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ECONOMETRIC METHODS FORECASTING THE IMPROVEMENT OF LIFE QUALITY OF THE ARTSAKH REPUBLIC POPULATION

Time series forecasting is hardly a new problem in data science and statistics. The term is self-explanatory and has been on business analysts' agenda for decades for a long time: The very first practices of time series analysis and forecasting trace back to the early 1920s.The underlying idea of time series forecasting is to look at data of interest to us from the time perspective, define the patterns, and yield short or long-term predictions on how – considering the captured patterns – target variables will change in the future. The use cases for this approach are numerous, ranging from sales and inventory predictions to highly specialized scientific works on bacterial ecosystems. Time series problems are always time-dependent and we usually look at four main components: seasonality, trends, cycles, and irregular components.

Keywords: *time series, trend, quality of life of the population, non-stationary time series, forecasting*

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ЭКОНОМЕТРИЧЕСКИЕ МЕТОДЫ ПРОГНОЗИРОВАНИЯ УЛУЧШЕНИЯ КАЧЕСТВА ЖИЗНИ НАСЕЛЕНИЯ РЕСПУБЛИКИ АРЦАХ

Прогнозирование временных рядов не новая проблема в науке о данных и в математической статистике. Термин не нуждается в пояснениях и за многие годы был на повестке дня бизнес–аналитиков: самая первая практика, анализа временных рядов и прогнозирования приходится на начало 1920-х годов. Основная идея прогнозирования временных рядов заключается в том, чтобы посмотреть на данные, представляющие интерес для нас с точки зрения зависимости от времени, определить закономерности предоставлять краткосрочные или долгосрочные прогнозы о том, как с учетом охваченных закономерностей – целевые переменные

будут меняться в будущем. Примеры использования этого подхода многочисленны - от прогнозов продаж и инвентаризации, до узкоспециализированных научных работ по бактериальным экосистемам. В проблемах временных рядов в качестве аргумента всегда выступает время, и обычно рассматриваются четыре основных компонента: сезонность, тенденции, циклы и случайные компоненты.

Ключевые слова: *временной ряд, тренд, качество жизни населения, нестационарный временной ряд, прогнозирование.*

Ռ. Զախարյան, Լ. Ավշարյան

ԱՐՑԱԽԻ ՀԱՆՐԱՊԵՏՈՒԹՅԱՆ ԲՆԱԿՉՈՒԹՅԱՆ ԿՅԱՆՔԻ ՈՐԱԿԻ ԲԱՐԵԼԱՎՄԱՆ ԿԱՆԽԱՏԵՍՄԱՆ ԷԿՈՆՈՄԵՏՐԻԿԱԿԱՆ ՄԵԹՈԴՆԵՐԸ

Ժամանակային շարքերի կիրառումը տվյալների կանխատեսման համար գիտության ու մաթեմատիկական վիճակագրության մեջ նոր խնդիր չէ: Տերմինը պարզաբանման կարիք չունի և տասնամյակների ընթացքում երկար ժամանակ եղել է բիզնես վերլուծաբանների օրակարգում: Ժամանակային շարքերի վերլուծության և կանխատեսման առաջին փորձը սկսվել է 1920-ականներին: Ժամանակային շարքերի կանխատեսման հիմնական գաղափարը կայանում է հետևյալում. դիտարկել տվյալները, որոնք, կախված ժամանակից, հետաքրքրություն են ներկայացնում, որոշել օրինաչափություն, և տալ կարճաժամկետ կամ երկարաժամկետ կանխատեսումներ այն մասին, թե ինչպես են օրինաչափությունների գրավմամբ հետագայում փոխվում նպատակային փոփոխականները: Այս մոտեցման օգտագործման օրինակները բազմաթիվ են՝ սկսած վաճառքի և գույքագրման կանխատեսումներից մինչև բակտերային էկոհամակարգերի վերաբերյալ նեղ մասնագիտացում ունեցող գիտական աշխատանքները: Ժամանակային շարքերում որպես արգումենտ հանդես է գալիս ժամանակը, և սովորաբար դիտարկվում են չորս հիմնական բաղադրիչներ՝ թրենդ, սեզոնայնություն, ցիկլիկ և ստոխաստիկ բաղադրիչներ:

Հանգի բառեր: *ժամանակային շարքեր, թրենդ, բնակչության կյանքի որակ, ոչ ստացիոնար ժամանակային շարքեր, կանխատեսում:*

Introduction

The average monthly nominal wage and per capita incomes are the most common among all indicators of the socioeconomic sphere by which life quality of the population can be assessed.

