TIME SERIES ANALYSIS OF THE RELATIONSHIP BETWEEN MORTALITY AND SELECTED ECONOMIC INDICATORS IN THE CZECH REPUBLIC

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Abstract

Changes in mortality rates are apparent for a long time. The main causes of death and the most common age of death are gradually changing not only in the Czech Republic. This paper will attempt to find a connection between the time series of mortality and selected socio-economic indicators such as unemployment rate, level of economic activity, inflation rate, GDP, average wage and average retirement pension, share of the average pension and wage, etc.Mortality time series will be represented in this analysis indicator of life expectancy (for 0 and 65-years old men and women). There will be a trend analysis of time series and their possible use for predicting the future. Thispaper will focus on analysing time series only those between which we found relevant relationships. We want to verify between which series of mortality and socio-economic exist relationships, which may be expressed by using time series analysis.

Time series will be based on individual data of deaths in the Czech Republic in the years 1990-2013.

Key words: Czech Republic, GDP, mortality, time series, unemployment

JEL Code:J11, C22

Introduction

The aim of this paper was to find a connection between the time series of mortality and selected socio-economic indicators such as unemployment rate, level of economic activity, inflation rate, GDP, average wage and average retirement pension, share of the average pension and wage, etc.

Mortality time series will be represented in this analysis indicator of life expectancy. We know that life expectancies in the Czech Republic have grown in the last decades apace. It is possible to say that the lengthening of the human life can have an impact in many areas. It would have a great impact on the structure of an employment, etc.(Löster and Langhamrová, 2011 and Dotlačilová, 2013). We want to verify between which series of mortality and socio-economic exist relationships, which may be expressed by using time series analysis.We analyse life expectancies at birth and for 65-years old men and women together with all of the above socio-economic lines. But after a thorough investigation we found the relevant relationship only between life expectancies and GDP. So that in the following text will be examined relationship only between these time series.

1 Data

On the basis of individual data of deaths in the Czech Republic in 1990-2013 (provided by Czech Statistical Office under a project No. IGS F4/68/2014) was calculated mortality tables with correction of mortality rates at the highest ages using a modified Gompertz-Makeham formula (by Fiala, 2005 and Koschin, 1999). All another socio-economic time series are from online database of Czech Statistical Office (CZSO). For socio-economic indicators we selected serieslike unemployment rate, level of economic activity, inflation rate, GDP, average wage and average retirement pension, share of the average pension and wage, etc.

2 Analysis of the relationship

In order to ascertain whether the time-series relationship exists, it is first necessary to prepare unit root test whether the analysed time series are stationary or non-stationary. Stationary time series are also known as time series with short memories, non-stationary time series are designated as series with long memories. While in series with short memories, the influence of shock from the last period of time is gradually disappearing, in series with long memory manifests itself constantly. Differences in the nature of these time series are given by fundamental differences in their generating processes (Arlt, 1998).

From the results in Table1 it implies that all the analysed time series are at the 5% significance level unsteady and their first differences are stationary, i.e. that all time series are type I (1).

Tab. 1:Unit Root Tests

	Time Series		First Differences	
	t_{ADF}	Prob.	t_{ADF}	Prob.
LE_0^F	-1.755845	0.3911	-5.526712	0.0002
LE_{65}^F	-2.945263	0.1677	-4.570069	0.0017
LE_0^M	-2.046103	0.2666	-4.989967	0.0006
LE_{65}^M	-2.878381	0.1868	-3.817957	0.0090
GDP	-1.456358	0.5362	-3.584070	0.0111

Source: data CZSO, calculation Eviews

The relationship between the two non-stationary time series exists only if their linear combination is stationary (Arlt, 1997 or Arlt, Arltová, 2009). Table 2 includes unit root tests of residues of simple regression models with various addictions for life expectancy of men and women on GDP. From this it follows that the long-term dependence on GDP will be identified only in three time series - LE_0^F, LE_{65}^F and LE_0^M. In the case of LE_{65}^M according to the GPD is only a spurious regression and this relationship is not considered.

Tab. 2:Unit Root Tests a_t

$Y_t = c + \beta X_{tt}$	$\hat{a}_t$	
	t_{ADF}	Prob.
GDP → LE_0^F	-3.199249	0.0028
GDP → LE_{65}^F	-2.107832	0.0362
GDP → LE_0^M	-2.749394	0.0084
GDP → LE_{65}^M	-2.888586	0.1577

Source: data CZSO, calculation Eviews

In the first part of the analysis we will estimate models for dependence of life expectancy of woman on GDP in the second part we do the same for men.

