TIME SERIES ANALYSIS AND THEIR DEVELOPMENT PREDICTION OF GROSS PREMIUM WRITTEN OF AGRICULTURAL INSURANCE IN THE FRAME OF THE CZECH INSURANCE MARKET

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Abstract

This paper deals with the time series analysis and their development prediction of gross premium written of crop and livestock insurance in the frame of the Czech insurance market for years 2010 and 2011. The time series are defined as a sequence of data points, measured typically at successive times, spaced at time intervals. Data in this modelling are gross premium written of crop and livestock insurance of members of ČAP (Czech Insurance Association and insurance company Agra, o. s.) at years 1997–2009, while Agra, o. s. began undertaking operating on the Czech insurance market since the year 2007. This analysis does not include economic factors (for example: inflation, economic progress, economic recession, economic shocks).

Introduction

The Czech insurance market ranks with small insurance markets, but the sum of gross premium written of agricultural insurance from insurance companies (members from Czech Insurance Association with Agra, o. s.) is in sum of year 2009 in the amount of 1 129 312 000 CZK. The percentage share of gross premium written of agricultural insurance in total gross premium written of non-life insurance was in year 2009 1,35 %. In the Czech insurance market five insurance companies, members of the Czech Insurance Association and one, which is not member it's Agra, o. s., operates, which provide agricultural insurance.

By the characterizing of the Czech insurance market, we will draw from several basic economic indicators (for example: gross premium written of life and non-life insurance, number of insurance contracts, number of employees in insurance companies, etc.). In this paper, there will be gross premium written of crop and livestock insurance in years 1997–2009 analyzed and their development prediction for years 2010 and 2011. The data for this analysis are from Czech Insurance Association and from Agra, o. s. About time series analysis there exist many textbooks, see Hamilton (1994) [3]; Hindls, Hronová and Novák (2000) [1]; Chatfield (2003) [4] and Tsay (2005) [2].

In the first part of this paper basic a characteristic development of time series will be analyzed.

The second part will be aimed at identification of the trend; by means of hypothesis tests acceptable model with prediction for the years 2010 and 2011 will be chosen. The estimate of trend function values will be analyzed by using the statistic program Statgraphic Centurion XVI. In the final tables *RMSE* (root mean square error), *I_adjusted^2* (adjusted index of determination), *t-tests* (tests criterion), *P-values* (critical significance limits) and total *F-test* will be presented.

1 Time series analysis

1.1 Elementary characteristic development of time series

For calculation of elementary characteristic development of time series it is necessary to adduce data about development of gross premium written of crop and livestock insurance and their percentage proportion (see table 1 and figure 1).

Tab. 1 Development of Gross Premium Written of Crop and Livestock Insurance [Czech Insurance Association and Agra, o. s. own elaboration]

Year (t)	Gross premium written of crop insurance in thousands CZK (y_t)	Gross premium written of livestock insurance in thousands CZK (y_t)	Total of gross premium written of agricultural insurance in thousands CZK	Percentage share of gross premium written of crop insurance in total gross premium written	Percentage share of gross premium written of livestock insurance in total gross premium written	Percentage share check
1997	500 687	532 661	1 033 348	48,45	51,55	100,00
1998	555 917	510 313	1 066 230	52,14	47,86	100,00
1999	553 234	423 645	976 879	56,63	43,37	100,00
2000	478 904	396 099	875 003	54,73	45,27	100,00
2001	521 832	416 738	938 570	55,60	44,40	100,00
2002	476 597	385 454	862 051	55,29	44,71	100,00
2003	544 431	373 618	918 049	59,30	40,70	100,00
2004	536 549	336 498	873 047	61,46	38,54	100,00
2005	614 843	330 228	945 071	65,06	34,94	100,00
2006	579 315	332 641	911 956	63,52	36,48	100,00
2007	755 517	295 355	1 050 872	71,89	28,11	100,00
2008	937 039	286 064	1 223 103	76,61	23,39	100,00
2009	857 825	271 487	1 129 312	75,96	24,04	100,00

