CHANGES IN MORTALITY OF THE CZECH POPULATION IN RECENT YEARS

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Abstract

In recent times, the length of human life has been continuously extended. As it was not compensated by a sufficient birth rate, the population was aging. Thus, the problem of the necessary reforms of the health and social system, which would solve the problem of population aging, was and is still being solved in individual European countries. However, the Covid-19 pandemic interfered with this development. When it broke out, it started to be discussed about what effect it would have on mortality and the length of human life. Will human life span be shortened? Alternatively, how big will the shortening be? The aim of this contribution is to analyze mortality of the population in the Czech Republic (especially in recent years). More attention will be paid to the mortality of the elderly (people in ages 60 and higher). Furthermore, the contribution will focus on analyzes of the impact of the Covid-19 pandemic.

Key words: mortality, mortality models, covid 19 pandemic

JEL Code: J10, J11, J19

Introduction

Extending of human life has been very frequently discussed topic in recent years. Thanks to improving in medical care, greater interest in a healthy lifestyle, people live longer. This positive development also means that it will be important to focus more on the care of the elderly in the future (this post will focus on mortality aged 60 and over).

1 Methodology

As was already said the attention will be focused on mortality in ages 60+. Several approaches could be used for analyzing mortality in these ages. One of them is an application of analytical functions. Very often frequentely used was the Gompertz-Makeham function (the oldest one) (Burcin et al., 2010 or Langhamrová, Fiala, 2013).

In recent years, logistics functions have been used very often for modelling of mortality (Boleslawski, Tabeau, 2001 or Dotlačilová, 2020). One of them will be used in this paper as well (Kannisto model).

The Czech Statistical Office also uses Kannisto model for its calculations (Czech Statistical Office, 2019).

Kannisto model

Kannisto model is a type of logistic function. It is one of the most frequentely used analytical function for modelling of mortality. This feature assumes to have a slower increase in level of mortality (Gavrilov, Gavrilova, 2011).

In this article, Kannisto model was used in shape (Kannisto et al., 1994 or Thatcher et al. 1998):

$$\mu_x = \frac{ae^{b.x}}{1 + ae^{b.x}}, \qquad (1)$$

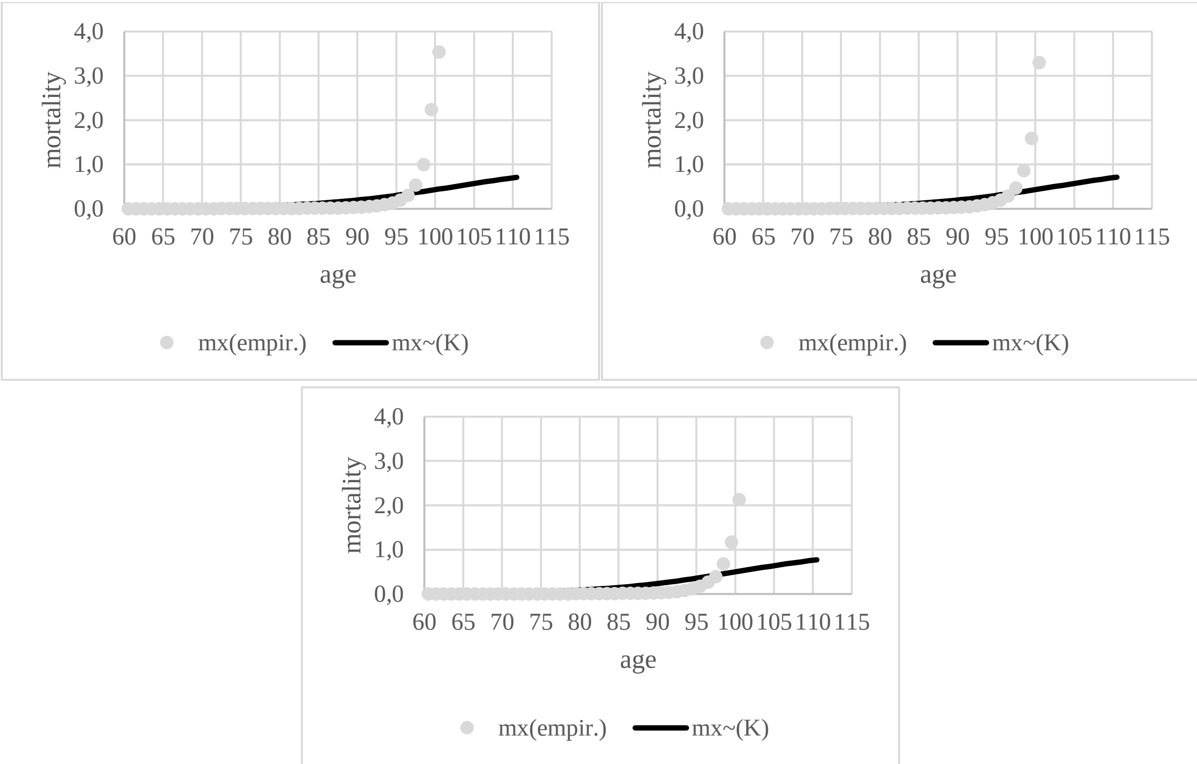
where a and b are unknown parameters of the model, x is the age.

