

## RELATION BETWEEN SUICIDES AND SELECTED ECONOMIC AND CLIMATIC INDICATORS

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### Abstract

Suicide is very often underestimated problem in society. Voluntarily committed suicide points to strange individual behaviour that is not consistent to nature and survival instinct. It shows on specific behaviour of individuals and also on deficiencies of the whole society. Statistics of suicide is very important. It is possible to set certain measures within it, which could reduce values of this phenomenon. The analysis of suicide trends and their possible dependency on social, economic and climatic factors could contribute to the implementation of certain measures to prevent suicidal behaviour. The aim of this paper is to determine, which factors could have a demonstrable impact on suicide rates.

**Key words:** suicidality, seasonality, time series, unemployment, inflation rate, climatic factors

**JEL Code:** E23, J19

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### Introduction

The first mention of suicidal behaviour is dated to the 6th century BC. However, in the late 19th century, suicidal behaviour is coming to the attention of professionals (physicians, philosophers and other specialists at the time). The first attempts to clarify the causes of this behaviour and aspirations to develop a theory of suicide appear in that period (Koutek, Kocourková, 2007). Approach to suicide has changed over the time and it is explained in different ways. Both of them agreed on two signs: the voluntariness of act and the intention to end life (Polášek, 2011). Mandatory definition of suicidal behaviour was set up in 1968 by the World Health Organization (WHO) and its still valid text declares: "Suicidal act is an act, by which the individual will cause physical harm, does not matter whether motivation is known or not, and regardless of the intention. Suicide is considered to be a death caused by a suicidal act." (Rubešová, 2006)

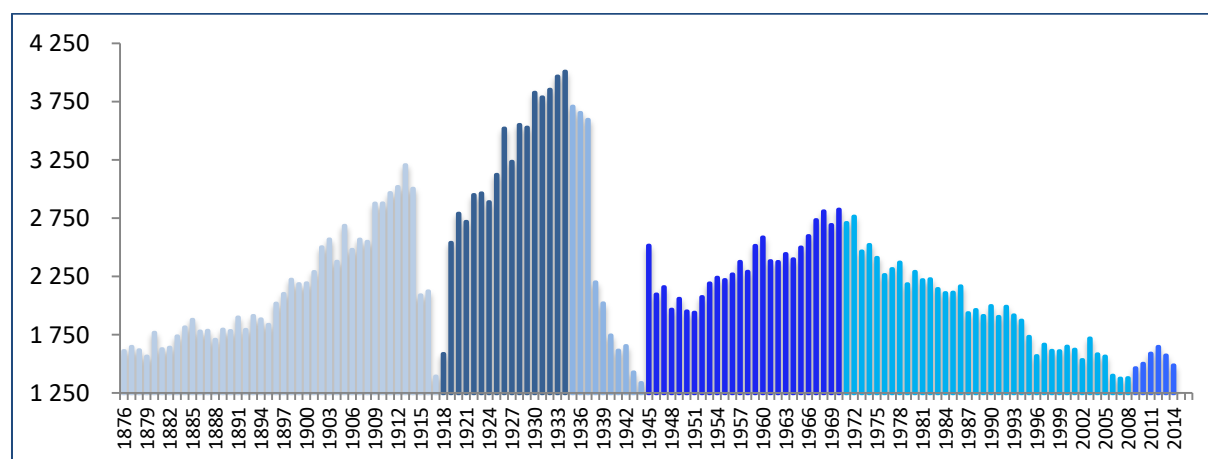
Nowadays, suicidality is a very serious and global issue. Suicides are responsible for the lost of more than one million lives every year. The latest available data concerning the

Czech Republic indicate that in average 4 people commit suicide every day. The Czech Statistical Office (CZSO) in co-operation with the Institute of Health Information and Statistics (IHIS), established by the Ministry of Health, as well as the Technology Department of Management and Informatics of the Police Presidium, maintain records of suicides in the Czech Republic. They quantify and classify this behaviour from many aspects (gender, age, used method, theme, scene, marital status, education, day of the week, month, permanent residency) and examine their interrelations and connections. This paper is focused on statistical analysis of selected and expected external influence on suicidal behaviour and tries to quantify the impact. It was taken into consideration that it is not possible to cover all the factors determining suicide, because it is the result of a combination of various factors. There were chosen only some of them and, as the important tool, the approach based on the analysis of time series is used.