The choice of these indicators is not accidental, since the indicators studied reflect many important economic processes taking place in the economy of the Artsakh Republic.

The main goal of the work is statistical analysis, modeling of dynamics and main indicators forecasting**.**

Forecasting of time series data is an important component of operations research, since these data often provide the basic for decision making models. The inventory model requires

estimates of future demands, the model of course scheduling and staffing for a university requires estimates of future student inflow, while the model of river flows for the nearest future. Time series analysis provides tools for selecting a model that can be used to predict future events. Time series modeling is a statistical problem. Predictions are used in computational procedures to estimate the model parameters. The latter are used for the allocation of limited resources or for the description of random processes such as those mentioned above. Time series models assume that observations vary according to some probability distribution that lies in the basic of time function.

Time series analysis is not the only way of obtaining predictions. Expert judgment is often used to predict long-term changes in the structure of the system. For example, qualitative methods such as the Delphi technique may be used to predict major technological innovations and their effects. Causal regression models try to predict dependent variables as a function of other independent variables that have been observed and correlated to them.

Statement of the problem

Traditional forecasting methods strive to bring stationarity into time series, i.e. make a number of statistical properties repeat constantly over time. Raw data doesn't usually provide enough stationarity to yield confident predictions. For instance, to the graph of improvement of life quality of the population, we must apply multiple mathematical transformations to render non-stationary time series at least approximately stationary. Then we'll be able to find patterns and make predictions that are more accurate than coin tossing, which is right in 50 percent of cases.

In the time series of dependent variables, there is a relationship between the values of the same random process. The identification of such a connection is of great importance in analyzing the dynamics of time series. A single trend model is constructed, the significance of the regression equation is evaluated, the adequacy of the model is checked, and the significance of the regression parameters is estimated by the Fisher criterion.

Structural model of time series:

$$Y(t) = f(t) + S(t) + C(t) + \varepsilon(t) \quad (1)$$

$f(t)$- trend - a smoothly changing component, a long trend of change in the trait;
$S(t)$ - seasonal component - regular fluctuations that are periodic or close to it and end in a year;
$C(t)$- cyclic component - long periods of relative rise and fall, cycles of variable duration and amplitude;
$f(t), S(t), C(t)$ are regular components of the time series;
$\varepsilon(t)$ is a random component, the influence of random factors that are not accountable and recorded.
Below is a table of basic socio-economic indicators.
As time series, we consider the indicators of socio-economic sphere of the Artsakh Republic, in order to predict the improvement of the quality of life of the population of the Republic.