Another point of this paper is the application of the test criterion which could be used for the evaluation of obtained results. This might give us an information about suitability of concrete model (in this paper will be only about evaluation). Here will be used adjusted R^2.

2 Results

In this paper, data about mortality of males and females in the Czech Republic from 2018 to 2020 will be analyzed. This period was chosen intentionally due to the impact of the Covid-19 pandemic on this data.

Fig. 1: Males – modelled mortality from 2018 to 2020



Source: data CZSO (2022), author's calculation

The first group of figures shows the comparison of empirical and modeled mortality. The used analytical function models the mortality from 2018 to 2019 relatively well. In 2020, Kannisto model deviates more from the empirical mortality (this is mainly noticeable for ages 90+).

The first table shows the estimates of the unknown parameters of the Kannisto model. It is also supplemented with *p*-values and results of the adjusted R^2.

Tab. 1: Males - estimated parameters of Kannisto and test criterion

	2018	*p*-value	2019	*p*-value	2020	*p*-value
beta	0,000011	0	0,000010	0	0,000008	0
gamma	0,111469	0	0,112708	0	0,116627	0
R^2_{adj}		0,9978		0,9979		0,9987

Source: data CZSO (2022), author's calculation

The first table shows that both parameters of the Kannisto model are significant in all three years. The results for the adjusted coefficient of multiple determination show that the model explains more than 99% of the variability of analyzed data. On the other hand, it is important to note that the adjusted R^2 refers only to the age interval <60; 90> years. We do not have any information about the suitability of the model for ages 90 and higher.

The following table serves to supplement the analysis of mortality and the impact of the covid-19 pandemic on the number of deaths. As results, indices of changes in actual number of deaths between years 2019 and 2018 (2020 and 2019) in the age range <60; 100> are calculated here.

