STATISTICAL ANALYSIS OF INSURANCE MARKET IN THE CZECH REPUBLIC BY USING GROSS PREMIUM WRITTEN OF NON-LIFE INSURANCE IN 1995-2012

Lenka Štibrányiová
*** Karina Mužáková**

Technical University of Liberec
Faculty of Economics
Department of Insurance Management
Studentská 2, 461 17, Liberec 1, Czech Republic
lenka.stibranyiova@tul.cz

* Technical University of Liberec
Faculty of Economics
Department of Insurance Management
Studentská 2, 461 17, Liberec 1, Czech Republic
karina.muzakova@tul.cz

Abstract

The insurance industry is a dynamic industry that responds to all current changes in the environment in which it operates. These are, first, changes in economic conditions, but also there are changes in the character of insurability of risks. The insurance market is always changing and depending on these factors. For this reason the paper deals with the statistical analysis of the insurance market development through one of the basic indicators of insurance, in particular by gross written premium. The analysis of the insurance market covers the period 1995–2012, according to available information from the Czech National Bank.

Introduction

The paper is focused on analysis of the insurance market in non-life insurance at years 1995-2012. To capture the development of the insurance market by using indicators gross written premium will be applied statstical analysis using time series. The first part explains basic characteristics of time series that are implemented on the selected value of the indicator. In the paper will be also evaluated an appropriate function for the development trend of gross premium written of non-life insurance and the development prediction by years 2013, 2014 and 2015. Values and diagrams are created using Microsoft Excel and Statgraphics Centurion XVI.

It is important to note that the analysis doesn't include any economic shocks, effects of inflation or other economic variables affecting the insurance market.

1 Elementary insurance indicators

To capture the development of the insurance market can be used several insurance indicators (gross premium written, insurance density or insurance penetration).

Gross premium written expresses the premium payable under insurance contracts. Using this indicator it is possible to express the level of the insurance market and also this indicator is a measure of the performance of insurance companies in the market. [4]

Given that gross premium written is also influenced by the size of the country it can be used other indicators in cases of comparison of insurance markets with other countries. Firstly we can mention insurance density that expresses premiums per capita or secondly insurance penetration expressing premiums in % of GDP. [4]

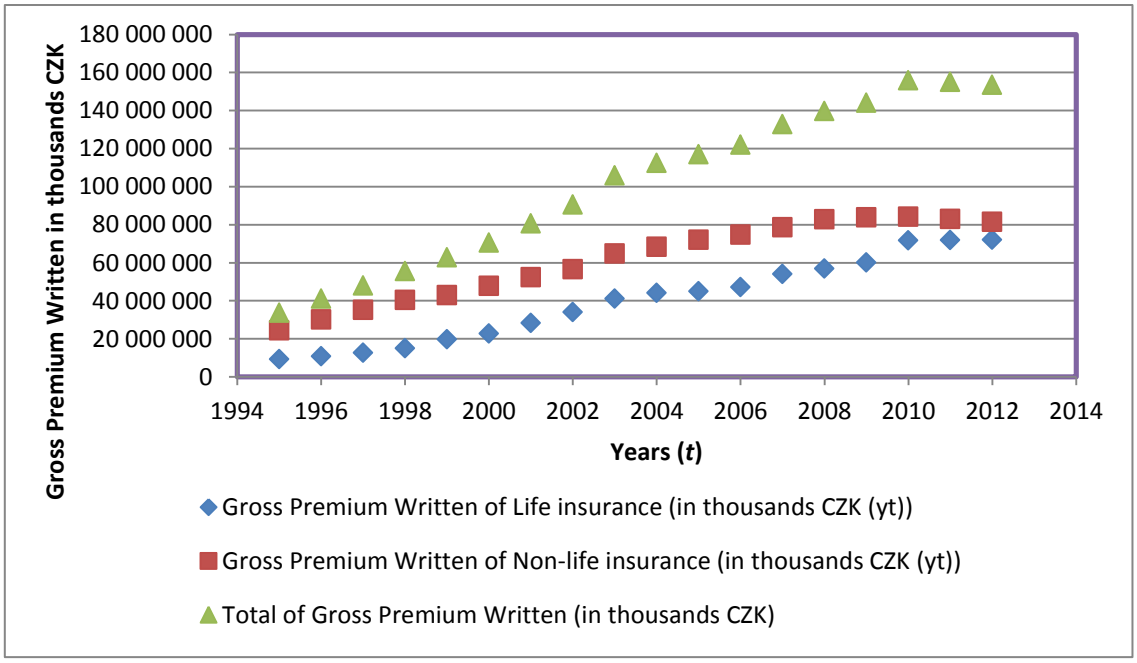
2 Development of gross premium written in the Czech Republic

