysed time period, the share of persons of pre-productive age increased to slightly above 20%. The number of persons of pre-productive age in 2019 was 30% lower than what it was in 1989.

By contrast, the percentage of persons of productive age increased during the first 20 years of the analysed time period; the largest increase occurred in the last years of the 20th century, when the numerically strong generation born in the mid-1970s gradually reached productive age and the significantly smaller generation born during the economic crisis of the 1930s gradually left this population group. Also, the majority of immigrants coming to Czechia were of productive age. The share of persons of productive age in the total population increased from less than 58% in 1989 to almost 65% in 2008, which was one of the highest percentages in the EU. However, the impact of low birth rates in the 1990s and the fact that the numerically strong generation born in the 1940s gradually reached post-productive age became apparent in the following years. In addition, immigration from abroad diminished as a result of the economic crisis. This is why the share of persons of productive age gradually fell below 60% between

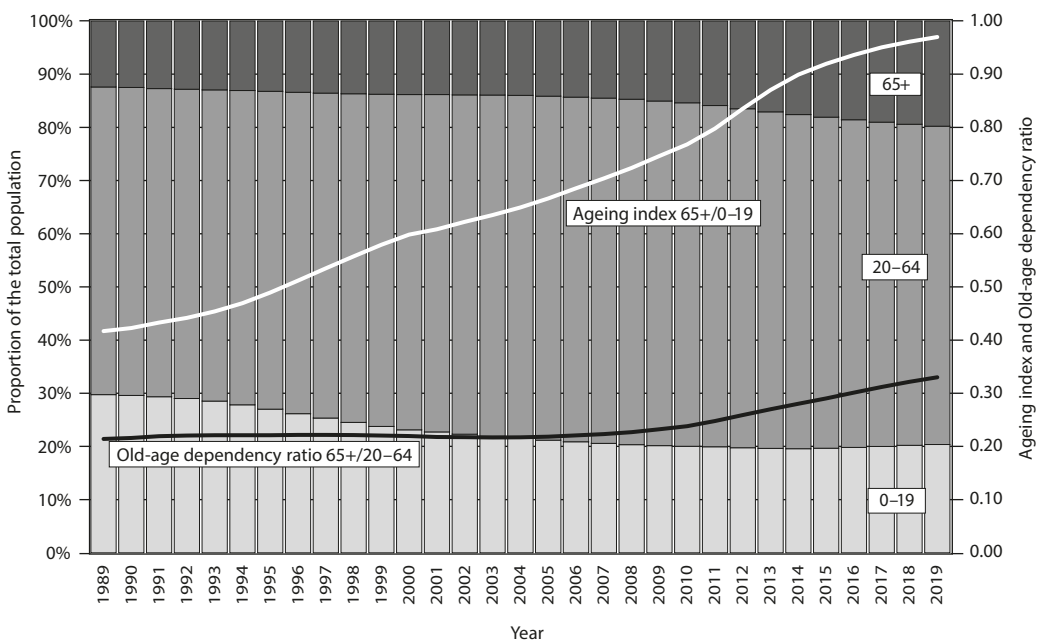
2008 and 2019. However, the number of persons of productive age in 2019 was still about 2% higher than the number in 1989.

The percentage of persons of post-productive age increased during the analysed time period. While in 1989 the share of persons of post-productive age was only slightly above 12%, it rose to more than 15% over the next 20 years. The biggest growth occurred during the last decade of the analysed time period; in 2019, people of post-productive age accounted for almost 20% of the total population. In addition to a permanent reduction in mortality rates, the main reason for this trend was that the numerically strong generation born after World War II gradually entered post-productive age. Throughout the analysed time period, the number of persons of post-productive age increased by about 65%, i.e. by almost two-thirds (Figure 5).

The economical ageing index (the ratio of the number of persons aged 65 and over to the number of persons under 20) grew much more smoothly than the biological age index, but it doubled nonetheless. While in 1989 there were more than two persons of pre-productive age per person of post-productive age (index 0.47), in 2019 this ratio was almost balanced (index 0.97).