Tab. 2: Males – changes in the number of deaths from 2018 to 2020

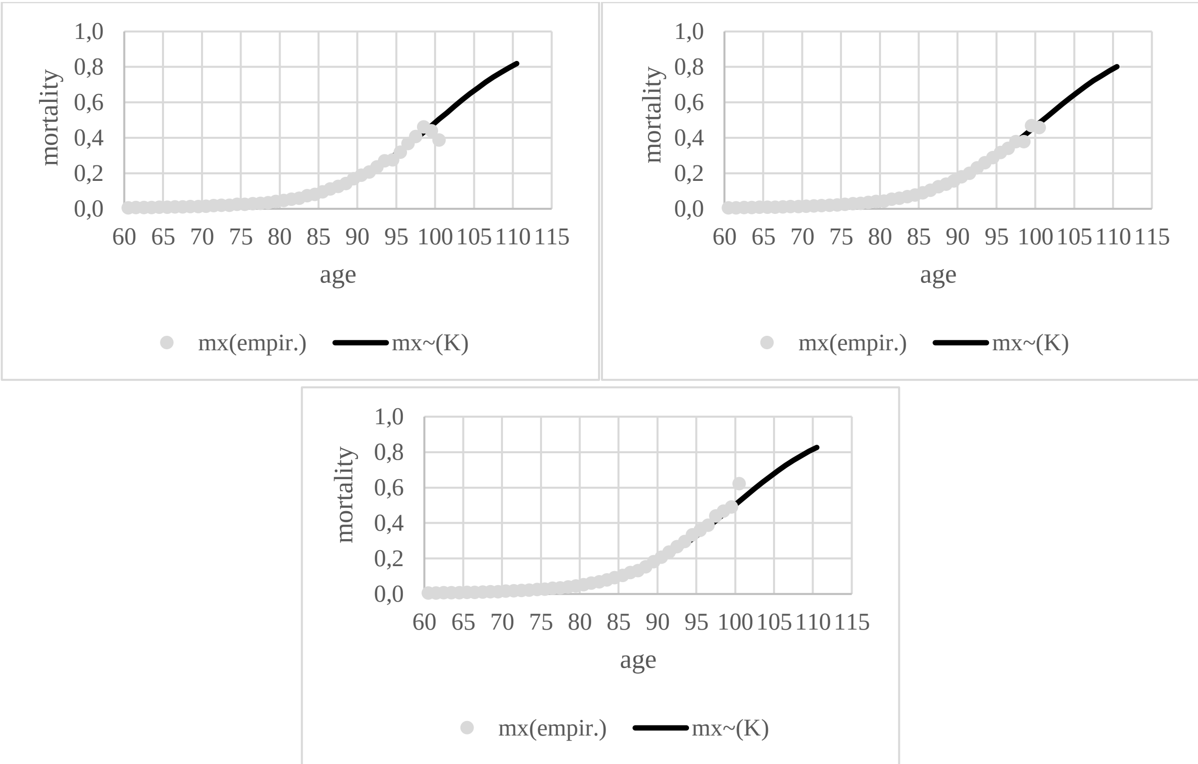
age	2019/2018	2020/2019	age	2019/2018	2020/2019
60	0,92	1,00	81	1,02	1,28
61	0,87	0,98	82	0,99	1,31
62	0,97	1,09	83	0,96	1,19
63	0,99	1,05	84	0,98	1,15
64	1,00	1,05	85	1,04	1,10
65	0,92	1,04	86	0,97	1,18
66	0,99	1,06	87	0,99	1,20
67	0,94	1,13	88	1,02	1,24
68	1,00	1,13	89	1,04	1,14
69	0,97	1,12	90	1,08	1,24
70	0,94	1,17	91	1,05	1,22
71	0,95	1,09	92	1,17	1,18
72	1,08	1,13	93	1,04	1,21
73	1,08	1,26	94	0,90	1,30
74	0,95	1,26	95	1,06	1,11
75	1,08	1,11	96	1,11	1,14
76	1,08	1,34	97	1,23	1,15
77	0,99	1,31	98	1,22	1,26
78	1,05	1,25	99	1,42	1,11
79	1,07	1,25	100	1,27	1,58
80	1,01	1,33			

Source: data CZSO (2022), author's calculation

Table 2 shows that between 2019 and 2018 there was no significant increase in the number of deaths in any of the selected ages. Between 2020 and 2019, the situation is different. For all ages is correct that the number of death has increased. The most significant increase is noticeable at the age of 100. However, at the highest ages it is necessary to realize that the number of people living and dying is low in these matters. The year-on-year index may therefore have a higher value.

The second group of figures shows empirical and modeled mortality for females in the Czech Republic from 2018 to 2020.

Fig. 2: Females – modelled mortality from 2018 to 2020



Source: data CZSO (2022), author's calculation

From all three figures it can be seen that the Kannisto model better models empirical mortality (compared to males). This also applies in 2020.

The following table contains the results of Kannisto model parameter estimates, *p*-values and results of the adjusted coefficient of R^2.

Tab. 3: Females - estimated parameters of Kannisto and test criterion

	2018	*p*-value	2019	*p*-value	2020	*p*-value
beta	0,000000	0	0,000000	0	0,000000	0
gamma	0,149120	0	0,146468	0	0,147219	0
R^2_{adj}		0,9991		0,9991		0,9995

Source: data CZSO (2022), author's calculation

Table 3 shows that both parameters of the Kannisto model are significant in all analyzed years. From the values of the adjusted R^2, it can be concluded that Kannisto model explains more than 99 % of the variability of the analyzed data. Even here, however, the values of the adjusted R^2 are calculated from the age interval <60; 90>.