## 1 Development and analysis of suicides in the Czech republic

The Czech Statistical Office keeps data of suicides in a comparable territory of the contemporary Czech Republic from 1876 onwards (Fig. 1).

**Fig. 1: Number of suicides in the Czech Republic in 1876–2014**



Source: Czech Statistical Office

Development of suicides is closely related to social, economic and political situation and recent historical events in the Czech Republic and can be divided into six periods.

The first period between the years 1876–1915 is characterized by a sharp rise of suicides, which is probably connected with economic and social changes during the global revolution of modern times, when suicides could become more common way of solving life

crisis. The second period covers almost the entire period of the First Republic, i.e. from the beginning of the Czechoslovak Republic in 1918 to 1934, and its sharp rise of suicides follows the first period. The top was reached in the year 1934, when 4007 individuals committed suicide due to the impact of global economic crisis (the number of unemployed reached almost one million). It has been the highest value measured in the above mentioned territory. The third period, from 1934 until the next peak in 1945, covered years of the Second World War. Data from the years 1917–1918 and 1940–1945 can probably be partly regarded as undervalued. It might have been caused by war suicides, which were not recorded as suicides, because of undetected or otherwise classified cause of death. We also have to take into consideration possibility, disclosed by Daňková (2003) and being based on Marshall's study (1981), i.e. the sudden decrease of suicides due to war as so called integrating effect. The fourth period is the one of communism in Czechoslovakia and the growing number of suicides can be divided into two phases. Decrease of suicides becomes apparent from 1945. Minimum suicide rate is in 1951. It is possible to notice a slow growth from above mentioned year to 1970, with the only significant fluctuation in 1960. The growth of suicides in the early 1950s could be associated to monetary reform and forming of agricultural cooperatives which many farmers did not accept and disagreed with. The top was reached in 1968–1974. It was probably the result of occupation of Czechoslovakia by the Warsaw Pact army troops and the following process of normalization.

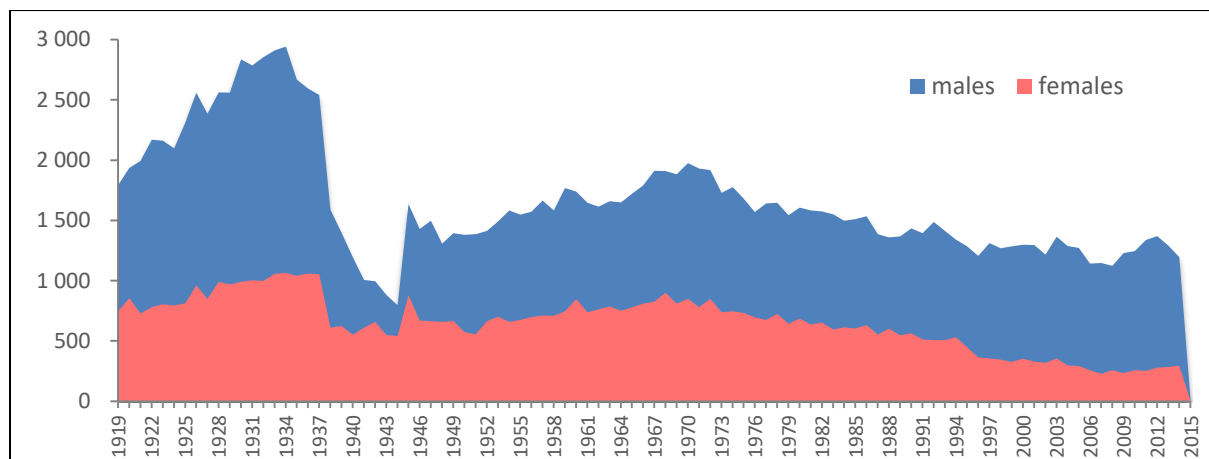
The fifth period covers the early 1970s to the year 2008, there is constant decline of suicides. The number of suicides keeps below the limit of 2,000 individuals from 1986 and there is only a low amount of fluctuations (in tens of people). Values are still falling. The events of November 1989 had a significant effect as well as a subsequent release of economic, political and social environment. Another reason could be better assistance of the society to endangered individuals, particularly in raising quality of psychiatric care and medication (e.g. Antidepressants) and also their willingness to admit their problems and seek professional aid.