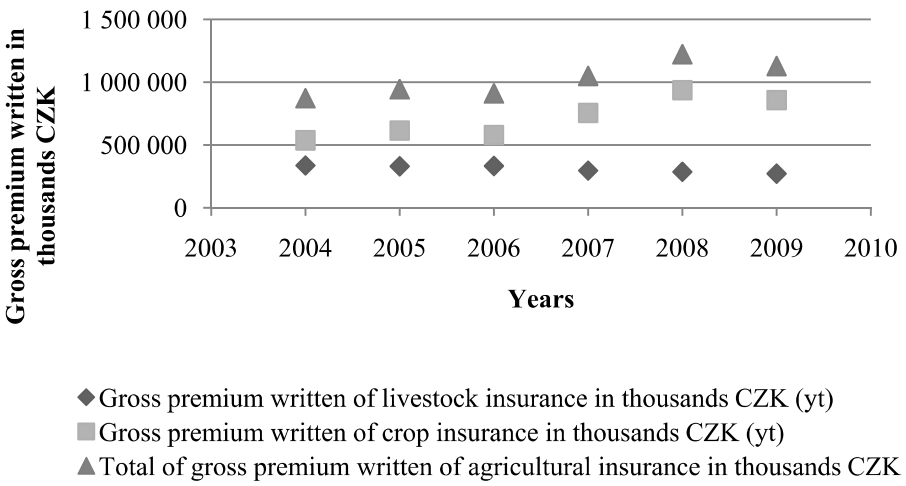

Fig. 1 Development of Gross Premium Written [own elaboration from table 1]

The values y_t for crop insurance are in the table 2 and for livestock insurance in the table 3. The subscript t in next equations characterises time period (in this paper one year).

We consider of next six indicators [1]:

the first difference (absolute gain, ${}_1\Delta_t$), the second difference

$$ {}_2\Delta_t = {}_1\Delta_t - {}_1\Delta_{t-1} \tag{1}$$

the growth coefficient

$$k_t = \frac{y_t}{y_{t-1}} \tag{2}$$

the growth rate

$$\delta_{y_t} = T_{y_t} - 100 \tag{3}$$

the increase rate

$$T_{y_t} = k_t \cdot 100 \tag{4}$$

are presented for crop insurance in the table 2 and for livestock insurance in the table 3.

The average absolute gain (5) and the average growth coefficient (6) belong to the important characteristics [1].

$${}_1\bar{\Delta} = \frac{\sum_{t=2}^{n} {}_1\Delta_t}{n-1} = \frac{y_n - y_1}{n-1}, \tag{5}$$

where n is the number of values (in this paper n = 13).

The results of average absolute gain is for crop insurance 29 761 500 CZK and for livestock insurance (-21 764 500) CZK.

$$\bar{k} = \sqrt[n-1]{\frac{y_n}{y_1}} \tag{6}$$

The results of average growth coefficient are for crop insurance 1,04589 (which corresponds to 4,60 %) and for livestock insurance 0,945052 (which corresponds to (-5,5 %)).

Tab. 2 Elementary Characteristic Development of Gross Premium Written of Crop Insurance[Czech Insurance Association and Agra, o. s. own elaboration]

Year (t)	Gross premium written of crop insurance in thousands CZK (y_t)	$_1\Delta_t$	$_2\Delta_t$	k_t	T_{yt}	δ_{yt}
1997	500 687	×	×	×	×	×
1998	555 917	55 230	×	1,110308436	111,0308436	11,0308436
1999	553 234	-2 683	-57 913	0,99517374	99,517374	-0,482626
2000	478 904	-74 330	-71 647	0,865644555	86,56445555	-13,4355445
2001	521 832	42 928	117 258	1,089638007	108,9638007	8,96380068
2002	476 597	-45 235	-88 163	0,913315013	91,33150133	-8,66849867
2003	544 431	67 834	113 069	1,142329893	114,2329893	14,2329893
2004	536 549	-7 882	-75 716	0,9855225	98,55224996	-1,44775004
2005	614 843	78 294	86 176	1,145921435	114,5921435	14,5921435
2006	579 315	-35 528	-113 822	0,942216143	94,2216143	-5,7783857
2007	755 517	176 202	211 730	1,30415577	130,415577	30,415577
2008	937 039	181 522	5 320	1,240261966	124,0261966	24,0261966
2009	857 825	-79 214	-260 736	0,915463497	91,54634973	-8,45365027

Tab. 3 Elementary Characteristic Development of Gross Premium Written of Livestock Insurance[Czech Insurance Association and Agra, o. s. own elaboration]