The following Tab. 1 contains data about the development of the insurance market in the Czech Republic in years 1995–2012 using the numeric expression of gross premium written in life and non-life insurance. From these values is apparent increasing trend of total gross premium written (see also Fig. 1). From percentage shares can be seen changing proportions of life and non-life insurance. Although there is higher percentage share of gross premium written of non-life insurance, we can see faster trend of growth in gross premium written of life insurance.

Tab. 1: *Development of gross premium written of life and non-life insurance (1995–2012)*

Year (*t*)	**Gross premium written of life insurance (in thousands CZK (y_t))**	**Gross premium written of non-life insurance (in thousands CZK (y_t))**	**Total of gross premium written (in thousands CZK)**	**Percentage share of gross premium written of life insurance in total gross premium written**	**Percentage share of gross premium written of non-life insurance in total gross premium written**
1995	9 341 715	24 453 990	33 795 705	27.64	72.36
1996	10 937 216	30 187 465	41 124 681	26.60	73.40
1997	12 692 286	35 292 424	47 984 710	26.45	73.55
1998	15 089 372	40 547 974	55 637 346	27.12	72.88
1999	19 793 331	42 990 785	62 784 116	31.53	68.47
2000	22 770 132	47 819 214	70 589 346	32.26	67.74
2001	28 281 966	52 462 237	80 744 203	35.03	64.97
2002	34 036 346	56 624 001	90 660 347	37.54	62.46
2003	41 128 802	64 817 070	105 945 872	38.82	61.18
2004	44 201 009	68 377 194	112 578 203	39.26	60.74
2005	44 954 269	72 125 154	117 079 423	38.40	61.60
2006	47 233 389	74 889 748	122 123 137	38.68	61.32
2007	54 128 225	78 767 841	132 896 066	40.73	59.27
2008	56 909 094	82 942 866	139 851 960	40.69	59.31
2009	60 209 323	83 961 630	144 170 953	41.76	58.24
2010	71 764 862	84 231 496	155 996 358	46.00	54.00
2011	72 009 104	83 083 478	155 092 582	46.43	53.57
2012	72 049 292	81 549 574	153 598 866	46.91	53.09

Source: Own elaboration [3]



Source: Own elaboration from Tab. 1

Fig. 1: *Development of gross premium written of life and non-life insurance (1995–2012)*

3 Elementary chracteristic of time series

Time series can be understood as sequence of values of a certain statistical indicator arranged in time. To assess properties of time series can be used number of characteristics to obtain basic elementary information. From the basic characteristics we used: the first difference, the second difference, the growth coefficient, the growth rate, the increase rate, the average absolute gain and the average growth coefficient. [2], [5], [6].

Absolute gain (the first difference) (1) expresses the change in the value of the indicator at time t to time $t-1$.

$$\Delta_t^{(1)} = y_t - y_{t-1} \tag{1}$$

The average absolute gain (2) represents the average annual change in the value of the indicator for the period studied.

$$\bar{\Delta} = \frac{(y_2-y_1)+(y_3-y_2)+\cdots+(y_T-y_{T-1})}{T-1} = \frac{\sum_{t=2}^{T}\Delta_t^{(1)}}{T-1} = \frac{y_T-y_1}{T-1} \tag{2}$$

The second difference (3) reflects increases or decreases in the value of the first differences.

$$\Delta_t^{(2)} = \Delta_t^{(1)} - \Delta_{t-1}^{(1)} \tag{3}$$

The growth rate (4) expresses how many times the value of the indicator changed.

$$k_t = \frac{y_t}{y_{t-1}} \tag{4}$$

Provided this indicator has multiplied 100 times, it characterizes by how many percent of the value at time $t-1$ increased at time t. This coefficient is also named the growth rate (T_{ty}).

