Development and prediction of the selected population movement indicators in the Czech Republic

Vývoj a predikce vybraných indikátorů pohybu obyvatelstva v České republice

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Abstract: The paper is aimed at the presentation of findings obtained in the study of the developmental trends of the population reproduction indicators in the territory of the Czech Republic in the reference period 1993–2003. The analysis of selected indicators is also aimed at a short-term extrapolation prediction. Developmental trends are specified of the population composition according to the main age groups, live births and natural increase of population. The population development in the reference period under study demonstrated increasing qualitative changes in the demographic behaviour of population after 1989. A characteristic feature of this stage of social development is the transition to the west-European model of reproduction behaviour intensified in part of the population by negative impacts of the social and economic transformation. A marked decrease in the number of live births and its point prediction for 2005 can bring about further irregularities in the age structure of population together with the development in the number of dead and external migration. Methods of regression and correlation analysis and development trends were applied for the mathematical-statistical analysis.

Key words: population, age structure, natality, mortality, natural increase, trend, prediction

Abstrakt: Příspěvek prezentuje dílčí poznatky získané při studiu vývojových tendencí demografických indikátorů populační reprodukce na území České republiky v referenčním období let 1993 až 2003. Předmětná analýza demografické dynamiky je vedle hodnocení indexních řad zkoumaných jevů a vývojových tendencí směrována i na extrapolační bodovou predikci vybraných ukazatelů. Populační vývoj v posuzovaném referenčním období prokázal prohlubující se kvalitativní změny demografického chování obyvatelstva po roce 1989. Charakteristickým znakem této etapy společenského vývoje je přechod k západoevropskému modelu reprodukčního chování, zintenzívněného u části populace negativními dopady sociální a ekonomické transformace. Výrazný pokles počtu živě narozených a jeho bodová predikce na rok 2005 může vyvolat další nepravidelnosti ve věkové struktuře populace a spolu s vývojem počtu zemřelých a zahraniční migrací ovlivnit jak počet obyvatelstva, tak i indikátor jeho stárnutí. Pro statistickou analýzu daného materiálu byly použito vývojových trendů a metod regresní a korelační analýzy.

Klíčová slova: obyvatelstvo, věková struktura, natalita, mortalita, přirozený přírůstek, trend, predikce

Specific position of demographic analysis represented by the achieved level of characteristics of the population movement and its reproduction as one of the important material conditions of social and economic development requires not only exact evaluation of the main developmental trends of the given phenomena in the past but also prediction of their future probabilistic development.

The conception of the presented study is oriented to the quantification of changes in the development of natality and mortality in the Czech Republic in the period 1993 to 2003. Within the reference period, time series were also analysed of the population number structure according to main age groups, live births and indicator of the death rate (mortality). The changes in the natality rate, mortality and age structure of the population as quantitative and qualitative changes of the characteristics of the population reproduction becomes more and more social process and not only biological process. The period that started in the Czech

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Republic at the turn of the 80's and 90's is the period of transformation from the central planned economy to the market economy and is very complicated from both social and economic aspects. It is not possible to eliminate the impact of the economic changes that slow down the positive factor of population reproduction, the net reproduction rate. An important role is played by the postponement of concluded marriages which causes a distinctive decrease of the natality. The expected further development of the fertility rate in the Czech Republic and the derived consequences in demographic, social and economic sphere must serve as an initial base for competent approach to the assessing of the purpose, aim and tools of the population policy.

Theoretical aspects and interpretation of the results of analytical activities in the sphere of the study of demographic events and processes have been dealt with by the number of authors. The following papers can be considered to be fundamental from the aspect of the conception of examination proper: Dufek (1999, 2003), Kretschmerová (2001), Maca, Palát (2004), Palát, Maca (2004), Roubíček (1996), Srb (2001), Fiala (2002) and Kaňáková (2002).

Methodological procedures of processing the factual data of analysed time series are based on the methods of descriptive statistics presented in the papers of Cyhelský et al. (1979) and Minařík (2000).

MATERIAL AND METHODS

Basic materials necessary for the implementation of the determined objectives of the analysis of time series of studied events were obtained from the database of the Czech Statistical Office. Methodological procedures of processing and evaluating the studied indicators of demographic dynamics were aimed according to the set objectives of the analysis at the evaluation of dynamics and trends of assessed phenomena including their short-term extrapolation prediction.