Year (t)	Gross premium written of livestock insurance in thousands CZK (y_t)	$_1\Delta_t$	$_2\Delta_t$	k_t	T_{yt}	δ_{yt}
1997	532 661	×	×	×	×	×
1998	510 313	-22 348	×	0,95804461	95,804461	-4,195539
1999	423 645	-86 668	-64 320	0,830166976	83,0166976	-16,9833024
2000	396 099	-27 546	59 122	0,934978579	93,49785788	-6,50214212
2001	416 738	20 639	48 185	1,05210566	105,210566	5,21056605
2002	385 454	-31 284	-51 923	0,924931252	92,49312518	-7,50687482
2003	373 618	-11 836	19 448	0,969293353	96,92933528	-3,07066472
2004	336 498	-37 120	-25 284	0,900647185	90,06471851	-9,93528149
2005	330 228	-6 270	30 850	0,981366903	98,13669026	-1,86330974
2006	332 641	2 413	8 683	1,007307073	100,7307073	0,73070727
2007	295 355	-37 286	-39 699	0,887909187	88,79091874	-11,2090813
2008	286 064	-9 291	27 995	0,96854294	96,85429399	-3,14570601
2009	271 487	-14 577	-5 286	0,949042872	94,90428715	-5,09571285

1.2 Identification of the trend

The results of tests of parameters of individual trend functions are in the table 4 (crop insurance) and table 5 (livestock insurance).

Tab. 4 Linear, Quadratic and Exponential Trend (Crop Insurance) [own elaboration]

Trend	**Linear trend**	**Quadratic trend**	**Exponential trend**
Trend function	$T_t = \beta_0 + \beta_1 t$	$T_t = \beta_0 + \beta_1 t + \beta_2 t^2$	$T_t = e^{(\beta_0 + \beta_1 t)}$
Trend function forecast	T_t= 400792000+ 29696600t	T_t =601431000- 50558700t+ 5732520t^2	T_t =$e^{(12983,8+44,5335t)}$
RMSE	95 599900	58 943 500	60 260 400
$I^2_{adjusted}$ (%)	57,9859	84,0282	59,8963
H_0 :	$\beta_0 = 0$	$\beta_0 = 0$	$\beta_0 = 0$
H_1 :	$\beta_0 \neq 0$	$\beta_0 \neq 0$	$\beta_0 \neq 0$
$\hat{\beta}_0$	400 792 000	601 431 000	12 983,80
Tests criterion t-test	7,1257	10,4245	159,783
P-value	0,000019 < 0,05	0,000001 < 0,05	0,000000 < 0,05
Test conclusion	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.
H_0 :	$\beta_1 = 0$	$\beta_1 = 0$	$\beta_1 = 0$
H_1 :	$\beta_1 \neq 0$	$\beta_1 \neq 0$	$\beta_1 \neq 0$
$\hat{\beta}_1$	29 696 600	-50 558 700	44,5335
Tests criterion t-test	4,19068	-2,66751	4,34999
P-value	**0,001509** < 0,05	**0,023593** < 0,05	**0,001155** < 0,05
Test conclusion	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.
H_0 :		$\beta_2 = 0$	
H_1 :		$\beta_2 \neq 0$	
$\hat{\beta}_2$		5 732 520	
Tests criterion t-test		4,35153	
P-value		0,001440 < 0,05	
Test conclusion		Disapprove H_0, prove H_1.	
H_0 :	The linear trend isn´t acceptable model.	The quadratic trend isn´t acceptable model.	The exponential trend isn´t acceptable model.
H_1 :	Non H_0	Non H_0	Non H_0
F-test	17,56	32,57	18,92
P-value	0,0015< 0,05	0,0000 < 0,05	0,0012 < 0,05
Test conclusion	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.

The root mean squared error "*RMSE*" (7) is calculated as:

$$RMSE = \sqrt{\frac{1}{n}\sum\left(y_i - \hat{T}_i\right)^2} \quad . \tag{7}$$

The adjusted index of determination (8) is defined by:

$$I^2_{adjusted} = 1 - \frac{(n-1)\left[\sum\left(y_i - Y_i\right)^2\right]}{(n-p)\left[\sum\left(Y_i - \bar{y}\right)^2 + \sum\left(y_i - Y_i\right)^2\right]} = 1 - \frac{(n-1)S_R}{(n-p)\left(S_T + S_R\right)} = 1 - \frac{(n-1)S_R}{(n-p)S_y} \tag{8}$$

where S_T is the theoretical sum of squares and S_R is residual sum of squares. Test criterion by the proof, the hypothesis H_0 has distribution F by $(p-1)$ and $(n-p)$ degrees of freedom.