The sixth and last period since 2009 shows increasing trend in suicides. We postulate the consequences of financial and economic crisis, which struck the whole world. The number of unemployed people, homeless and socially excluded individuals has increased in the Czech Republic. The empirical analysis presented at the end of the paper deals with the influence of unemployment on suicides. Analysis is based on article Arltová, Antovová (2016), which was published in journal *Demography*, but is expanded by other economic factor.

### 1.1 Suicides by sex

Suicides according to the gender are presented in Fig. 2. It is evident, that men commit suicides several times more often than women.

**Fig. 2: Number of suicides by sex in the Czech Republic in 1919–2014**



Source: Czech Statistical Office

The development of suicides of both genders in a long-term comparison is almost similar; periods of increase, stagnation or decline are identical or slightly different. Until 1990, the proportion of female suicides on total number was around 30 % up to 1990. The maximum was recorded in 1945 (35 %). A different tendency in suicides appears after 1990. The number of female suicides rapidly decreased while male suicides decreased too but very slowly (the current share is: 18 % female ones to 82 % male ones). That means there is less than one female suicide to more than four male suicides (2011: There were 5.3 times more male suicides the female ones in 2011). The long term ratio was two male suicides per one female one. Higher number of male suicides is related to chosen method of suicide. „Hard methods“ are typical for men because they are more reliable (such as a gun). Women choose more often „soft methods“, such as poisoning with pharmaceuticals, which can fail easily. (Antovová, 2013)

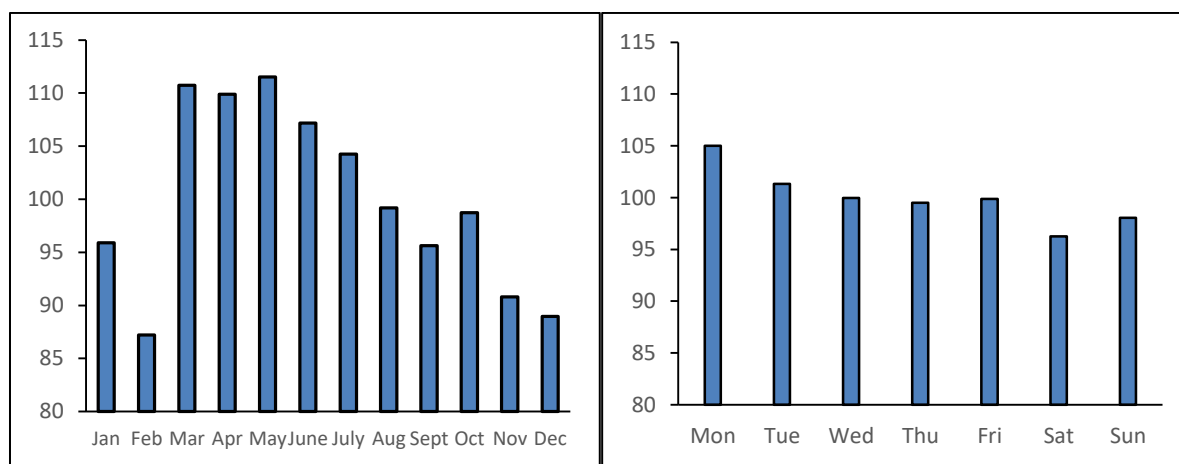
### 1.2 Suicides by month and day of the week

It is well known from the long-term monitoring, that one of suicide factors, which significantly affect number of suicides, is annual periods (Yip, Chao, Chiu, 2000). The month time series of suicides of particular months in the period from 1961 to 2013 (Fig. 3) prove apparently substantial and relatively regular seasonality of time series.