The following table is used to supplement the analysis of mortality and also the impact of the covid-19 pandemic on the number of deaths.

Tab. 4: Females – changes in the number of deaths from 2018 to 2020

age	2019/2018	2020/2019	age	2019/2018	2020/2019
60	0,85	0,99	81	1,04	1,19
61	0,87	0,92	82	0,99	1,20
62	0,97	0,93	83	0,94	1,14
63	1,02	0,95	84	0,94	1,17
64	0,94	1,01	85	0,91	1,15
65	0,95	0,97	86	0,91	1,13
66	0,90	1,05	87	0,98	1,04
67	0,93	1,06	88	1,00	1,10
68	1,02	1,14	89	0,96	1,19
69	0,94	1,09	90	0,98	1,19
70	0,94	1,08	91	0,99	1,20
71	0,94	1,07	92	1,00	1,18
72	1,07	1,08	93	0,97	1,15
73	1,07	1,23	94	1,04	1,16
74	0,88	1,24	95	1,02	1,09
75	1,06	1,08	96	1,00	1,17
76	1,07	1,25	97	1,05	1,23
77	1,03	1,23	98	1,05	1,38
78	1,10	1,13	99	1,61	1,34
79	1,09	1,16	100	1,30	1,90
80	0,97	1,31			

Source: data CZSO (2022), author's calculation

Table 4 shows the values of year-on-year indices, which represent changes in the actual number of deaths. As with males, we observe a more significant increase in mortality between 2019 and 2020 for females. However, the increase is not as significant as for males. This could also be one of the reasons why Kannisto model models females' mortality well in all analyzed years.

3 Discussion

The authors Gavrilov and Gavrilova deal with the modeling of mortality using analytical functions. In their articles, they mention using of one of the oldest function - Gompertz-Makeham function. They also mention using of logistic functions.

The authors Thatcher and Kannisto also deal with this issue. They prefer logistic functions for modeling. They also mention that they are suitable for "long-lived" populations (that is, populations that have a low level of mortality rate). They are also the authors of logistic models: Thatcher's and Kannisto's. In their book: *The Force of Mortality at Ages 80 to 120*, they provide

a basic overview of analytical functions. Functions are divided into several basic groups according to their type (exponential, logistic, power, quadratic, polynomial).
From the Czech authors, Burcin, Hulíková – Tesárková, Šídlo deal with mortality modeling. Those for mortality modeling use analytical functions. They also mention the differences between individual models.
Another approach to modeling mortality is represented by groups of stochastic models. Among the most important is the Lee-Carter model. Its advantage is that it can also be used to predict the development of mortality. Today, it is probably one of the most commonly used model for mortality prediction.

Conclusion

The aim of this paper was to analyze mortality of population in the Czech Republic from 2018 to 2020. This period was chosen due to analyze the impact of the covid 19 pandemic. The Kannisto model was used for modeling of mortality in ages 60+. At the end of analysis, the effects of the covid-19 pandemic were also examined.

It is clear from the obtained results that Kannisto model shows worse results for males in the Czech Republic compared to females. This is especially true for 2020, where the impact of the covid-19 pandemic should already be noticeable. To explain why Kannisto model comes out worse in the last year, could be used the results for year-on-year indices for the actual number of deaths. For males, there was a more significant increase in the number of deaths in essentially all analyzed cases. This development could be one of the reasons why Kannisto model has been worse for males in the last year.

As was already mentioned, the situation for females is somewhat different. Kannisto's model performs reasonably well in all analyzed years. This conclusion can be supported with the help of year-on-year indexes of the current number of deaths. In the comparison between the selected years, there was no significant number of death females.

At the end, the contribution dealt with the evaluation of the appropriateness of the used model. As a criterion for evaluation was used adjusted R^2. For both males and for females, Kannisto's model explains more than 99 % of the variability of the analyzed data.

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