According to the results of *RMSE*, adjusted index of determination, *t-tests*, *P-values* and total *F-test* the quadratic trend is available [2], [3], [4]. The forecast of this model see figure 2. By the values in the table 4 have been selected as a suitable model the quadratic model.

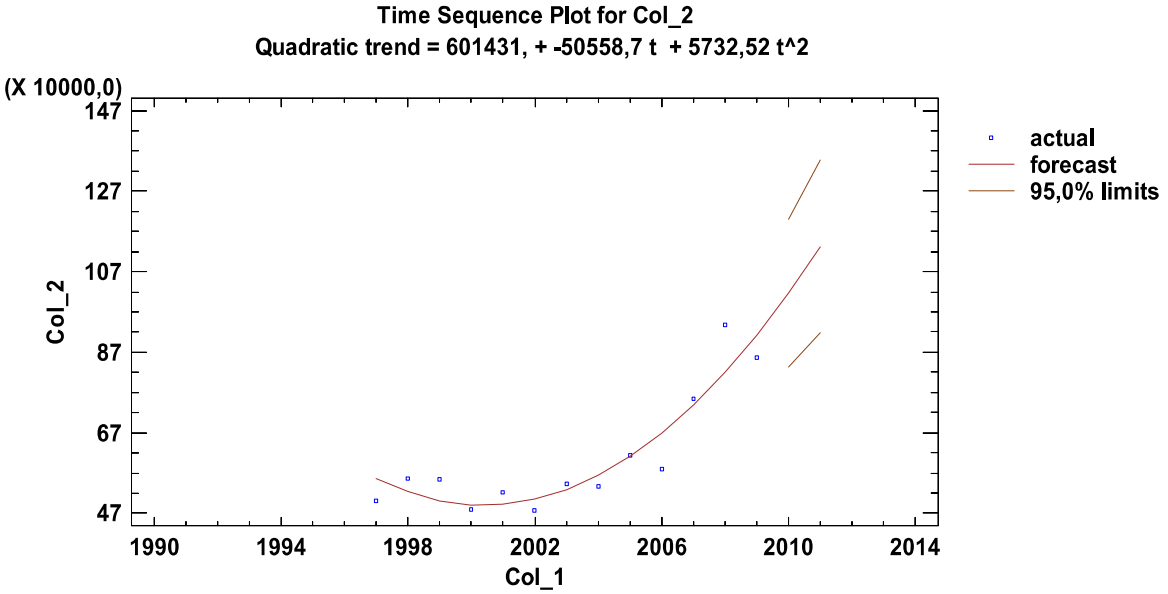

Fig. 2 *Time Series Equalization By Quadratic Trend and Forecast of Development by Next Two Years [own elaboriation]*

According to the results of statistic program Statgraphics the predicted values of gross premium written of crop insurance with 95 % confidence level will be in the year 2010 in the interval 572 414 000 CZK – 1 060 680 000 CZK (with point prediction 816 545 000 CZK) and in the year 2011 in the interval 917 970 000 CZK – 1 347 760 000 CZK (with point prediction 1 132 870 000 CZK).

Tab. 5 Linear, Quadratic and Exponential Trend (Livestock Insurance) [own elaboration]