A much more important characteristic from an economic point of view is the old-age dependency ratio, defined as the ratio of the number of persons of post-productive age to the number of persons of productive age. Unlike the old-age index, this index slightly increased between 1989 and 1997 (from 0.214 to 0.222) and then it decreased slightly to 0.217 in 2003. This is a result of the fact that the increase in the number of people of post-productive age was offset by the increase in the number of persons of productive age because the numerically strong generation born in the 1970s gradually moved into this group. The index started growing steadily and faster after 2004, amounting to 0.330 in 2019. While there were about 4.7 persons of productive age per person of post-productive age in 1989 and still 4.6 persons of productive age per person of post-productive age in 2003, this ratio had dropped by 2019 to only three persons of productive age per person of post-productive age.

Figure 5 **Broad age groups defined by productive age**



Source: Czech Statistical Office (2020a), authors' calculations.

This index is often used as a gross indicator of the financial burden represented by a retirement system that is based on PAYG funding. However, this indicator is not entirely correct for Czechia. While the age of 20 can be considered a relatively good estimate of when economic activity starts, the age when economic activity ends (or at least the age when people start to collect their old-age pension) is generally below 65 years. Up until the end of 1995, men retired at the age of 60 and women with two children at the age of 55. Since the year 1996, the retirement age has been increasing, based on the year of birth, by two months (in the case of men) and four months (in the case of women) for each subsequent year of birth. People in Czechia are not expected to retire as late as the age of 65 until 2031 (*Zákon* 155, 1995). Thanks to this gradual increase in retirement age, the actual ratio of the number of persons at retirement age to the number of persons of productive age was higher than the aforesaid index, but it was relatively stable throughout the analysed time period.

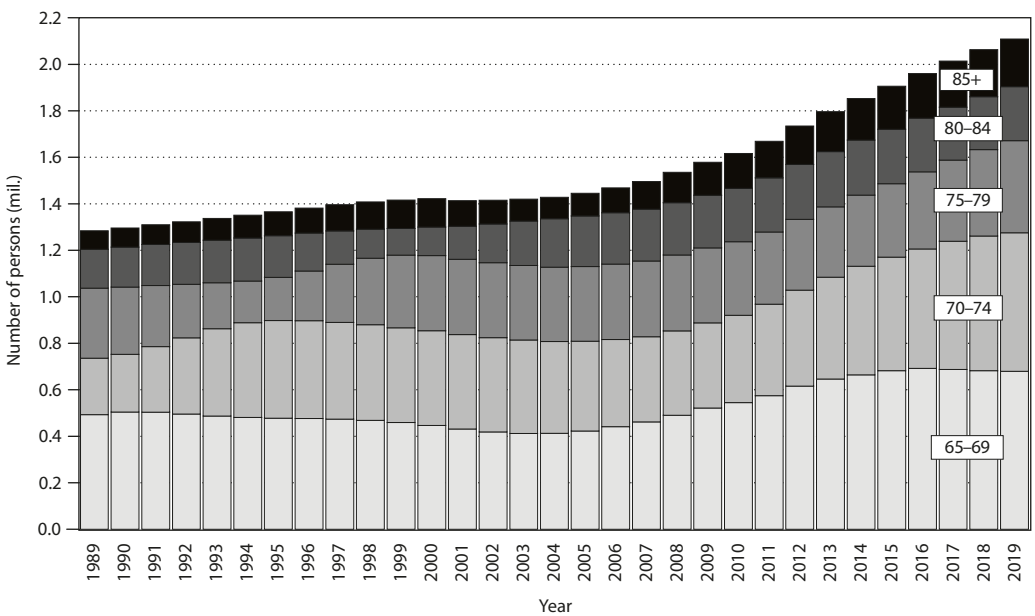
The total number of persons aged 65 and over continued to increase throughout the analysed time period. However, while the number of senior citizens was increasing on average by 10,000 persons a year during the 1990s and even by less at the beginning of this century, the number of senior citizens after 2010 was increasing by about 50,000 persons a year because the numerically strong generation(s) born after World War II became seniors. Overall, the number of senior citizens increased from almost 1.3 million to more than 2.1 million, i.e. by 64%.

The uneven age structure in 1989 resulted in an uneven increase in the number of persons in individual five-year senior groups. The number of persons aged 65–69 and 75–84 in 2019 was only about 30–40% higher than that in 1989. On the other hand, the number of persons aged 70–74 and the number of persons aged 85 and over increased about 2.5 times over the same time period (Figure 6). The number of persons aged 90–94 increased more than 3.7 times and the number of persons aged 95 and over increased more than 5 times.

