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TREND MODELS FOR THE ANALYSIS OF SOCIO-ECONOMIC SECURITY

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ТРЕНДОВЫЕ МОДЕЛИ ДЛЯ АНАЛИЗА СОЦИАЛЬНО-ЭКОНОМИЧЕСКОЙ БЕЗОПАСНОСТИ

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Abstract. The correctness of the trend choice for forecasting the characteristics of socio–economic security statistics can be qualified by the mean square error and the aspect of “Ascending” and “Descending” series (although there are other aspects, for example, the aspect based on the median of the sample). According to the proposed model, it is possible to predetermine the average monitoring errors for the development of the lower and upper limits of the forecast version of the values of the characteristics of socio-economic security statistics. The creation of a model is a rather labor–intensive process, as a result of which it is advisable to use, as a rule, the deterministic component of trend models when predicting the characteristics of socio–economic security statistics.

Аннотация. Корректность выбора тренда для прогнозирования характеристик статистики социально–экономической безопасности возможно квалифицировать при помощи величины среднеквадратической ошибки и аспекта «Восходящих» и «Нисходящих» серий (хотя есть и иные аспекты, к примеру, аспект, базирующийся на медиане выборки). По предложенной модели возможно предопределять средние ошибки мониторинга для разработки нижнего и верхнего пределов прогнозного варианта значений характеристик статистики социально–экономической безопасности. Создание модели — довольно трудозатратный процесс, вследствие чего при прогнозировании характеристик статистики социально-экономической безопасности целесообразно применять, как правило, детерминированную составляющую трендовых моделей.

Keywords: socio-economic security, government, society, enterprise, employee, threat, security, interests, economics, analysis, system.

Ключевые слова: социально-экономическая защищенность, государство, общество, предприятие, работник, угроза, защищенность, интересы, экономика, анализ, система.

The correctness of the trend selection for predicting the characteristics of socio-economic security statistics can be qualified by means of the mean square error and the aspect of the "Ascending" and "Descending" series (although there are other aspects, for example, the aspect based on the median of the sample) [1].

The aspect of the "Ascending" and "Descending" series is based on the analysis of deviations of the calculated levels of socio-economic security statistics from those available in the time series. Range $\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_n$, demonstrating the difference between the available (Y_j) and settlement ($\widehat{Y}_j$) indicators of a time series of levels of characteristics of socio-economic security statistics, changing the sequence of pros and cons, calculated by comparing the varieties of a number of random variables ($\varepsilon_{j+1} - \varepsilon_j$) with 0. If $\varepsilon_{j+1} - \varepsilon_j > 0$, the plus sign is affixed if $\varepsilon_{j+1} - \varepsilon_j < 0$, that is put down a minus sign. If there are 2 adjacent values $\varepsilon_{j+1} = \varepsilon_j$ and $\varepsilon_{j+1} = 0$, the is growing only one of them. The total sum of pluses and minuses will be less than or equal to n, where n is the number of random variables. The series length is calculated from a number of pros and cons *Кмах*, which is characterized by the number of consecutive pluses and minuses and the number of series V(n).

The assumption about the random nature of deviations of empirical values of the time series from the trend for the 5% significance value is not rejected, if the next 2 circumstances are made:

$$V(n) > \frac{1}{3}\left[(2n-1) - 1{,}96\sqrt{\frac{16n-29}{90}}\right] \qquad (1)$$

$$K_{max}(n) \leq K_0(n) \qquad (2)$$

Value $K_0(n)$ it is calculated as follows: n < 26 equal to 5, when $26 < n < 153$ and $153 < n < 1170$ K_0 equals 6 and 7.

The deviation grounds have all chances to be an incorrect trend configuration, a very impressive length of the longest series, a short dynamic series, a small number of series, etc.

The standard error is found by the formula:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(Y_j - \widehat{Y}_j)}{N - p - 1}} \qquad (3)$$

where: Y_j — available levels of socio-economic security statistics;

$\widehat{Y}_j$— calculated levels of socio-economic security statistics;

N — number of data levels of socio-economic security statistics in the time series;

p — the number of parameters of the trend model.

We will determine the characteristics of the trend model, calculate the standard error and use the aspect of "Ascending" and "Descending" series on the model of linear form (for the remaining models we will give the final results without preliminary calculations) (Table 1, 2).