The average growth coefficient (5) is calculated as the geometric mean of individual coefficients of growth. Growth rates are also used as criterion to find an appropriate trend function.

$$\bar{k} = \sqrt[T-1]{k_2 \cdot k_3 \cdot \ldots \cdot k_T} = \sqrt[T-1]{\frac{y_2}{y_1} \cdot \frac{y_3}{y_2} \cdot \ldots \cdot \frac{y_T}{y_{T-1}}} = \sqrt[T-1]{\frac{y_T}{y_1}} \quad (5)$$

The increase rate (6) expresses the percentage change in value of the indicator.

$$\delta_{y_t} = T_{y_t} - 1 \quad (6)$$

4 Elementary characteristic development of gross premium written of non-life insurance in the Czech Republic

Tab. 2 contains elementary characteristics of gross premium written of non-life insurance in the Czech Republic. These characteristics indicate that the biggest increase in the volume of gross premium written of non-life insurance was in 2003. It can be explained by the increase of various natural disasters, especially floods that hit the Czech Republic in 2002.

Tab. 2: *Elementary characteristic of gross premium written of non-life insurance in the Czech Republic*

Years (*t*)	**Gross premium written of non-life insurance (in thousands CZK (y_t))**	$\Delta_t^{(1)}$	$\Delta_t^{(2)}$	k_t	T_{yt}	δ_{yt}
1995	24 453 990.00	×	×	×	×	×
1996	30 187 465.00	5 733 475.00	×	1.23	123.45	23.45
1997	35 292 424.00	5 104 959.00	-628 516.00	1.17	116.91	16.91
1998	40 547 974.00	5 255 550.00	150 591.00	1.15	114.89	14.89
1999	42 990 785.00	2 442 811.00	-2 812 739.00	1.06	106.02	6.02
2000	47 819 214.00	4 828 429.00	2 385 618.00	1.11	111.23	11.23
2001	52 462 237.00	4 643 023.00	-185 406.00	1.10	109.71	9.71
2002	56 624 001.00	4 161 764.00	-481 259.00	1.08	107.93	7.93
2003	64 817 070.00	**8 193 069.00**	4 031 305.00	1.14	114.47	14.47
2004	68 377 194.00	3 560 124.00	-4 632 945.00	1.05	105.49	5.49
2005	72 125 154.00	3 747 960.00	187 836.00	1.05	105.48	5.48
2006	74 889 748.00	2 764 594.00	-983 366.00	1.04	103.83	3.83
2007	78 767 841.00	3 878 093.00	1 113 499.00	1.05	105.18	5.18
2008	82 942 866.00	4 175 025.00	296 932.00	1.05	105.30	5.30
2009	83 961 630.00	1 018 764.00	-3 156 261.00	1.01	101.23	1.23
2010	84 231 496.00	269 866.00	-748 898.00	1.00	100.32	0.32
2011	83 083 478.00	-1 148 018.00	-1 417 884.00	0.99	98.64	-1.36
2012	81 549 574.00	-1 533 904.00	-385 886.00	0.98	98.15	-1.85

Source: Own elaboration from Tab.1

The result of average absolute gain is for non-life insurance 3 358 564 thousand CZK. The result of average growth coefficient is 1.07341816205 (which corresponds to 107.3%).