Analysis of the trend of the assessed time series is based on the application of models of developmental tendencies of the following type:

$$y' = a_{yt} + b_{yt} \times t \quad (1)$$

$$y' = a_{yt} + b_{yt} \times \ln t \quad (2)$$

$$y' = a_{yt} + b_{yt} \times t + c_{yt} \times t^2 \quad (3)$$

$$y' = a_{yt} + b_{yt} \times \frac{1}{t} \quad (4)$$

$$y' = a_{yt} \times t^{b_{yt}} \quad (5)$$

$$y' = a_{yt} \times e^{b_{yt}} \times t \quad (6)$$

Informative abilities and accuracy of the applied analytical functions were tested by means of correlation indices I_{yt}. The statistical significance of correlation indices was tested on the significance level $P = 0.05$ and $P = 0.01$. Determination indices I^2_{yt} were used for verification of the indicators developmental trend models and their short-term extrapolation prediction.

Mathematical-statistical processing of the data comes from the methodology given in papers of Minařík (2000), Seger et all. (1998), Klíma, Palát (2003a, 2003b, 2004) and Palát, Maca (2004).

Table 1. The development trends of selected indicators of the population movement in the Czech Republic in the period 1993 to 2003

Indicator	Measured unit	Model type	Model parameters of developmental trends			I^2_{yt} (%)
			a_{yt}	b_{yt}	c_{yt}	
Mid-year population	thousands of person	1	10 369.2	–14.6636	–	91.37^{++}
Incl. the age: 0–14	thousands of person	1	2 063.2	–46.4818	–	99.40^{++}
15–64	thousands of person	1	6 962.4	23.5	–	96.77^{++}
65 and more	thousands of person	1	1 343.5	8.3182	–	84.40^{++}
Live births per 1000 population	‰	4	8.4269	3.2134	–	90.36^{++}
Deaths per 1000 population		3	11.8624	–0.2962	0.0177	85.14^{++}

Type of the function: (1) – linear, (3) – quadratic, (4) – inverse
Determination index I^2_{yt} significant on the level: $^{+}\alpha = 0.05$; $^{++}\alpha = 0.01$

RESULTS AND DISCUSSION

The population development which occurred in the assessed territorial unit and defined time interval confirmed and intensified marked qualitative changes in the demographic behaviour of population appearing after the transition of centrally directed economy to market economy after 1989. The main demographic trends of selected indicators of the population movement in the reference period are presented in Table 1 and Figure 1.

There is an enormous annual decrease of the mid-year population of the pre-productive population (2.99%) and a little increase of the post-productive population (0.58%). Based on the data presented above on the population movement, it is possible to observe a relative increase of the productive population by 0.32% and a total decrease of the mid-year population by 0.14%.

The negative direction of the mid-year population development in the reference period is compensated by the number of migrants (105 974 persons). After eliminating them, the trend function of the modified time series would reach the following values:

$$y' = 10\,362\,402.75 - 15\,086.51818 \times t$$

$$= 90.50\ \%^{++}$$

and mean annual relative decrease by 0.15%.

The most marked feature of the population development was the enormous decrease of marriages and born children and subsequently also the intensity of the processes. The problem of a considerable decrease in natality and its extrapolation prediction in the degree of decrease in 2005 as compared with its absolute level in 2003 will show consequences in the creation of other irregularities in the age structure of population. Together with the further development of mortality and migration, it will manifest itself in the number of population and its ageing. An overall quantification of the development of time series of the selected indicators of the population movement provides parameters of analytical trend functions according to main age groups of mid-year population, live births, deaths and natural increment. A strong relative decrease in the reference period was also proved for the positive component of the population reproduction, presented by the relative rate of general natality (with an average annual relative decrease by 1.99%). When assessing the trend of the relative rate of general mortality as the rate of the number of deaths a year to the mid-year population (per mille) and a negative component of the population reproduction in the reference period, we can see its average annual decrease by 0.79%. Interpreting the indicators of both components of the population reproduction, it is to be stressed that both of the rates – natality and mortality are dependent on the age population structure. Results of this stage of analytical activities are given in Table 2.

The extrapolate point prediction of the mid-year population for 2005 presented in the Table 2 a distinc-