The system of normal equations will be as follows

$$\begin{cases} \Sigma Y = a_0 N + a_1 \Sigma t \\ \Sigma Yt = a_0 \Sigma t + a_1 \Sigma t^2 \end{cases} \qquad (4)$$

$$\begin{cases} 87067 = 16a_0 + 136a_1 \\ 867980 = 136a_0 + 1496a_1 \end{cases}$$

$$a_0 = \frac{\begin{vmatrix} \Sigma Y & \Sigma Y \\ \Sigma Yt & \Sigma t^2 \end{vmatrix}}{\begin{vmatrix} N & \Sigma t \\ \Sigma t & \Sigma t^2 \end{vmatrix}} = \frac{\begin{vmatrix} 87067 & 136 \\ 867980 & 1496 \end{vmatrix}}{\begin{vmatrix} 16 & 136 \\ 136 & 1496 \end{vmatrix}} = 224{,}925$$

$$a_1 = \frac{\begin{vmatrix} N & \Sigma Y \\ \Sigma t & \Sigma Yt \end{vmatrix}}{\begin{vmatrix} N & \Sigma t \\ \Sigma t & \Sigma t^2 \end{vmatrix}} = \frac{\begin{vmatrix} 16 & 87067 \\ 136 & 867980 \end{vmatrix}}{\begin{vmatrix} 16 & 136 \\ 136 & 1496 \end{vmatrix}} = 376{,}207$$

The trend model of the linear form takes the form $Y = 2243{,}925 + 376{,}207t$, where t for $t + 1$ г. = 17.

Using this model, we calculate the values of Y in $t - 15 \div t$ and define the value$Y_j - \hat{Y}_j$ (table 5.6. column (6). If $Y_j - \hat{Y}_j > 0$, the sign "+", when $Y_j - \hat{Y}_j < 0$ – «-».

Table 1.

PRIMARY DATA AND PRELIMINARY CALCULATIONS
FOR CALCULATING THE PARAMETERS OF THE TREND MODEL OF THE LINEAR FORM

Год	Y	t	Y_t	t^2	$Y - \hat{Y}$
1	2	3	4	5	6
t-15	3450	1	3450	1	-829,868
t-14	2570	2	7140	4	-573,661
t-13	3720	3	11160	9	-347,453
t-12	3890	4	15560	16	-141,246
t-11	4015	5	20075	25	+109,961
t-10	4135	6	24810	36	+366,169
t-9	4430	7	31010	49	+447,376
t-8	4639	8	37112	64	+614,583
t-7	5074	9	45666	81	+555,791
t-6	5317	10	53170	100	+688,998
t-5	5660	11	62260	121	+722,205
t-4	6270	12	75240	144	+488,413
t-3	6968	13	90584	169	+166,620
t-2	7748	14	108472	196	-237,173
t-1	8625	15	129375	225	-737,965
t	9556	16	152896	256	-1292,758
Σ	87067	136	867980	1496	-4160,124
					+4160,166

Source: elaboration of author

The standard error will be equal to ±639,534:

$$\sigma = \sqrt{\frac{(-829{,}868)^2 + \cdots + (1292{,}758)^2}{16 - 1 - 1}} = \pm 639{,}534$$

From table 2. you can see that $K_{max} = 7$, V(n)=4. Thus, the trend model of the linear form does not make sense to use for forecasting the data of economic statistics, because

$$V(n) > \frac{1}{3}\left[(2 \times 16 - 1) - 1{,}96\sqrt{16 \times 16 - \frac{29}{90}}\right] = 7{,}220$$

$$K_0(n) = 5$$

Trend models 2-16 will look like:

$Y_t = 3806{,}217 - 144{,}5828t + 30{,}63514t^2$,

$Y_t = 6376{,}873 - \frac{44256{,}67}{t}$,

$Y_t = 8116{,}604 - \frac{199933{,}7}{t} + \frac{1564967}{t^2}$,

$Y_t = (0{,}0002990973 - 0{,}000000907865t)^{-1}$,

$Y_t = (0{,}0002990973 - 0{,}000000907865t - 0{,}000000002060924t^2)^{-1}$,

$Y_t = 1160{,}220 \times t^{0{,}3540418}$,

$Y_t = 2644{,}263 + 4412{,}476\, lgt$,

$Y_t = 17837{,}59 - 21601{,}6111 lgt + 7839{,}529\, lgt^2$,

$Y_t = 0{,}7016990 \times t^{1{,}743727} + 3412{,}954$,

$Y_t = 2930{,}298 \times 1{,}006697^t$,

$Y_t = 2930{,}298 \times e^{0{,}006675617t}$,

$Y_t = 522{,}414 \times e^{0{,}01582776t} + 2849{,}258$,

$Y_t = \frac{t}{0{,}006711343+0{,}00092224431t}$,

$Y_t = \frac{t}{0{,}0005123886+0{,}0003330353t-0{,}000001416418t^2}$,

$Y_t = \sqrt{2055910 - 413294{,}4t = 5085{,}797t^2}$,

Table 2.