5 Elementary methods of modeling the trend component

The trend in time series can be described by trend functions unless the development of time series corresponds to a particular function of time (for example: linear, quadratic and exponential). [2]

Linear trend function (line) has the following form (7):

$$T_t = \beta_0 + \beta_1 t \tag{7}$$

Quadratic trend function (parabola) has the following form (8):

$$T_t = \beta_0 + \beta_1 t + \beta_2 t^2 \tag{8}$$

Exponential trend function has the following form (9):

$$T_t = \beta_0 \beta_1^t \tag{9}$$

For trend identification and forecast of gross premium written of non-life insurance in the Czech Republic for the period 1995–2012 was used the program Statgraphics Centurion XVI. We considered three basic trends: linear trend, quadratic trend and exponential trend. To evaluate the suitability of the trend have been identified and assessed values of trend function forecast, values of the root mean squared error (*RMSE*) and values of modified index of determination (R_M^2). [2]

RMSE (10):

$$\text{RMSE} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{y}_t)^2} \tag{10}$$

where $\hat{y}_t$ is modeled values at time *t*.

Determination modified index (R^2_M.) (11):

$$R_M^2 = R^2 - \frac{(1-R^2)(k-1)}{T-k} \tag{11}$$

Because of possibility of comparison of trend functions R_M^2 was selected whereas apply the higher value of this index the better model captures the trend of time series. It follows that the most suitable trend function will have the highest value of this index.

It was also performed hypothesis testing. There were created two hypotheses – the tested hypothesis is known as the null hypothesis (H_0) and the second is an alternative hypothesis (H_1). At null hypothesis we consider the parameter is not acceptable and on the other hand we consider at the alternative hypothesis that the parameter is acceptable. For the conclusion of testing is also decisive P-value, which is the lowest level of significance at which can be rejected the hypothesis. Necessary to noted that we considered the significance level $\alpha = 0.05$. In conclusion was performed total F-test, under which it can be decided about the suitability of the model as a whole.

6 Identification of trend in non-life insurance and forecast

6.1 Linear trend function

Trend function forecast: $\widehat{T_t} = 25\,942\,500\,000 + 3\,731\,920\,000t$

RMSE: 4 766 420 000

R_M^2: 94.5689%

Tab. 3: *Hypothesis testing (linear trend)*

H_0:	$\beta_0 = 0$	$\beta_1 = 0$	The line isn't acceptable model.
H_1:	$\beta_0 \neq 0$	$\beta_1 \neq 0$	Non H_0
Parameter:	$\hat{\beta}_0$: 25 942 500 000	$\hat{\beta}_1$: 3 731 920 000	×
Test criterion:	t-test: 11.0679	t-test: 17.2341	F-test: 297.01
P-value	0.0000 ‹ 0.05	0.0000 ‹ 0.05	0.0000 ‹ 0.05
Test conslusion	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.

Source: Own elaboration

6.2 Exponential trend function

Trend function forecast: $\widehat{T_t} = 24.1201 \cdot 0.0690854^t$

RMSE: 8 474 620 000

R_M^2: 89.0137%

Tab. 4: *Hypothesis testing (exponential trend)*

H_0:	$\beta_0 = 0$	$\beta_1 = 0$	Exponential function isn't acceptable model.
H_1:	$\beta_0 \neq 0$	$\beta_1 \neq 0$	Non H_0
Parameter:	$\hat{\beta}_0$: 24.1201	$\hat{\beta}_1$: 0.0690854	×
Test criterion:	t-test: 379.916	t-test: 11.7787	F-test: 138.74
P-value:	0.0000 ‹ 0.05	0.0000 ‹ 0.05	0.0000 ‹ 0.05
Test conclusion:	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.

Source: Own elaboration

6.3 Quadratic trend function

Trend function forecast: $\widehat{T_t} = 15\,648\,800\,000 + 6\,820\,020\,000t - 1\,62\,532\,000t^2$

RMSE: 2 455 720 000

R_M^2*:* 98.5583%

Tab. 5: *Hypothesis testing (quadratic trend)*

H_0:	$\beta_0 = 0$	$\beta_1 = 0$	$\beta_2 = 0$	Parabola isn't acceptable model.
H_1:	$\beta_0 \neq 0$	$\beta_1 \neq 0$	$\beta_2 \neq 0$	Non H_0
Parameter:	$\hat{\beta}_0$: 15 648 800 000	$\hat{\beta}_1$: 6 820 020 000	$\hat{\beta}_2$: −1 62 532 000	×
Test criterion:	t-test: 8.0291	t-test: 14.4398	t-test: −6.72876	F-test: 582.10
P-value:	0.0000 › 0.05	0.0000 › 0.05	0.0000 › 0.05	0.0000 › 0.05
Test conclusion:	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.	Disapprove H0, prove H1.	Disapprove H_0, prove H*1*.