Prospective age indicators

The aforesaid indicators of population ageing work on the assumption that the old-age threshold is constant at 65 years, which is the retirement age

Figure 6 **Trend in the number of persons aged 65 and over**



Source: Czech Statistical Office (2020a), authors' calculations.

in many European and other countries. However, this assumption is somewhat one-sided and problematic, given the continuing increase in life expectancy and the continuing improvement of the health of the population. Ryder (1975) was already arguing 45 years ago that the commonly used chronological measurement of age, such as the number of years elapsed since birth, was appropriate only from birth to adulthood and after that chronological age is no longer important as a guideline for other socioeconomic characteristics. Ryder suggests measuring old age in terms of the number of years remaining until death, replacing the commonly used fixed old-age threshold of 65 with the age at which the given tabular population has a remaining life expectancy of 10 years and considering this age as the old-age threshold. Thus, as mortality decreases and life expectancy increases, the old-age threshold increases as well. Many other authors followed up on this idea later on, such as Fuchs (1984). At the end of the last century, Siegel (1993) suggested that a remaining life expectancy of 15 years should be the old-age threshold. Sanderson and Scherbov further developed the issue of measuring the old-age threshold based on remaining life expectancy. They proposed adjusting a number of ageing indicators so that they take into account not only chronological age but also the expected remaining years of life (so-called prospective age). Some indicators based on prospective age for Czechia were published by Klapková, Šídlo and Šprocha (2016).

When for the population of Czechia we use the remaining life expectancy of 15 years (calculated as the average life expectancy of men and women based on the mortality tables for the relevant calendar year) as the old-age threshold instead of the age of 65, we see a rather sharp increase in this old-age threshold after 1989 due to the relatively fast decrease in mortality in Czechia. This newly defined old-age threshold was only about 62 years and 8 months in 1989, but it was over 65 years in 1998 and almost 69 years and 3 months at the end of the analysed time period. The old-age threshold thus increased by more than 6.5 years over the entire analysed time period (Figure 7).

As already mentioned, people in Czechia will not be retiring at age 65 until 2030. Since 1996 the retirement age of men has increased somewhat more slowly than the old-age threshold mentioned above; the retirement age of men is about one year higher than the age

Figure 7 **Prospective old-age threshold and retirement age**

Source: Czech Statistical Office (2020a, 2020b), authors' calculations.

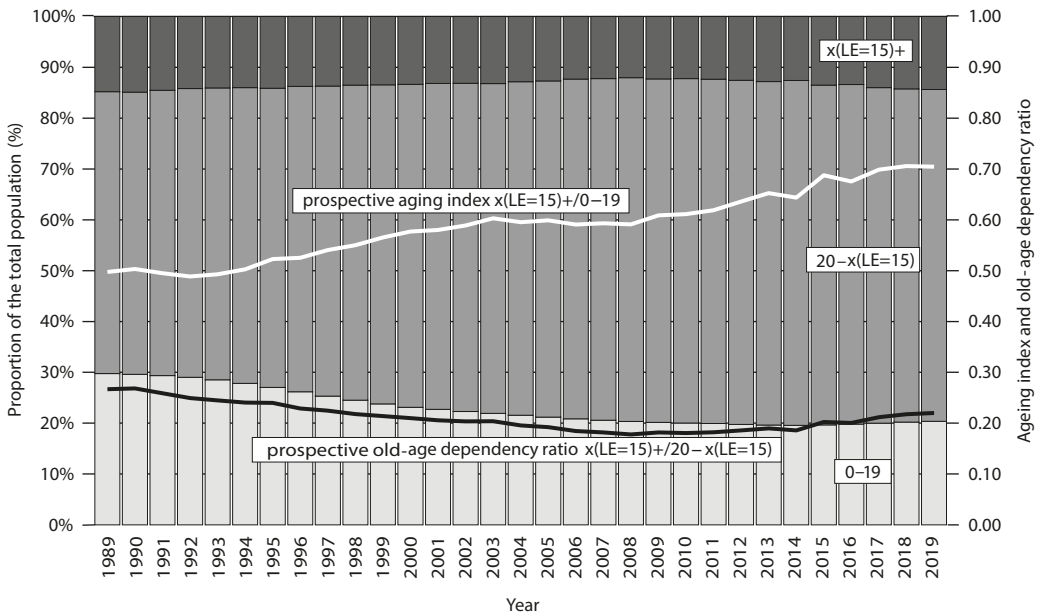
at which the remaining life expectancy is 20 years and the retirement age of women with two children is still more than one year lower than this age.