THE TOTAL NUMBER OF SERIES AND THE LENGTH OF THE LONGEST OF THE SERIES $K_{(N)}$, CALCULATED FOR MODELS 1-16

V_l	K_l	V_l	K_l
$V_1 = 4$	$K_1 = 7$	$V_9 = 3$	$K_9 = 8$
$V_2 = 7$	$K_2 = 5$	$V_{10} = 7$	$K_{10} = 5$
$V_3 = 2$	$K_3 = 10$	$V_{11} = 5$	$K_{11} = 7$
$V_4 = 3$	$K_4 = 8$	$V_{12} = 4$	$K_{12} = 7$
$V_5 = 7$	$K_5 = 5$	$V_{13} = 8$	$K_{13} = 4$
$V_6 = 8$	$K_6 = 3$	$V_{14} = 4$	$K_{14} = 7$
$V_7 = 4$	$K_7 = 8$	$V_{15} = 8$	$K_{15} = 3$
$V_8 = 2$	$K_8 = 8$	$V_{16} = 5$	$K_{16} = 6$

Source: elaboration of author.

As a result of the application of the aspect of "Ascending" and "Descending" series, it is revealed that trend models 6,13,15 adequately characterize the dynamics of data levels of socio-economic security statistics in t-15÷t.

According to the models, the presence of cycles in a time series of levels of socio-economic security statistics was studied (Table 3.).

Elaboration of Table 3. allows to recognize that in a time series of values of characteristics of social and economic security statistics it is impossible to note exact cycles, but in the column 2nd and 3rd there are on 2 four-year cycles, in the 2nd, third and fourth-according to it 1, 2, 3 and 2 three - year. However, this does not represent a basis for the conclusion about the presence of cycles in a time series of values of characteristics of socio-economic security statistics because these cycles do not coincide in time, there is no clear priority of exceeding the actual values of the characteristics of socio-economic security statistics over the calculated ones calculated by models, or, on the contrary, calculated over the actual ones [2; 3]. The shortest root-mean-square error is obtained from the 15th model.

Table 3.

PRELIMINARY CALCULATIONS TO IDENTIFY THE PRESENCE OF CYCLES
IN A TIME SERIES OF DATA LEVELS OF SOCIO-ECONOMIC SECURITY STATISTICS

Year	*Model*		
	6	*13*	*15*
$t-15$	0,999	0,999	0,924
$t-14$	1,000	1,001	0,996
$t-13$	1,004	1,008	1,017
$t-12$	1,009	1,014	1,025
$t-11$	0,997	1,003	1,011
$t-10$	0,980	0,984	0,990
$t-9$	0,998	0,999	1,003
$t-8$	0,989	0,986	0,989
$t-7$	1,018	1,010	1,014
$t-6$	0,997	0,985	0,990
$t-5$	0,986	0,971	0,976
$t-4$	1,006	0,989	0,995
$t-3$	1,019	1,004	1,010
$t-2$	1,019	1,014	1,015
$t-1$	1,005	1,019	1,010
t	0,965	1,014	0,968

Source: elaboration of author

When calculating the magnitude of the forecast error, different approaches are used. For example, the time series of data levels of socio-economic security statistics (1,..., N) is divided into 2 parts: retrospective-p (1... K) and preemption — L(K +1,..., N). By indicators of the retrospective period the model is built Y=a_0+a_1t and represents the forecast for K+1,..., N years. Forecast errors ε in K+1,..., N years is calculated as the difference between the available levels of socio-economic security statistics and the predicted ones identified by the developed model. Then at the same time one-year duration of flashbacks (I,...., K +1) and decreases the duration of the lead period (K +2,..., N).

Again built a predictive model and calculated forecast errors, etc. until that time, is still the period of pre-emption. The average forecast errors for each of the years of the lead period L find the means of dividing the number of errors for the year, identified by different models, but their number (for the last year of the lead $\vec{\varepsilon}$= ε, since for the calculation of ε is applied to only one model, built 1,..., N data —1). On the basis of the obtained indicators, a forecast model is built that demonstrates the dependence of the average forecast error on 2 indicators - the size of the pre-forecast period (p) and the size of the lead (L):

$$\varepsilon = \varphi(p, L) \tag{5}$$

According to the proposed model, it is possible to predetermine the average monitoring errors for the development of the lower and upper limits of the forecast version of the values of the characteristics of socio-economic security statistics. Creating a model is a labor-intensive process so that when predicting the characteristics of socio-economic security statistics, it is advisable to use, as a rule, a deterministic component of trend models.

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