1.1 Relationship between life expectancy at birth for women and GDP

Both time series are non-stationary (Table 1). Using the Granger test cointegration (Engle, Granger, 1987), we find that the time series are cointegrated because their linear combination is on the 5% level of significance stationary (Table 2).

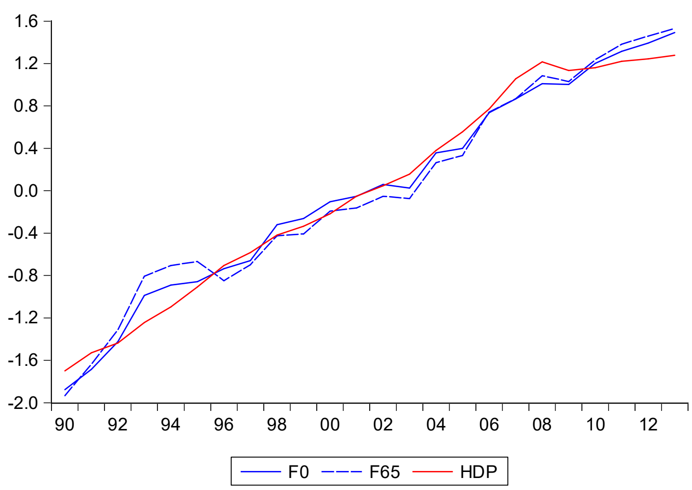
Since the $\hat{a}_t$ is autocorrelated, we used to estimate the ADL model

$$Y_t = c + \alpha_1 Y_{t-1} + \beta_1 X_t + \beta_2 X_{t-1} + \beta_3 X_{t-3} + \alpha_t, \tag{1}$$

$$\underset{(11.807)}{L\hat{E}_0^F = 45.7153} + \underset{(0.157)}{0.39485 LE_{0\ t-1}^F} + \underset{(0.00000039)}{0.00000118 GDP_t} - \underset{(0.00000065)}{0.00000168 GDP_{t-1}} + \underset{(0.00000039)}{0.00000131 GDP_{t-2}} \tag{2}$$

wherein LE_0^F at time t depends proportionally on the value at time t-1 and also on previous values of GDP, and directly proportional to the time t and t-2 and inversely proportional to time t -1.

Fig. 1: Life expectancy at birth and for 65-years old women depending on GDP



*Data was normalized to the same mean and variance

Source: data CZSO, calculation Eviews

If this model is expressed in the form of error correction model (EC) we get

$$\Delta Y_t = c + (\alpha_1 - 1)\Delta Y_{t-1} + \beta_1 \Delta X_t + (\beta_1 + \beta_2)\Delta X_{t-1} + (\alpha_1 - 1)(Y_{t-2} - \frac{\beta_1 + \beta_2 + \beta_3}{1 - \alpha_1} X_{t-2}), \tag{3}$$

than

$$\begin{aligned} \Delta L\hat{E}_{0\ t}^F &= 45.7153 - 0.60515 \Delta LE_{0\ t-1}^F + 0.00000118 \Delta GDP_t - 0.0000005 \Delta GDP_{t-1} \\ &- 0.60515 (LE_{0\ t-2}^F - 0.00000134 GDP_{t-2}), \end{aligned} \tag{4}$$

where the parameter 0.00000134 expresses long-term directly proportional relationship between the analysed time series.

Tab. 3: Diagnostic tests

Breusch-Godfrey Serial Correlation LM Test	0.077444	Prob. F(2,15)	0.9258
Normality Test: Jarque-Bera	0.483750	Prob	0.7851
Heteroskedasticity Test: Breusch-Pagan-Godfrey	1.405981	Prob. F(1,19)	0.2503

Source: data CZSO, calculation Eviews

1.2 Relationship between life expectancy of 65-year old women and GDP

Even in this case, both time series areon the 5% level of significance non-stationary (Table 1). Granger cointegration test shows that the linear combination is stationary (Table 2), but also it is autocorrelated. Once again we use to estimate the ADL model

$$Y_t = c + \alpha_1 Y_{t-1} + \alpha_3 Y_{t-3} + \beta_2 X_{t-2} + \alpha_t, \quad (5)$$

$$\hat{LE}_{65}^{F} = 11.3015 + 0.655 LE_{65\,t-1}^{F} - 0.39366 LE_{65\,t-3}^{F} + 0.00000064 GDP_{t-2}, \quad (6)$$

(3.078) (0.170) (0.157) (0.00000018),

wherein LE_{65}^{F} at time *t* depends proportionally on the value at time *t*-1 and inversely proportional to time *t*-3 and directly proportional to the previous value of GDP in time *t*-2.