Trend	**Linear trend**	**Quadratic trend**	**Exponential trend**
Trend function	$T_t = \beta_0 + \beta_1 t$	$T_t = \beta_0 + \beta_1 t + \beta_2 t^2$	$T_t = e^{(\beta_0 + \beta_1 t)}$
Trend function forecast	$\hat{T}_t$= 515208000-19856000t	$\hat{T}_t$ =552970000-34961000t+1078930t^2	$\hat{T}_t$ =$e^{(13183,2-52,2292t)}$
RMSE	23 942 200	19 937 500	20 396 500
$I^2_{adjusted}$ (%)	91,188	93,8894	94,8749
H_0 :	$\beta_0 = 0$	$\beta_0 = 0$	$\beta_0 = 0$
H_1 :	$\beta_0 \neq 0$	$\beta_0 \neq 0$	$\beta_0 \neq 0$
$\hat{\beta}_0$	515 208 000	552 970 000	13 183,2
Tests criterion t-test	26,5749	28,3361	475,036
P-value	0,000000 < 0,05	0,000000 < 0,05	0,000000 < 0,05
Test conclusion	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.
H_0 :	$\beta_1 = 0$	$\beta_1 = 0$	$\beta_1 = 0$
H_1 :	$\beta_1 \neq 0$	$\beta_1 \neq 0$	$\beta_1 \neq 0$
$\hat{\beta}_1$	-19 856 000	-34 961 000	-52,2292
Tests criterion t-test	-11,1883	-5,45333	-14,9379
P-value	**0,0000000**< 0,05	**0,000280**< 0,05	**0,000000** < 0,05
Test conclusion	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.	Disapprove H_0, prove H_1.
H_0 :		$\beta_2 = 0$	
H_1 :		$\beta_2 \neq 0$	
$\hat{\beta}_2$		1 078 930	
Tests criterion t-test		2,42135	
P-value		0,035979 < 0,05	
Test conclusion		Disapprove H_0, prove H_1.	
H_0 :	The linear trend isn´t acceptable model.	The quadratic trend isn´t acceptable model.	The exponential trend isn´t acceptable model.
H_1 :	Non H_0	Non H_0	Non H_0
F-test	125,18	93,19	223,14
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.

According to the results of RMSE, adjusted index of determination, t-tests, P-values and total F-test the exponential trend is available. The forecast of this model see figure 3.

According to the results of statistic program Statgraphics the predicted values of gross premium written of livestock insurance with 95 % confidence level will be in the year 2010

in the interval 226 724 000 CZK – 288 486 000 CZK (with point prediction 255 747 000 CZK) and in the year 2011 in the interval 214 406 000 CZK – 274 801 000 CZK (with point prediction 242 733 000 CZK).

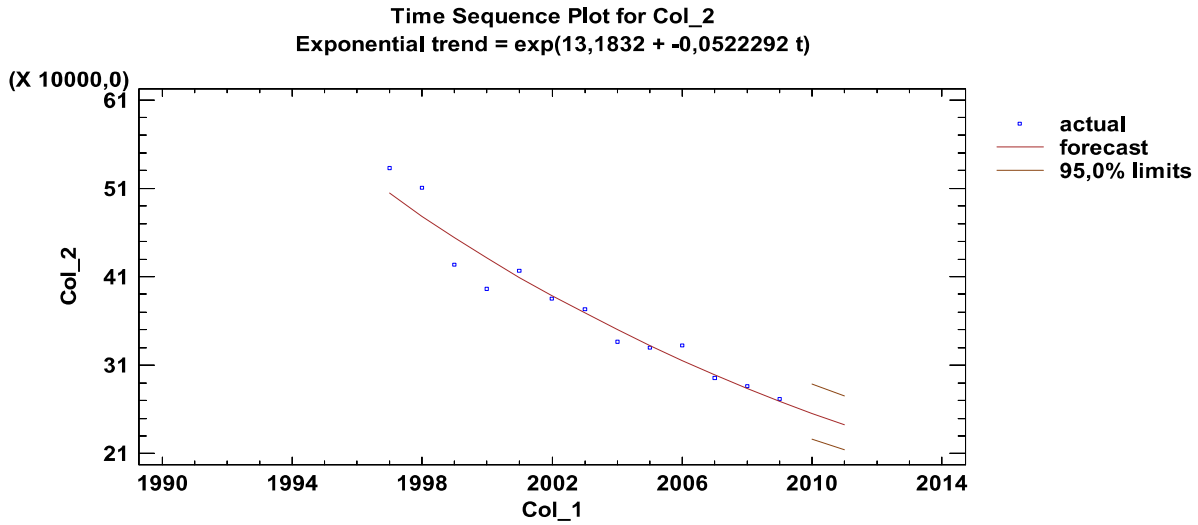

Fig. 3 *Time Series Equalization By Exponential Trend and Forecast of Development by Next Two Years [own elaboriation]*

Conclusion

The development of gross premium written of crop insurance can be modelled with quadratic trend. The development point prediction with 95 % confidence level for next two years is: 816 545 000 CZK for year 2010 and 1 132 870 000 CZK for year 2011.