When using a tabular remaining life expectancy of 15 years and not the age of 65 as the upper limit of productive age to calculate broad age groups and relevant indices, we get a completely different picture of the trend in Czechia than when using standard indicators. The percentage of persons of productive age defined in this way continued to increase during the first 20 years and slightly decreased only in the last decade of the analysed period. However, the number of persons of productive age in 2019 was still more than 20% higher than what it was in 1989. The number and percentage of persons of post-productive age defined prospectively (i.e. persons with a life expectancy of 15 years and less) continued to slightly decline during the first 20 years, only to rise again during the last decade of the analysed period and almost reach the level it was at in 1989 (Figure 8).

The prospective old-age index (the ratio of the number of persons with a life expectancy of 15 years or less to the number of persons under 20) continued to grow much more slowly than the standard index. The index was around 0.5 during the first half of the 1990s and gradually increased, reaching 0.6 in the year 2003. An additional increase all the way to 0.7 occurred during the last decade of the analysed time period.

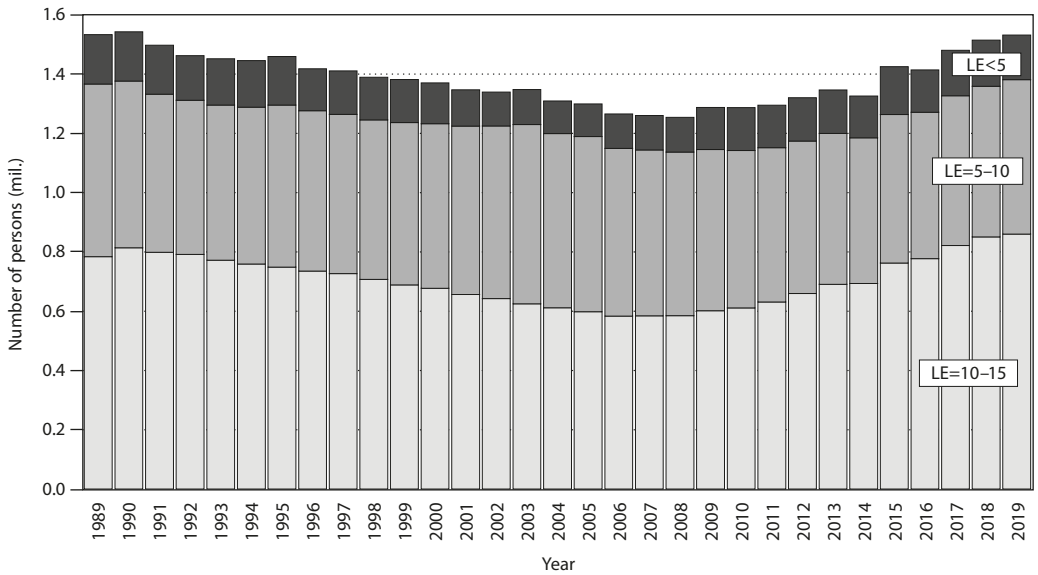
On the other hand, the prospective old-age dependency ratio (the ratio of the number of persons with a life expectancy of less than 15 years to the number of persons aged 20 and over with a life expectancy of more than 15 years) continued to slightly decrease during the first 20 years of the analysed time period. This is because life expectancy was constantly going up while the numerically strong generation born during the 1970s moved from pre-productive age to productive age. This index started to increase slightly during the last decade of the analysed time period. This is because the numerically weak generation born in the 1990s entered productive age, while the numerically strong generation(s) born at the end of and especially after World War II gradually moved to the group of persons with a life expectancy of less than 15 years. However, the index was still lower in 2019 than it was in the first half of the 1990s.

Figure 8 **Prospective broad age groups, economic ageing index and old-age dependency ratio**



Source: Czech Statistical Office (2020a, 2020b), authors' calculations.