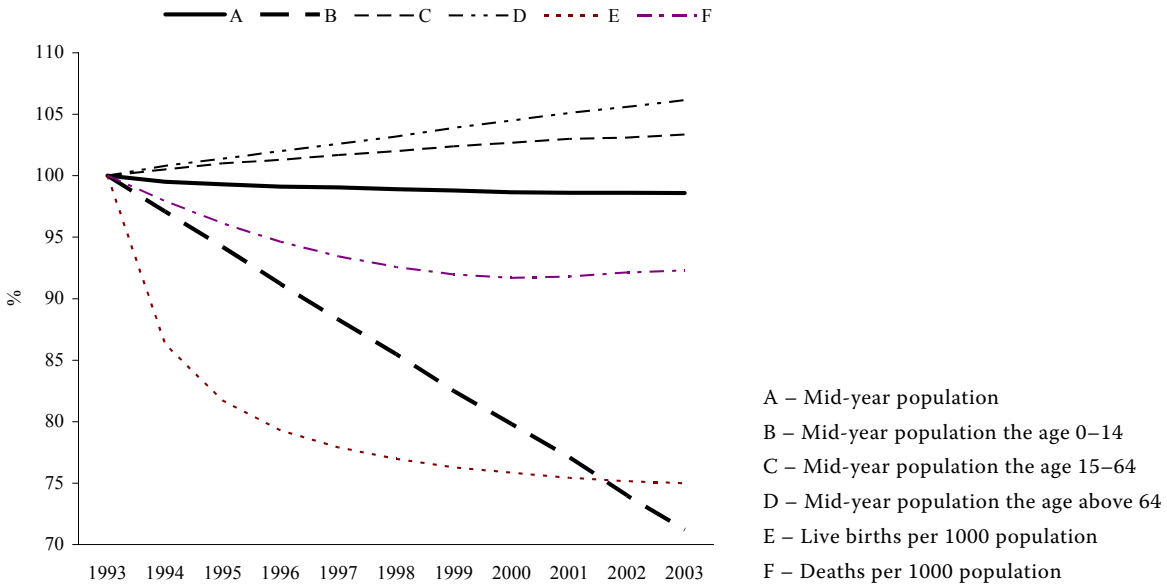

Figure 1. Dynamics of fitted values of selected indicators of the population movement in the Czech Republic in the period 1993 to 2003

Table 2. Short-term extrapolation point prediction of the population movement indicators in the Czech Republic compared with selected previous years

Indicator		Point estimate for 2005	Reality in the year		
			1948	1990	2003
Mid-year population (thousands of person)		10 179	8 893	10 363	10 202
Include the age:	0–14	1 459	.	2 223	1 571
	15–64	7 268	5 493	6 844	7 211
	65 and more	1 452	.	1 296	1 420
Live births per 1000 population		8.67	22.2	12.6	9.2
Deaths per 1000 population	‰	11.00	11.4	12.5	10.9
Natural increment per 1000 population		–2.3	10.8	0.1	–1.7

tive increase by 14.3% as against 1948 and indistinctive decreases in the years 1990 (by 1.78%) and 2003 (by 0.23%). Decrease in the estimated mid-year pre-productive population by 34.3% as against 1990 and decrease in the estimated mid-year pre-productive population by 7.13% as against 2003. Decrease of the post-productive population by 12.10% in the prediction year as against 2003. There was an enormous decrease in the live-born (by 60.95%) as against 1948 and as against 1990 (by 31.2%) and as against 2003 (by approximately 5.8%). Decrease in deaths per 1000 inhabitants of the mid-year population by 3.51% as against the 1948 and by 12.0% as against 1990 in the prediction in 2005 are also manifested. The same way of interpretation is possible to use for the version assessing the dynamics of natural increases or decreases to the defined unit of measure, which would decrease by 37.06% in 2005 as against 2003.

CONCLUSION

The paper is aimed at the presentation of findings obtained in the study of the development of time series of the population movement in the defined territorial unit and time interval 1993–2003. In addition to the exact evaluation of the dynamics and trend, the analysis of selected indicators is also aimed at a short-term extrapolation prediction. The population development in the reference period under study demonstrated increasing qualitative changes in the demographic behaviour of population after 1989. A characteristic feature of this stage of a social development is a transition to the west-European model of reproduction behaviour intensified in part of the population by negative impacts of the social and economic transformation. A decrease in the number of both concluded marriages and birth rate, in spite of an extraordinarily favourable age structure, appears to be a serious and negative feature of the population development. A marked decrease in the number of live births and its point prediction for 2005 can bring about further irregularities in the age structure of population and together with the development in the number of dead to affect both the number of population and the indicator of its ageing. The changes of the economic and social situation with its social and economic aspects are characterized not only with a continual increase of the expectation of life, but also by the decrease of the natality rate and putting off the marriage to the higher age. Both of these negative assessed processes can lead as far as the depopulation which exists at present in many European countries (from 1995 continuously in Italy, Hungary, Germany, Romania, Russia, Slovenia, Sweden). The expected further development of the fertility rate in the Czech Republic and the derived demographic, economic and social consequences have to motivate competent government authorities to change their approach to the population policy.

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