The dynamics of socio-economic indicators

Time	X_1	X_2	X_3	X_4	Y_1	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	Y_2
1995	126	602	36345	3103	4126		1640	7854	4060	3724	2107	27503	341		1744	4222	2478	307		52,6
1996	131	641	36965	4055	7984	14221	3201	11360	7102	3976	2352	27768	376		1556	6179	4624	310		70,4
1997	135	682	36637	5107	12261	19796	2564	9692	4701	4354	3533	29483	488		1931	8247	6317	552		93,3
1998	137	690	33975	3630	16170	17697	4275	11631	8249	9021	3963	29529	484		2514	9247	6733	1352		113,1
1999	139	541	47015	3189	24828	20999	3893	11817	8352	5517	4216	32571	205		2303	12171	8247	1081	28000	128
2000	134	1037	47794	3541	27 222	23149	4855	13452	7424	7960	4421	32502			2495	11904	9409	1560	30325	176,1
2001	136	1231	48862	3461	28178	23881	5904	13906	6404	6416	4584	43688			2395	11421	9026	3633	52646	196,7
2002	137	948	49768	3403	29673	26478	8083	15176	6734	4323	5286	44343	84	9262	2564	11686	9121	5093	62205	215,1
2003	137	826	50123	3314	33661	33884	11125	21160	8694	4982	5936	48614	284	10018	3536	12678	9141	4152	83644	251,2
2004	137	789	51404	3278	41170	42830	18579	21715	9139	6704	6463	50505	427	9167	4973	14881	9908	6651	115582	313,9
2005	138	744	52860	3515	51127	51379	17773	21055	12597	7623	8316	53886	168	7298	7074	20687	13613	9732	133118	376,4
2006	138	867	54599	3560	56700	61886	24204	20736	17602	10530	9171	58481	159	11914	10008	26663	15414	7814	158511	420,5
2007	139	918	56112	3004	68610	70791	22437	23813	17602	14694	13364	69809	361	11818	12459	31928	19469	10178	277393	497,9
2008	140	1101	58503	3464	80480	87148	25346	31157	20810	14130	19432	98789	585	21108	21045	51706	30661	17334	305064	577,3
2009	141	1555	58792	3531	88768	102339	34092	30657	25836	1680	25327	127056	875	39570	22185	56244	34059	28995	293967	624,9
2010	144	1353	58028	3445	92736	118187	42992	32130	34481	26732	28621	137349	683	46418	24665	63244	38580	42229	348235	674,8
2011	145	1289	60064	3313	98453	35499	45823	39920	42769	20079	33451	147788	1008	50214	26563	68267	41703	59437	92707	780,5
2012	147	1268	60865	2915	102777	150016	40872	50313	43360	18249	35812	161085	876	74708	29619	68224	38605	78927	349012	853,6
2013	144	1027			128621	168564	44339	55172	45220	18673	39548	164216	206	56163	28834	70584	41750	82162	328470	921,4
2014	145	1119			141193	188840	52047	57647	49670	26303	40141	170429	367	59477	32323	79130	46807	97536	366651	1013,4
2015	145	1292			151058	209346	53541	64310	50145	53043	42837	178256	675	68005	35309	84480	49171	99806	314557	1053,1
2016	146	1249			152707	229652	59000	68468	45656	23485	43768	197929	1027	39245	34687	85716	51028	117736	337966	1076,2

Variables in Table 1:

X_1 - Population size (at the end of year), thsd. persons
X_2 - Natural growth of population: persons
X_3 - Average number of employed in the economy, persons
X_4 - Total number of officially registered unemployed, persons
Y_1 - Average monthly nominal wage of persons engaged in the economy, drams
X_5 - Gross Domestic Product: total, mln. drams
X_6 - Industrial output, mln. drams
X_7 - Agricultural output, mln.drams
X_8 - Capital construction, mln. drams
X_9 - Commissioning of fixed assets in construction, mln. drams
X_{10} - Goods turnover of general purpose transport, thsd. t-km
X_{11} - Passenger turnover of general purpose transport, thsd. passenger-km
X_{12} – Humanitarian relief of the Republic of Nagorno-Karabakh, thsd.USD
X_{13} – Investments, mln. drams
X_{14} - Receipts of state and regional budgets, mln. drams
X_{15} - Outlays of state and regional budgets, mln. drams
X_{16} - Deficit of state and regional budgets, mln. drams
X_{17} - Credit investments in the economy of rezidents of NKR, mln. drams
X_{18} - External trade turnover, thsd. US dollars
Y_2 - Money incomes of population per capita, thsd. Drams

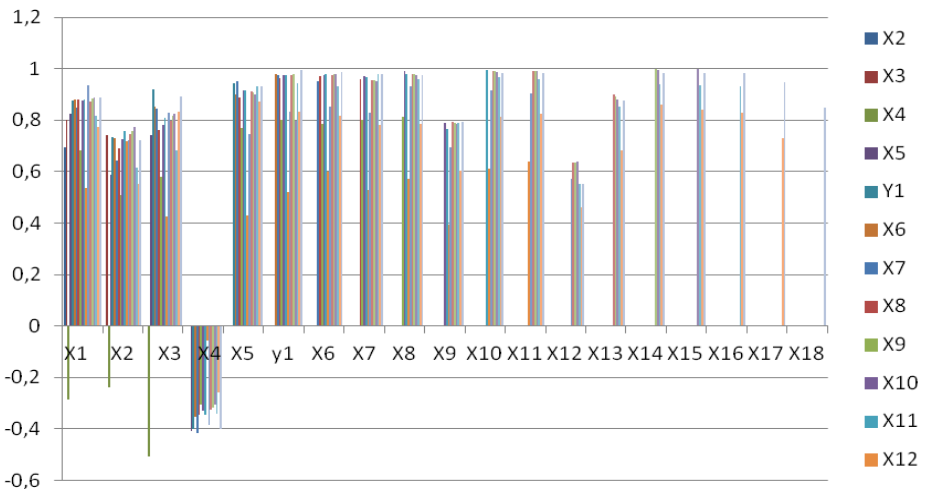


Fig.1. Correlation coefficient diagram

Analysis of the dynamics of the average monthly nominal wage and income per capita with the help of graphical analysis in the period from 1995 to 2016.