Source: Own elaboration

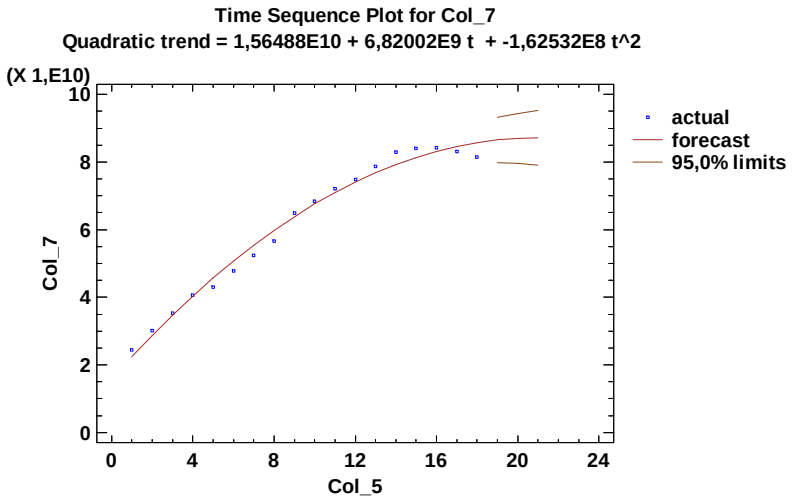
6.4 Summary of results

Based on results of partial t-tests and total F-test can be said that the most suitable model is quadratic trend. This trend also has the highest value of modified index of determination.

Using by Statgraphics Centurion XVI was constructed forecast of time series development of gross premium written of non-life insurance for years: 2013, 2014 and 2015. Fig. 2 shows time series equalization by quadratic trend and forecast of development by next three years.

According to the results of statistic program the predicted values of gross premium written of non-life insurance with 95% confidence level will be:

- in year 2013 between 79 872 900 000 CZK and 93 237 800 000 CZK;
- in year 2014 between 79 718 100 000 CZK and 94 355 200 000 CZK;
- in year 2015 between 79 080 700 000 CZK and 95 305 100 000 CZK.



Source: Own elaboration

Fig. 2: *Time series equalization by quadratic trend and forecast of development by next three years*

To check the correctness of our choice was in the program Statgraphics Centurion XVI constructed by using automatic prediction of the model, which uses so-called "Akaike Information Criterion". (12) Using this method is chosen as the most suitable model for the analyzed time series the model with the lowest value of the criterion. [1]

$$AIC = -2\ \text{(maximum log likelihood)} + 2\ \text{(number of independently adjusted parameters)} \quad (12)$$

Other methods were excluded mainly due to an insufficient number of indicator values. Based on the results of automatic prediction was confirmed that the best model is the quadratic trend.

Conclusion

By using the analysis of the insurance market through indicator of gross premium written of non-life insurance can be seen growing trend in the period 1995–2010 and since 2011 can be observed a decrease. The development of this indicator recorded the most dynamic growth in 2003.

According to the results we can say that the most appropriate model for time series equalization of gross premium written of non-life insurance is quadratic trend. According to the forecast by next three years we can observe growing trend at a slower pace. According to the results of statistic program the predicted values of gross premium written of non-life insurance with 95% confidence level will be in year 2013 between 79 872 900 000 CZK and 93 237 800 000 CZK; in year 2014 between 79 718 100 000 CZK and 94 355 200 000 CZK and in year 2015 between 79 080 700 000 CZK and 95 305 100 000 CZK.

Acknowledgements

This paper was created on the financial support provider within specific university research projects, specifically within the project of SGS titled: "EU approaches to the regulation of financial markets and its influence on the Czech financial sector" number 38009 that is realized in Department of Insurance Management in the Technical University of Liberec.