Figure 9 **Distribution of the oldest persons by prospective age**



Source: Czech Statistical Office (2020a, 2020b), authors' calculations.

While the number of persons aged 65 and over continued to increase during the analysed time period, the number of persons with a life expectancy of less than 15 years continued to decrease until 2008 – from more than 1.5 to less than 1.3 million. After that, this number started going up and by 2019 reached almost the same level as it was in 1989. The number of persons with a remaining life expectancy of between 10 and 15 years increased by about 10%. Conversely, the number of persons with a shorter remaining life expectancy (between 5–10 years and up to 5 years) decreased by approximately 10% (Figure 9).

CONCLUSION

The ageing of the Czech population accelerated after 1989 because of a relatively rapid increase in life expectancy and a drop in fertility, especially in the last years of the 20th century. This was partly offset by international migration. The biggest increase in the mean age of the population was observed in the years around the turn of the millennium, when the number of births was very low. Conversely, the ageing slowed down a little bit in the late 2000s when net migration and natality were relatively high. The highest increase in the proportion of older persons was observed in the oldest-old age group (85+ years of age).

Because of the retirement age in Czechia is below 65 years the actual ratio of the number of persons of retirement age to the number of persons of productive age is still higher than the standard old-age dependency ratio (65+/0–19) and will remain so until 2031.

The financial impact of the increase in the proportion of older persons on the old-age pension system has been offset by the continuous increase in the statutory retirement age since 1996, especially in the case of females. Because of this measure to increase the retirement age, the pension system remained relatively stable during the period analysed.

Alternative indicators of population ageing based on the concept of prospective age (i.e. on remaining life expectancy) offer another picture of population ageing. While the number of persons aged 65 and over grew throughout the period analysed, owing to the relative rapid improvement of mortality even in senior age, the number of persons with a remaining life expectancy that is less than 15 years had a slowly decreasing tendency until 2008, and despite a later increase its present values are approximately the same as they were in the initial year of this analysis in 1989.

Acknowledgment

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Population and vital statistics of the Czech Republic: 2019, 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	10,669,324	10,693,939	54,870	24,141	112,231	31,797	112,362	288	175	–131	44,270	44,139	5.1	2.3	10.5	10.5	4.1
Praha	1,315,311	1,324,277	6,841	2,743	14,933	3,670	12,178	30	18	2,755	12,890	15,645	5.2	2.1	11.4	9.3	11.9
Střední Čechy	1,377,505	1,385,141	6,872	3,381	14,836	4,010	13,471	29	15	1,365	14,444	15,809	5.0	2.5	10.8	9.8	11.5
Jihozápad	1,230,676	1,233,982	6,290	2,712	12,692	3,712	13,241	31	20	–549	7,726	7,177	5.1	2.2	10.3	10.8	5.8
Severozápad	1,115,344	1,115,629	5,800	2,716	10,921	4,341	12,613	41	24	–1,692	1,636	–56	5.2	2.4	9.8	11.3	–0.1
Severovýchod	1,515,301	1,517,999	7,637	3,583	15,835	4,484	16,066	31	19	–231	4,537	4,306	5.0	2.4	10.5	10.6	2.8
Jihovýchod	1,698,900	1,701,802	8,830	3,661	18,825	4,535	17,826	44	29	999	3,862	4,861	5.2	2.2	11.1	10.5	2.9
Střední Morava	1,214,851	1,214,570	6,116	2,651	12,133	3,549	13,205	35	22	–1,072	229	–843	5.0	2.2	10.0	10.9	–0.7
Moravskoslezsko	1,201,436	1,200,539	6,484	2,694	12,056	3,496	13,762	47	28	–1,706	–1,054	–2,760	5.4	2.2	10.0	11.5	–2.3
Hlavní město Praha	1,315,311	1,324,277	6,841	2,743	14,933	3,670	12,178	30	18	2,755	12,890	15,645	5.2	2.1	11.4	9.3	11.9
Středočeský kraj	1,377,505	1,385,141	6,872	3,381	14,836	4,010	13,471	29	15	1,365	14,444	15,809	5.0	2.5	10.8	9.8	11.5
Jihočeský kraj	643,145	644,083	3,284	1,433	6,665	1,998	6,885	18	9	–220	2,170	1,950	5.1	2.2	10.4	10.7	3.0
Plzeňský kraj	587,531	589,899	3,006	1,279	6,027	1,714	6,356	13	11	–329	5,556	5,227	5.1	2.2	10.3	10.8	8.9
Karlovarský kraj	294,807	294,664	1,593	694	2,827	978	3,405	9	5	–578	346	–232	5.4	2.4	9.6	11.5	–0.8
Ústecký kraj	820,537	820,965	4,207	2,022	8,094	3,363	9,208	32	19	–1,114	1,290	176	5.1	2.5	9.9	11.2	0.2
Liberecký kraj	442,947	443,690	2,288	1,180	4,659	1,618	4,607	13	8	52	1,282	1,334	5.2	2.7	10.5	10.4	3.0
Královéhradecký k.	551,208	551,647	2,797	1,286	5,504	1,584	5,901	9	6	–397	1,023	626	5.1	2.3	10.0	10.7	1.1
Pardubický kraj	521,146	522,662	2,552	1,117	5,672	1,282	5,558	9	5	114	2,232	2,346	4.9	2.1	10.9	10.7	4.5
Kraj Vysočina	509,370	509,813	2,666	1,030	5,497	1,315	5,636	10	8	–139	678	539	5.2	2.0	10.8	11.1	1.1
Jihomoravský kraj	1,189,530	1,191,989	6,164	2,631	13,328	3,220	12,190	34	21	1,138	3,184	4,322	5.2	2.2	11.2	10.2	3.6
Olomoucký kraj	632,141	632,015	3,213	1,377	6,359	1,872	6,914	15	9	–555	78	–477	5.1	2.2	10.1	10.9	–0.8
Zlínský kraj	582,710	582,555	2,903	1,274	5,774	1,677	6,291	20	13	–517	151	–366	5.0	2.2	9.9	10.8	–0.6
Moravskoslezský k.	1,201,436	1,200,539	6,484	2,694	12,056	3,496	13,762	47	28	–1,706	–1,054	–2,760	5.4	2.2	10.0	11.5	–2.3