Between years 1961 and 2013 was monthly average number of suicides 129.3. Period with above average suicide rate was from March to August, with a peak in May, below average from September to February, with a minimum in December.

Maximum average number is reached on Monday (5.16). Wednesday is not significantly different from average value. The second half of the week, from Thursday to Sunday, is a typical one with below the average values. Minimum number of suicides is committed on Saturday (3.88).

**Fig. 3: Seasonal index of suicides by months and days of the week 1961-2013**



Source: own calculation

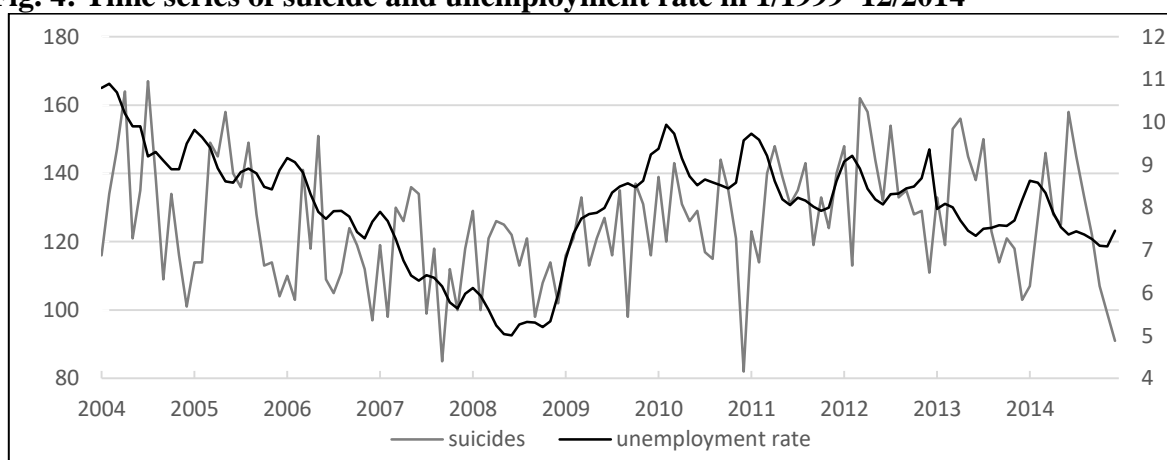
## **2 Development and analysis of suicides by selected economic and climatic factors in years 2004-2014**

In this section, there will be analyzed the influence of selected factors on the development of suicidality in the Czech Republic (analysis is based on Arltová, Antovová, 2016). In this context, we recognize that it is not possible to capture all the factors influencing suicide rates. Particularly as regards endogenous factors, which belong to pathology (psychic and somatic), genetic, social and psychological area (Smejkal, 2003). However, we could attempt to analyze the influence of some exogenous factors from economic and climate area. It might be at first sight, compared to exogenous ones, quite minor. Nevertheless, predicted and frequently analyzed by experts (eg. in Deisenhammer, 2003; Hamermesh and Soss, 1974; Kordić, Babić, Petrov, Kordić, Jelavić, Pivić, 2010; Milic, 2010; Monestier, 2003). We used an approach based on multivariate time series as a tool for analysis.

## 2.1 Suicides and economic conditions

Direct relation between suicides and rate of unemployment is mentioned in the economic theory of Hamermesh and Soss (1974), which is based on maximisation of individual lifelong utility. Utility is a function of age and permanent income. Income is mainly represented by funds raised from work. Unemployed person cannot afford consumption, which would satisfy his requirements. There is a higher risk of suicide as the individual has no opportunity in the form of income that he could acquire. Marginal utility from consumption decreases with age. In practice, the same quantity of goods will satisfy young people much more than old ones. Unemployment brings low income and also low utility – the risk of suicide increase.