Literature

[1] AKAIKE, H.: *Canonical Correlation Analysis of the Time Series and the Use of an Information Criterion.* [online]. [accessed 2013-06-02]. Available from WWW: <http://www.sciencedirect.com/science/article/pii/S0076539208608693>.

[2] ARLT, J.; ARLTOVÁ, M.; RUBLÍKOVÁ, E.: *Analýza ekonomických časových řad s příklady.* Praha: Vysoká škola ekonomická v Praze, 2002. [online]. [accessed 2013-05-26]. Available from: <http://nb.vse.cz/~arltova/vyuka/crsbir02.pdf>.

[3] ČNB. *Základní ukazatele o sektoru pojišťoven*. [online]. [accessed 2013-05-21]. Available from WWW: <http://www.cnb.cz/cs/dohled_financni_trh/souhrnne_informace_fin_trhy/zakladni_ukazatele_fin_trhu/pojistovny/index.html>.

[4] DAŇHEL, J. et al: *Pojistná teorie.* Druhé vydání. Praha: Professional Publishing., 2005. ISBN 80-86946-00-2.

[5] HINDLS, R.; HRONOVÁ, S.; SEGER, J.; FISCHER, J.: *Statistika pro ekonomy.* Professional Publishing, Praha, 2007. ISBN 978-80-86946-43-6.

[6] KOZÁK, J.; HINDLS, R.; ARLT, J.: *Úvod do analýzy ekonomických časových řad.* Praha: Vysoká škola ekonomická v Praze, 1994. ISBN 80-7079-760-6.

Analýza pojistného trhu v ČR pomocí předepsaného hrubého pojistného neživotních pojištění v letech 1995-2012

Pojišťovnictví je dynamické odvětví, které reaguje na veškeré aktuální změny prostředí, ve kterém funguje. Jedná se jednak o změny ekonomických podmínek, ale také o změny v charakteru pojistitelnosti rizik. Pojistný trh se tak stále mění v závislosti na výše uvedených skutečnostech. Z tohoto důvodu je příspěvek zaměřen na analýzu pojistného trhu pomocí jednoho ze základních pojistných ukazatelů, konkrétně pomocí předepsaného hrubého pojistného. Analýza pojistného trhu se vztahuje k období 1995–2012 dle dostupných informací z České národní banky.

Die Analyse des Versicherungsmarkets in der Tschechischen Republik durch Brutto Prämien von allgemeinen Versicherungsbedingungen in den Jahren 1995-2012

Die Versicherungswirtschaft ist eine dynamische Branche, die für alle aktuellen Veränderungen in der Umwelt, in der sie tätig reagiert. Dies sind zum einen die Veränderungen der wirtschaftlichen Bedingungen, sondern auch durch Veränderungen im Charakter der Versicherbarkeit von Risiken. Der Versicherungsmarkt ist immer im Wandel und in Abhängigkeit von den oben genannten Fakten. Aus diesem Grund wird das Papier auf der Analyse des Versicherungsmarktes durch eine der grundlegenden Indikatoren der Versicherung, insbesondere durch die gebuchten Bruttoprämien konzentriert. Die Analyse des Versicherungsmarktes deckt den Zeitraum 1995–2012, nach den vorliegenden Informationen aus der Tschechischen Nationalbank.

Analiza rynku ubezpieczeń w Czechach przez brutto ubezpieczeń majątkowych w latach 1995-2012

Branża ubezpieczeniowa jest dynamicznie rozwijający się sektor, który odpowiada na wszystkie obecne zmiany w środowisku, w którym funkcjonuje. Są to, po pierwsze, zmiany w warunkach ekonomicznych, ale także zmiany w charakterze ubezpieczeniu ryzyka. Rynek ubezpieczeń zawsze się zmienia w zależności od wyżej. Z tego powodu, papier koncentruje się na analizie rynku ubezpieczeń przez jeden z podstawowych wskaźników ubezpieczenia, w szczególności przez składki przypisanej brutto.Analiza rynku ubezpieczeń obejmuje lata 1995–2012, zgodnie z dostępnymi informacjami z Czeskiego Banku Narodowego.