Radek Havel

Population and vital statistics of the Czech Republic in towns with population above 50 thousands: 2019

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	1,315,311	1,324,277	6,841	2,743	14,933	3,670	12,178	2,755	12,890	15,645	5.2	2.1	11.4	9.3	11.9
Brno	380,654	381,346	2,072	854	4,642	1,204	4,052	590	75	665	5.4	2.2	12.2	10.6	1.7
Ostrava	288,357	287,968	1,524	641	3,076	882	3,460	–384	–776	–1,160	5.3	2.2	10.7	12.0	–4.0
Plzeň	173,979	174,842	812	385	1,852	480	1,863	–11	2,412	2,401	4.7	2.2	10.6	10.7	13.8
Liberec	104,585	104,802	538	312	1,159	403	1,034	125	232	357	5.1	3.0	11.1	9.9	3.4
Olomouc	100,576	100,663	571	226	1,114	303	1,016	98	42	140	5.7	2.2	11.1	10.1	1.4
České Budějovice	94,133	94,463	531	225	1,048	299	1,090	–42	491	449	5.6	2.4	11.1	11.6	4.8
Hradec Králové	92,745	92,939	489	192	944	209	1,018	–74	271	197	5.3	2.1	10.2	11.0	2.1
Ústí nad Labem	92,751	92,716	479	240	954	403	1,043	–89	–147	–236	5.2	2.6	10.3	11.2	–2.5
Pardubice	91,078	91,727	404	211	1,010	264	1,008	2	1,037	1,039	4.4	2.3	11.1	11.1	11.4
Zlín	74,940	74,935	361	165	736	225	803	–67	5	–62	4.8	2.2	9.8	10.7	–0.8
Havířov	71,531	71,200	437	143	619	250	913	–294	–409	–703	6.1	2.0	8.7	12.8	–9.8
Kladno	69,214	69,337	341	148	730	223	799	–69	352	283	4.9	2.1	10.5	11.5	4.1
Most	66,208	66,034	329	154	661	271	744	–83	–69	–152	5.0	2.3	10.0	11.2	–2.3
Opava	56,525	56,450	322	128	592	196	628	–36	–152	–188	5.7	2.3	10.5	11.1	–3.3
Frýdek–Místek	55,722	55,557	267	140	566	154	608	–42	–332	–374	4.8	2.5	10.2	10.9	–6.7
Karviná	52,496	52,128	265	104	509	172	741	–232	–464	–696	5.0	2.0	9.7	14.1	–13.3
Jihlava	50,982	51,216	267	128	516	191	547	–31	402	371	5.2	2.5	10.1	10.7	7.3