The development of gross premium written of livestock insurance can be modelled with exponential trend. The development point prediction with 95 % confidence level for next two years is: 226 724 000 CZK for year 2010 and 242 733 000 CZK for year 2011.

This analysis doesn´t include economic factors (for example: inflation, economic progress, economic recession, economic shocks).

Abroad, there follows a detailed statistical analysis, the conclusions of the article cannot therefore be compared with results from other countries.

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ANALÝZA ČASOVÝCH ŘAD A PREDIKCE VÝVOJE PŘEDEPSANÉHO HRUBÉHO POJISTNÉHO ZEMĚDĚLSKÉHO POJIŠTĚNÍ V RÁMCI ČESKÉHO POJISTNÉHO TRHU

Tato práce se zabývá analýzou časových řad a predikcí vývoje hrubého předepsaného pojistného u pojištění plodin a hospodářských zvířat v rámci českého pojistného trhu pro roky 2010 a 2011. Časové řady jsou definovány jako sekvence datových bodů, měřených obvykle po sobě jdoucím čase, které jsou umístěny v časových intervalech. Daty v této modelaci jsou hrubé předepsané pojistné u pojištění plodin a hospodářských zvířat členů ČAP (České asociace pojišťoven, včetně pojišťovací společnosti Agra, o. s.) za období let 1997–2009, přičemž Agra, o. s. začala působit na českém pojistném trhu až od roku 2007. Tato analýza nezahrnuje ekonomické faktory (například: inflaci, hospodářský pokrok, hospodářskou recesi, ekonomické šoky).

ZEITREIHENANALYSE UND PROGNOSE DER BRUTTOPRÄMIEN DER LANDWIRTSCHAFTLICHEN VERSICHERUNG AUF DEM TSCHECHISCHEN VERSICHERUNGSMARKT

Diese Arbeit beschäftigt sich mit der Zeitreihenanalyse und der Prognose von Bruttoprämien für die Versicherung von Kulturpflanzen und Nutztieren auf dem tschechischen Versicherungsmarkt für die Jahre 2010 und 2011. Zeitreihen werden als Folge von üblicherweise in zeitlicher Abfolge gemessenen Datenpunkten definiert, die in zeitlichen Intervallen angeordnet sind. Die Daten in dieser Modellierung bestehen in den Bruttoprämien bei Feldfrüchten und Nutztieren der Mitglieder der ČAP (Tschechischer Versicherungsverband, inkl. Versicherungsgesellschaft Agra, o. s.) für den Zeitraum 1997–2009, wobei die Agra, o. s. bereits seit dem Jahr 2007 auf dem tschechischen Versicherungsmarkt tätig ist. Diese Analyse schließt wirtschaftliche Faktoren wie Inflation, wirtschaftlichen Fortschritt, wirtschaftliche Rezession ökonomische Schocks usw. nicht mit ein.

ANALIZA SZEREGÓW CZASOWYCH I PROGNOZOWANIE SKŁADKI PRZYPISANEJ BRUTTO Z UBEZPIECZEŃ ROLNYCH NA CZESKIM RYNKU UBEZPIECZEŃ

Niniejsze opracowanie dotyczy analizy szeregów czasowych i prognozowania składek przypisanych brutto w przypadku ubezpieczeń upraw i zwierząt gospodarskich na czeskim rynku ubezpieczeń w latach 2010 i 2011. Szeregi czasowe określone są jako ciąg punktów danych, mierzonych zazwyczaj kolejno w pewnych odstępach czasu. Dane w omawianym modelowaniu stanowią składki przypisane brutto z tytułu ubezpieczenia upraw i zwierząt gospodarskich członków CZU (Czeskie Zrzeszenie Ubezpieczycieli), w tym firmy ubezpieczeniowej Agra, o.s., w okresie 1997–2009, przy czym firma Agra, o.s. rozpoczęła działalność na czeskim rynku ubezpieczeniowym dopiero w 2007 roku. Analiza ta nie obejmuje czynników ekonomicznych (takich jak: inflacja, postęp gospodarczy, recesja gospodarcza, wstrząsy gospodarcze).