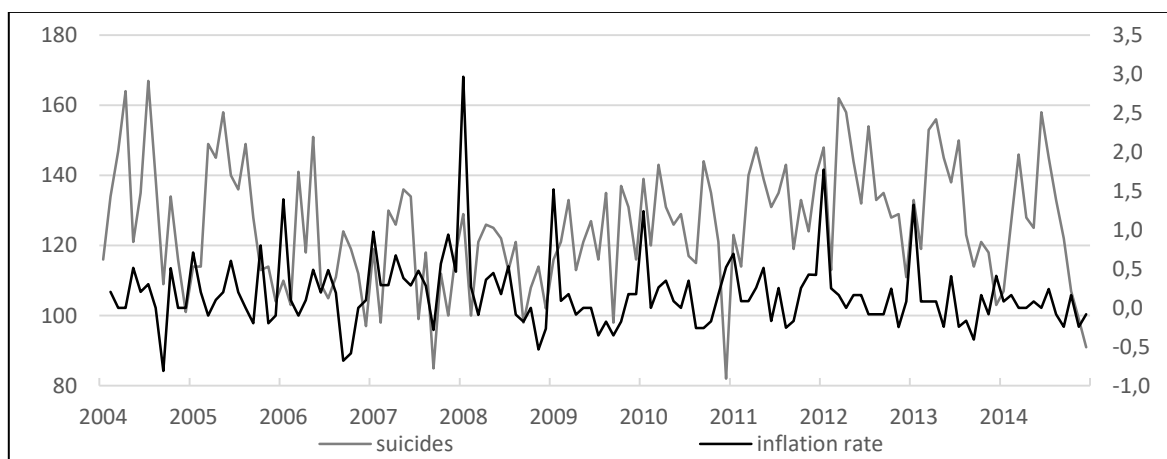
**Fig. 4: Time series of suicide and unemployment rate in 1/1999–12/2014**



Source: Czech Statistical Office, Ministry of Labour and Social Affairs

Economic theories are connecting unemployment rate with inflation. In the case of growth inflation rate, prices are rising faster than revenues and it leads to concerns of economical subjects about the future, which ultimately may cause increasing risk of suicide.