Analysis of the autocorrelation function (ACF) helps to identify the structure of the time series, namely, determines the lag at which the autocorrelation coefficient is the highest, i.e. lag, in which the relationship between the current and previous values of the series is the closest.

The coefficient of autocorrelation is calculated by the formula:

$$r(k) = \frac{\sum_{t=2}^{n}(Y_t-\overline{Y}_t)(Y_{t-k-1}-\overline{Y}_{t-k-1})}{\sqrt{\sum_{t=2}^{n}(Y_t-\overline{Y}_t)^2\sum(Y_{t-k-1}-\overline{Y}_{t-k-1})^2}}, \quad (2)$$

where $\overline{Y}_t = \frac{\sum_{t=k+1}^{n} Y_t}{n-1}$, $\overline{Y_{t-1}} = \frac{\sum_{t=k+1}^{n} Y_{t-1}}{n-1}$, n-number of observations, k-lag.

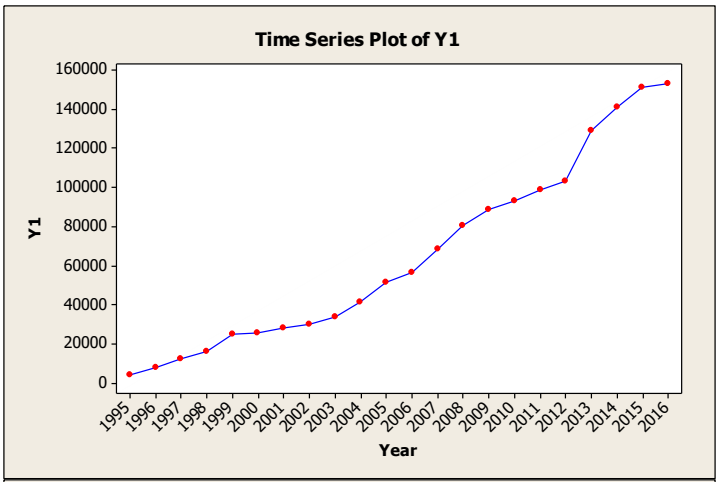
Having built in the Minitab 16.0 application, we can conclude that the series under investigation contain a linear or near-linear trend or a relationship between the current and previous levels of the series. This conclusion is based on the fact that the first coefficient of autocorrelation turned out to be significant and the highest r (1) = 0.88.

Modeling the trend of time series

It was found out that the time series under consideration contains a near-linear trend. Therefore, the general form of the additive model of the time series under investigation can be represented in the following form:

$$Y_t = T + E_t, \quad (3)$$

where T is the trend value, and E_t is the error, i.e. deviation of the actual values of the series from the trend.



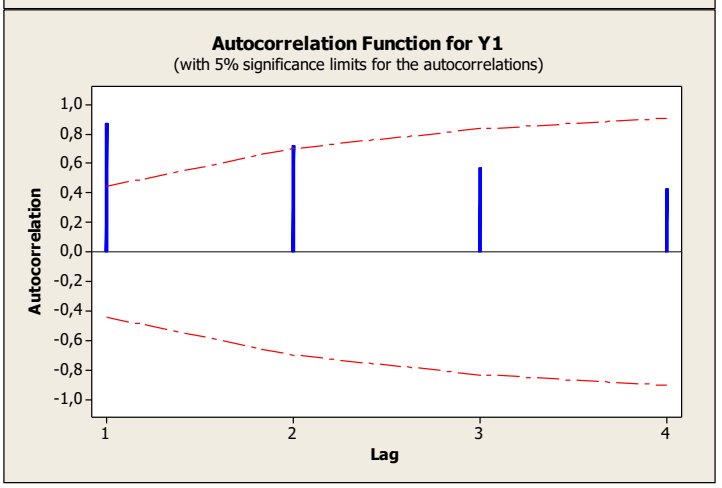


Fig.2. Time series of Y_1

Fig.3. Autocorrelation Function: Y_1

Lag	ACF	T	LBQ
1	0,866146	4,06	18,86
2	0,715317	2,12	32,37
3	0,565896	1,41	41,27
4	0,427830	0,98	46,64