If this model is expressed in the form of error correction model (EC) we get

$$\Delta Y_t = c + (\alpha_1 - 1)\Delta Y_{t-1} + (\alpha_1 - 1)\Delta Y_{t-2} + \beta_2 \Delta X_{t-2} + (\alpha_3 + \alpha_1 - 1)(Y_{t-3} - \frac{\beta_3}{1-\alpha_1-\alpha_3} X_3), \quad (7)$$

than

$$\Delta \hat{LE}_{65\,t}^{F} = 11.3015 - 0.3450 \Delta LE_{65\,t-1}^{F} - 0.3450 \Delta LE_{65\,t-2}^{F} + 0.00000064 \Delta GDP_{t-2} - 0.73866 (LE_{65\,t-3}^{F} - 0.00000087 GDP_{t-3}), \quad (8)$$

where the parameter 0.00000087expresses long-term directly proportional relationship between the analysed time series.

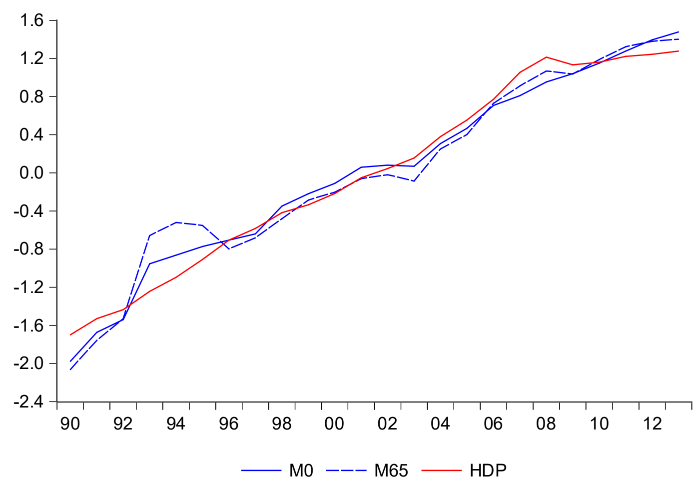
Tab. 4: Diagnostic tests

Breusch-Godfrey Serial Correlation LM Test	0.023935	Prob. F(2,15)	0.9764
Normality Test: Jarque-Bera	0.925241	Prob	0.6296
Heteroskedasticity Test: Breusch-Pagan-Godfrey	2.527233	Prob. F(1,18)	0.1293

Source: data CZSO, calculation Eviews

1.3 Relationship between life expectancy at birth for men and GDP

Fig. 2: Life expectancy at birth and for 65-years old men depending on GDP



* Data was normalized to the same mean and variance

Source: data CZSO, calculation Eviews

Even in this case, both time series are non-stationary (Table 1). And as for women alsofor men cointegration test at 5% significance level confirmed that the time series are cointegrated (Table 2). But non-systematic component $\hat{a}_t$is autocorrelated, so we use for the estimation ADL model

$$Y_t = c + \alpha_1 Y_{t-1} + \beta_1 X_t + \alpha_t, \qquad (9)$$

$$\underset{(8.593)}{\hat{LE}_0^M = 26.5049} + \underset{(0.129)}{0.6101} LE_0^M{}_{t-1} + \underset{(0.00000025)}{0.00000067} GDP_t, \qquad (10)$$

wherein LE_0^M at time *t* depends proportionally on the value at time *t*-1 and also on present value of GDP.

If this model is expressed in the form of error correction model (EC) we get

$$\Delta Y_t = c + \beta_1 \Delta X_t + (\alpha_1 - 1)(Y_{t-1} - \frac{\beta_1}{1-\alpha_1} X_{t-1}) , \qquad (11)$$

than

$$\Delta L\hat{E}_{0\ t}^{M} = 26.5049 + 0.00000067 \Delta GDP_t - 0.389869(LE_{0\ t-1}^{M} - 0.00000172 GDP_{t-1}), \qquad (12)$$

where the parameter 0.00000172expresses long-term directly proportional relationship between analyses time series.

Tab. 5: Diagnostic tests

Breusch-Godfrey Serial Correlation LM Test	0.338578	Prob. F(2,18)	0.7172
Normality Test: Jarque-Bera	19.39028	Prob	0.0064
Heteroskedasticity Test: Breusch-Pagan-Godfrey	2.65E-05	Prob. F(1,20)	0.9959

Source: data CZSO, calculation Eviews

Conclusion

We analyse life expectancies at birth and for 65-years old men and women together with all of the above socio-economic lines. But after a thorough investigation we found the relevant relationship only between life expectancies and GDP. Specifically, we found cointegration between series of life expectancy at birth for males and females, and 65-years old women always with a series of GDP. For all these relationship we construct ADL and error correction models with parameters, whichexpress long-term directly proportional relationshipsbetween analyses time series.

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