Radek Havel

Abstracts of Articles Published in the Journal Demografie in 2020 (Nos. 1–3)

Oldřich Hašek

THE REGIONAL DIFFERENTIATION OF FERTILITY BY RURAL TYPOLOGY IN CZECHIA

The aim of this article is to show the influence different typologies of regions have on the results on the regional differentiation of fertility in Czechia. The selected typologies focus primarily on rural diversification. Selecting typologies for comparison is in itself a complex task, given the complexity of external factors, and not just socio-economic and functional ones, which therefore need to be taken into account in the selection process. The analysis therefore examines total fertility levels in relation to the selected typological divisions/the selected typologies. At the same time, it compares what picture of fertility development is presented by the different types of typologies. In general, however, regional differences in fertility levels do exist between the selected rural typologies.

Keywords: Czechia, regional differentiation, fertility, countryside, typology **Demografie,** 2020, **62: 3–13**

Kateřina Maláková – Luděk Šídlo – Jan Bělobrádek

THE REGIONS, AGE AND AVAILABILITY OF HEALTH SERVICES: GENERAL PRACTICAL MEDICINE IN CZECHIA

The age structures of the population and of the providers of health services are significant factors that influence the availability of these services. The aim of the paper is to identify where the biggest problems with ensuring the availability of the selected segment of health services at the regional level in Czechia could occur as a result of the age structure of the population and physicians. This selected segment of health services focused on here is general practice. The main prerequisite for this work is that areas with a higher proportion of elderly people and areas with a higher proportion of older physicians may face significant difficulties with ensuring the provision of necessary health care. For this purpose, a typology of 'catchment areas' was created from which to define potentially problematic areas. The research revealed significant regional differences in the age structure of the population and physicians. Moreover, the current distribution of GP supply (measured as the number of FTE general practitioners) is relatively even in Czechia, but the availability of these services may be influenced by the departure of physicians from the system because of their age, especially in rural regions.

Keywords: Region, age, health services, availability, population, general practitioners, urban and rural areas, Czechia **Demografie,** 2020, **62: 14–26**

Robert Šanda

THE RATE OF RESPONSE FOR THE TOPIC OF COMMUTING IN THE 2011 POPULATION AND HOUSING CENSUS AND THE RECONSTRUCTION OF THE RESPONSE RATE USING THE JARO-WINKLER METHOD

The article analyses the item response rate for data on commuting from the 2011 census and seeks to discover the main reasons for the unusually large shares of unknown values. A research method using the Jaro-Winkler algorithm of probabilistic record linkage is then applied to the raw records of census forms, aiming to improve the resulting response rates by identifying answers harmed by partial inconsistencies or mistakes. As a result, the share of recognized values increased significantly. Based on the findings the article then proposes basic conceptual recommendations for the next census.

Keywords: Population and housing census, Czechia, data quality, commuting, record linkage

Demografie, 2020, **62: 27–42**

Filip Hon – Jitka Langhamrová

INTERPOLATING AGE-SPECIFIC FERTILITY RATES IN THE CZECH REPUBLIC USING THE QUADRATIC SPLINE MODEL IN SELECTED YEARS

The aim of this paper is to contribute to fertility research on women in the Czech Republic from a new perspective. The Quadratic spline model, a modern statistical method designed for the purpose of analysing age-specific fertility rates, is presented in the paper and tested on data for the Czech Republic. Attention is also devoted to the development of this model's parameters since the Velvet Revolution in 1989. The final part focuses on estimating age-specific fertility rates, which is one of the practical uses of this model.