**Fig. 5: Time series of suicide and inflation rate in 1/2004–12/2014**



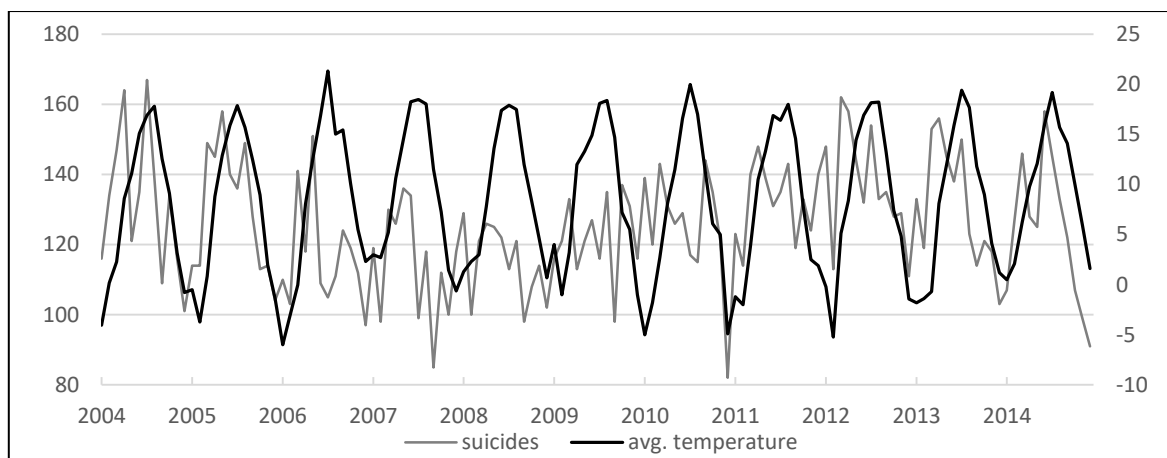
Source: Czech Statistical Office

## 2.2 Suicides and climate conditions

The idea of climate-factor influence on suicidality is based on bio meteorological hypothesis, which introduced explanation of seasonal influences in the 19th century. Temperature and its changes should have influenced directly suicides (Monestier, 2003). There was an assumption, that high temperature increases sensitivity of neural system and causes the excess of energy in the body, which is not consumed in a natural way and should be discharged with other methods. The result of it is that during summer the activity of organism increases, which could cause suicidal behaviour. Later, the theory was enriched with other effects of climate, such as length of sunshine, barometric pressure (it affects the stability of human mind), solar activity, humidity of air and precipitation.

Influence of meteorological factors, such as average temperature, sunshine duration, precipitation and barometric pressure, is analysed by field of human bioclimatology. It studies beneficial effect of various components of climate on human's biological functions, as well as adverse influence, which can lead to various pathological conditions.

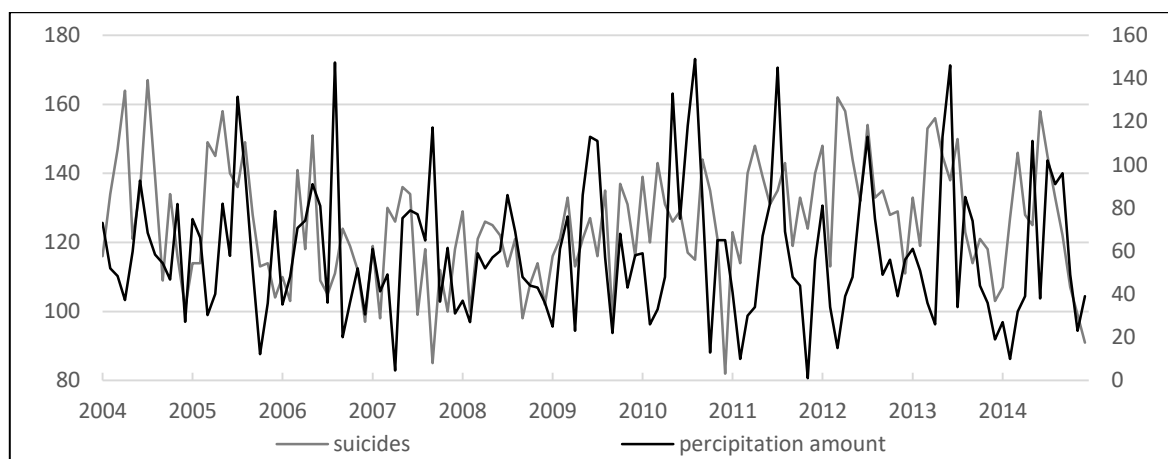
**Fig. 6: Development of suicides and average temperature in 1/1999–12/2014**



Source: Czech Statistical Office, Czech Hydro Meteorological Institute

Fig. 6 illustrates tendency of suicides and average temperatures in the Czech Republic from January 2004 to December 2014. Time series of suicides reached maximum in spring (April, May, June). In contrast, time series of average temperature have the highest values in summer (July and August). For both series is minimum in winter (December and January). This would imply that in periods with lower average temperatures is lower probability of suicide and vice versa.

**Fig. 7: Development of suicides and precipitation amount in 1/1999–12/2014**

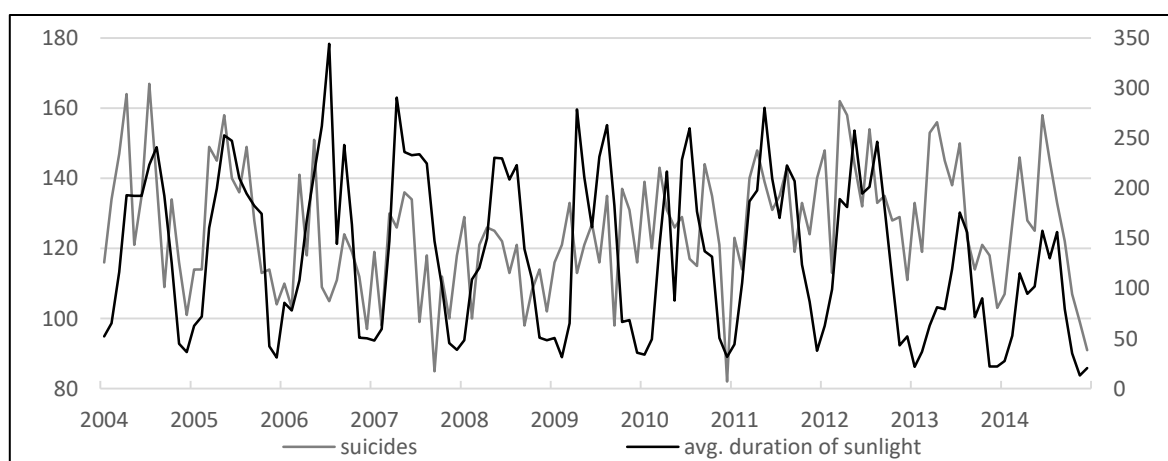


Source: Czech Statistical Office, Czech Hydro Meteorological Institute

Another analysed element is precipitation in the Czech Republic. It is evident from Fig. 7 that precipitation probably is not connected with suicides.

The last analysed climatic factor is the duration of sunlight. In comparison with the time series of suicides in Fig. 8, it is possible to see the same tendency and seasonality. When the length of sunlight increases (days are longer), the number of suicides is growing and vice versa. If this is statistically confirmed, it will demonstrate bio meteorological hypothesis on the data of the Czech Republic.

**Fig. 8: Development of suicides and average duration of sunlight in 1/1999–12/2014**



Source: Czech Statistical Office, Czech Hydro Meteorological Institute



### 2.3 The empirical analysis of the impact of climatic and economic factors on development of suicide in years 2004-2014

It is possible to see from figures of the previous section that suicide could be closely linked to socioeconomic and climate factors. All the above-mentioned time series, i.e. time series of unemployment rate in % (*UR*), the inflation rate in % (*IR*), the average temperature in °C (*T*), the average length of sunlight in hours (*SL*) and precipitation in millimetres (*P*) will be applied for the empirical analysis. Time series of climatic elements were taken over from the Czech Hydro Meteorological Institute (CHMI). There are average values of these elements for the Czech Republic. The rate of unemployment is calculated and published by the Ministry of Labour and Social Affairs (MoLSA). The time series of suicide (*S*) were provided by the Czech Statistical Office (CZSO).

The analysis was worked out on monthly time series from January 1998 to December 2013. All used time series exhibit constant (or approximately constant) tendency and contain significant and regular seasonal components. From the analysis can be assumed, that the influence of climatic factors and the unemployment rate is exogenous and number of suicides has endogenous character. Therefore it is possible to use one-equation regression model (Arlt, Arltová, 2009).

As it was not found on the basis of HEGY unit roots test (Hylleberg, Engle, Granger, Yoo, 1990), that time series contains unit root in so-called zero non-seasonal frequency ( $S_t$   $t_{\text{HEGY}} = -4.792710$  [0.0001],  $UR_t$   $t_{\text{HEGY}} = -2.705215$  [0.0478],  $IR_t$   $t_{\text{HEGY}} = -7.820365$  [0.0000],  $T_t$   $t_{\text{HEGY}} = -10.23336$  [0.0000],  $SL_t$   $t_{\text{HEGY}} = -9.288597$  [0.0000],  $P_t$   $t_{\text{HEGY}} = -8.599749$  [0.000]). Therefore, all the time series are stationary so the suitable model will be the dynamic one of distributed lagged variables (ADL) (Hendry, Pagan, Sargan, 1984), which includes time-shifted variable (explanatory  $Y_t$  and  $X_t$  explanatory). Generally, it can be written as

$$Y_t = c + \sum_{i=1}^p \alpha_i Y_{t-i} + \sum_{j=1}^q \beta_j (B^{j-1}) X_t + a_t, \quad (1)$$