Keywords: Age-specific fertility rates, statistical modeling, projection, second demographic transition

Demografie, 2020, **62: 71–88**

Branislav Šprocha – Vladimír Bačík

POSTPONEMENT OF THE CHILDBIRTH AND THE LATE FERTILITY IN THE EUROPEAN AREA

The main aim of the paper is to analyse late fertility in the European area. Based on historical data, we highlight developmental changes in this phenomenon for selected European populations both in terms of their intensity and how they contribute to overall fertility. In connection with the current postponement fertility transition, we then identify the main spatial differences in terms of the timing of having a first child and contributions to the total fertility rate. We also point out the differences in the weight of late fertility and in the age distribution of fertility with respect to the upper and lower quartiles.

Keywords: Late fertility, fertility postponement, Europe

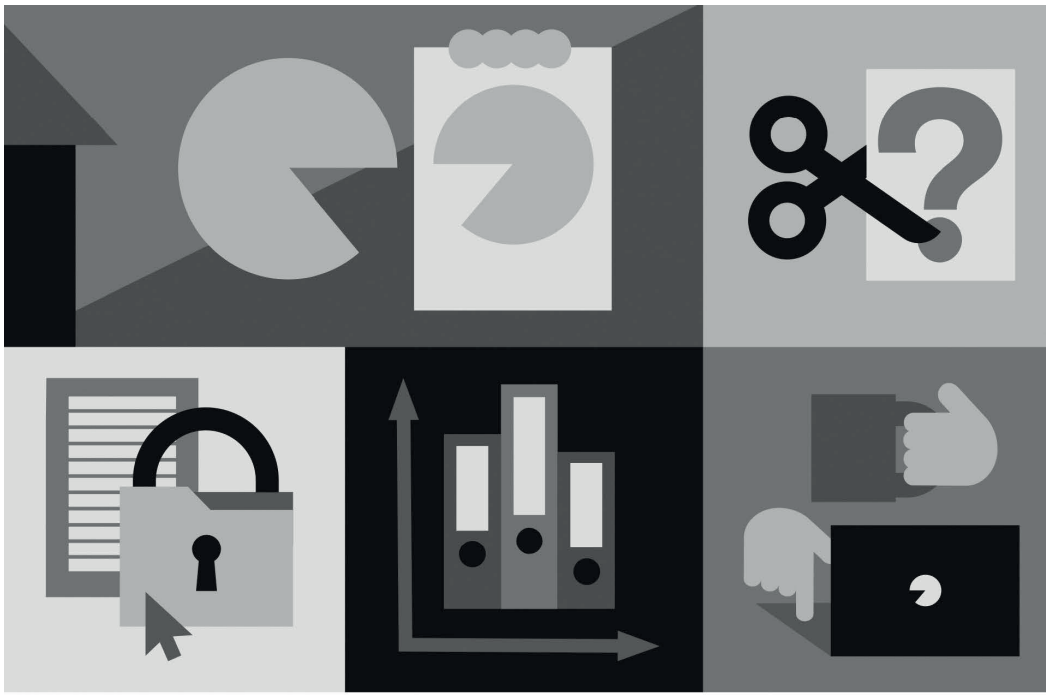
Demografie, 2020, **62: 123–141**

Eddy Suratman – Restiatun Massardi

FAMILY PLANNING VILLAGES AND CONTRACEPTIVE SELECTION BEHAVIOUR IN WEST KALIMANTAN PROVINCE, INDONESIA: A PRELIMINARY STUDY

High population growth is a population problem in Indonesia. The establishment of the Family Planning Village is believed to be able to bring family planning programmes closer to the community and especially the poor. One indicator of success since the launching of the Family Planning Village is the increase in the number of users of modern contraceptives, both effective contraception and permanent contraception. This study is based on a field experiment in which the research subjects were two Family Planning villages in West Kalimantan Province (Mekarsari and Kampung Beting Village) as the treatment groups, and two non-Family Planning villages (Limbung and Tanjung Hilir Village) as the control groups. This research found that the Family Planning villages did not significantly influence some changes in contraceptive selection behaviour. Changes in contraception selection behaviour are significantly affected only by the number of children in the household and belief or religion. It is therefore necessary to cooperate with religious leaders in disseminating the importance of contraception.

Keywords: FP village, impact evaluation, contraceptive, behaviour **Demografie,** 2020, **62: 142–156**



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- *Potraty*. 2005. Prague: Ústav zdravotnických informací a statistiky.

Articles in periodicals

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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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