$Y_t$  is explained variable in time  $t$ ,  $Y_{t-i}$  is explained variable in delay  $t-i$ , where  $i = 1, \dots, t-p$ ,  $X_t$  is matrix of explanatory variables in time  $t$  and delay  $t-j$ , where  $j = 1, \dots, t-q$ ,  $\alpha$  a  $\beta$  are parameters in model and  $c$  is constant.  $a_t$  has property of process of white noise, i.e. it is the series of uncorrelated random variables  $cov(a_t, a_{t-k}) = 0$ , probability distribution  $N(0, \sigma_a^2)$ , with zero mean  $E(a_t) = 0$  and constant variance  $D(a_t) = \sigma_a^2$ .

To estimate model parameters were used econometric program EViews 9.5. Final model (2) was obtained after the gradual elimination of time series with statistically

insignificant parameter estimates. From results is evident, that were (at the 5% significance level) proved effect of unemployment rate and average temperatures on number of suicides and were not proved effect of inflation rate, precipitation and duration of sunlight. Estimated model ADL has the form

$$\hat{S}_t = 69.739 + 0.161S_{t-1} - 8.063UR_t + 12.464UR_{t-1} + 6.189IR_{t-2} + 2.212T_t - 1.423T_{t-1} - 0.0581SL_t \quad (2)$$

(11.061) (0.087) (3.934) (3.895) (2.761) (0.476) (0.341) (0.028)

and demonstrates, that (at the 5% significance) suicides directly depends on the number of suicides in the previous month, inversely on unemployment rate in the same month and directly to the previous month, directly to inflation rate two months ago, directly to average temperature in the same month and inversely in previous month and inversely on average length of sunlight hours in the same month. Model explains about 45 % of dynamics (measured by index of determination) time series of suicide. Diagnostic tests proved, that non-systematic component of model has a normal distribution (Jarque-Bera test = 1.6873 [0.4301]) is homoscedastic (ARCH test = 1.1881 [0.2778]) and not autocorrelated (Breusch-Godfrey test = 1.6565 [0.1952]), and fulfils the conditions of process of white noise.

From the previous sections of the paper, it appears obvious that it is not possible to capture all the factors, which have effect on psyche of individual, let alone it is impossible to exactly quantify. Therefore, there is for us acceptable result demonstration impact of economic (unemployment rate and inflation rate) and climatological indicators (average temperature and average length of sunlight hours) on number of suicides. Remaining influence, unexplained with the model, may originate from biological, psychological or other climate factors, which were not included in the model and were not considered in this paper.

## Conclusion

Suicidality is an upcoming topic, because more than one thousand individuals are leaving the world by self-harm every year in the Czech Republic. Average 4 people per day commit suicide. The long-term trend is, that men commit suicide several times more than women.

Statistical analysis demonstrated affection of seasons on suicides, because most of them are committed in springtime and least of them in late autumn and winter. Mondays and Tuesdays dominate in number of suicides among the days of the week.

We tried, on base of selected measurable socioeconomic (unemployment and inflation rate) and climate (average temperature, average length of sunlight, precipitation) factors using

multivariate econometric model, to explain whether some of them can significantly affect suicide rates. Among the economic factors proved the impact of the unemployment rate and inflation rate. In terms of weather, we have demonstrated the dependence number of suicides on average temperature and average length of sunlight hours, i.e. on data of the Czech Republic we have confirmed bio meteorological hypothesis, even if on two climatic elements. Weather could be only as a "trigger mechanism", to which must be taken into consideration other mediating factors, such as e.g. psychological aspects and mental illness, health problems, family conflicts and problems.

We suppose, that results demonstrated in our model, should be taken carefully. It means, that we cannot say with confidence: "If unemployment rate increase, suicidality will have the same trend". Too many factors, which cannot be calculated, affect suicidality. On the other hand, bad economic situation is very often the reason of male suicide and as it was stated men constitute the majority share of completed suicide. It could be mentioned that the rate of unemployment, inflation rate, average temperature and average length of sunlight hours may have, under certain conditions in conjunctions with other factors, share on suicidality.

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