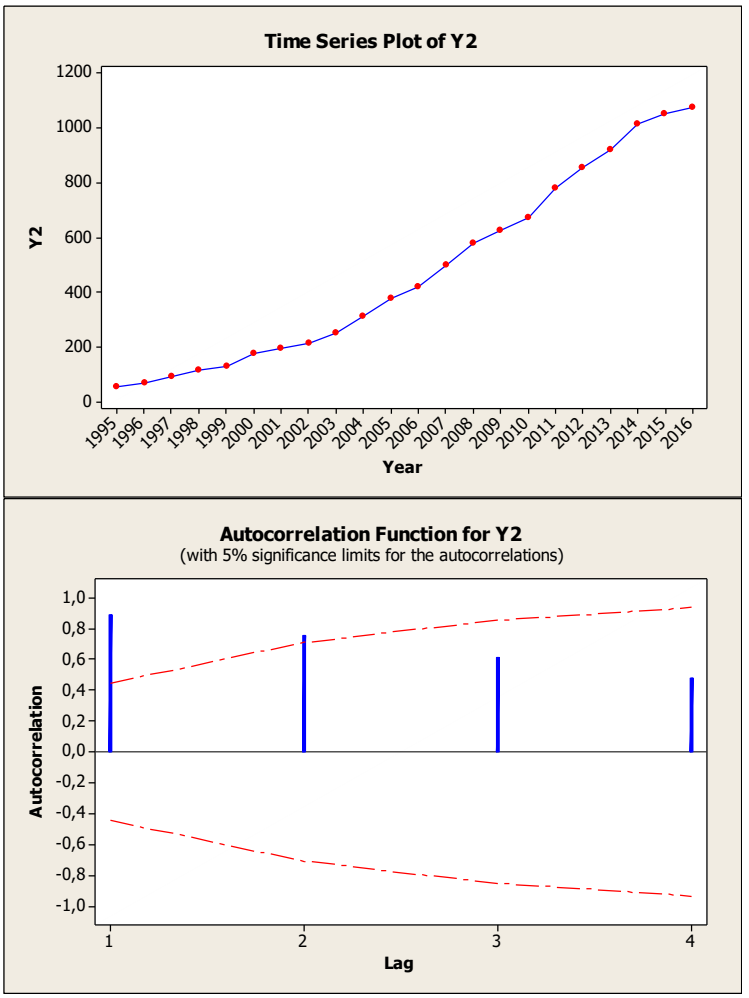


Fig.4. Time series of Y_2

Fig.5. Autocorrelation Function: Y_2

Lag	ACF	T	LBQ
1	0,881949	4,14	19,56
2	0,749849	2,20	34,40
3	0,610079	1,49	44,74
4	0,474428	1,06	51,35

The construction of functions characterizing the dependence of the values of the series under study on time is the main way of modeling the trend of the time series. For the construction of trends, linear and continuous trend models are used.

The adjusted determination coefficient for the linear model turned out to be quite high, more than 0.75, which indicates a strong approximation (it is generally considered sufficient) for the quality of the model $R^2 = 0.75$. Therefore, it is desirable to use these models for the forecast, since it can prove to be reliable.

Linear models for the average monthly nominal wage and per capita income are as follows:

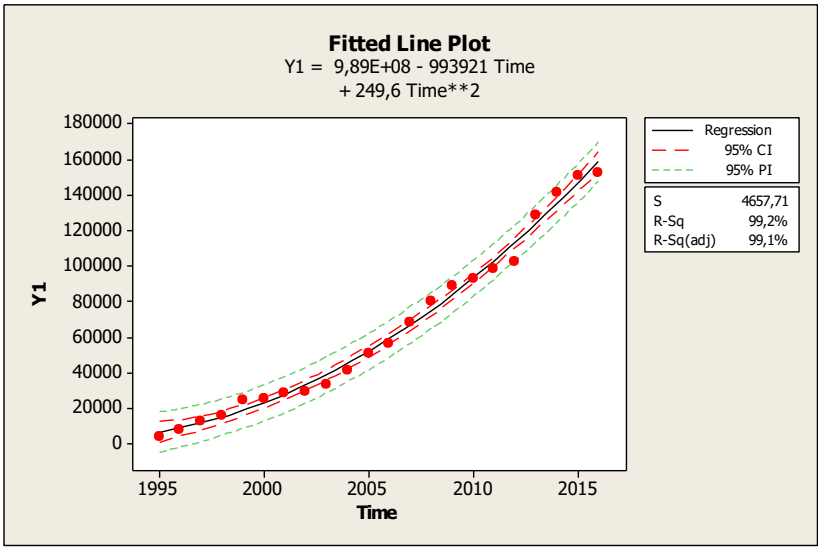
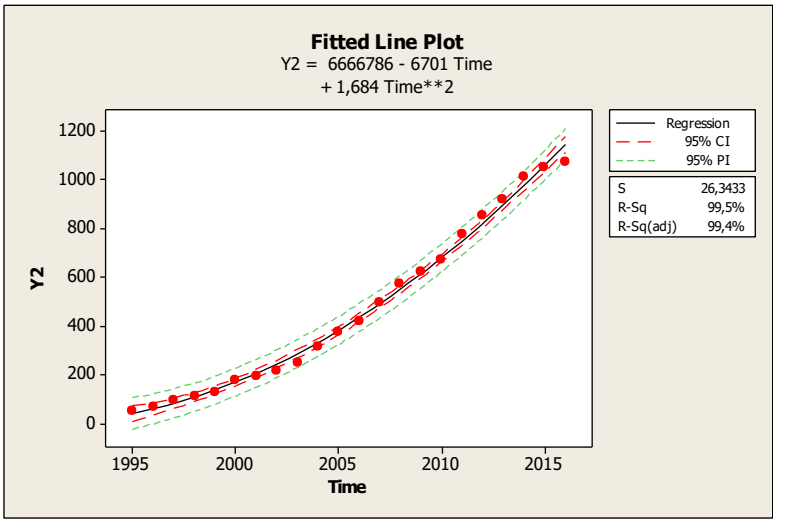


Fig.6. Residual Plots for Y_1

Polynomial Regression Analysis: Y1 versus Time

The regression equation is
Y1 = 9,89E+08 - 993921 Time + 249,6 Time**2
S = 4657671 K-Ый = 9962% K-Ый(фво) = 9961%
Analysis of Variance

	F	P
Regression	1115	0,000



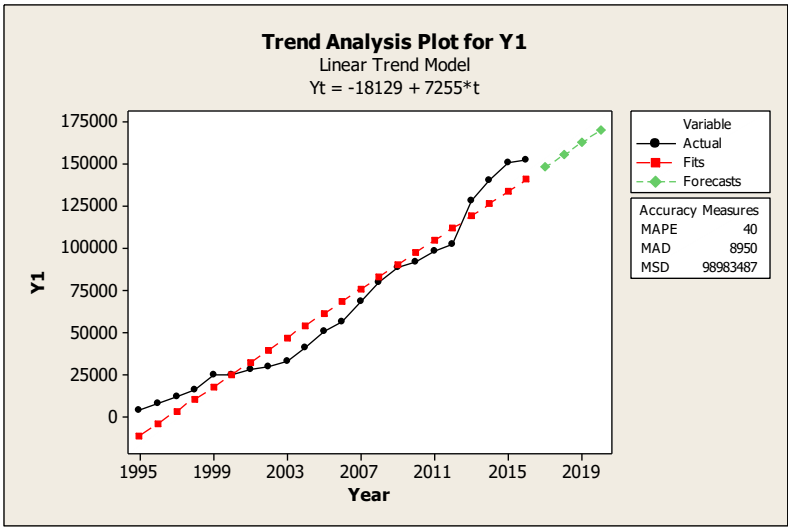
Polynomial Regression Analysis: Y2 versus Time
The regression equation is
Y2 = 6666786 - 6701 Time + 1,684 Time**2
S = 26,3433 R-Sq = 99,5% R-Sq(adj) = 99,4%

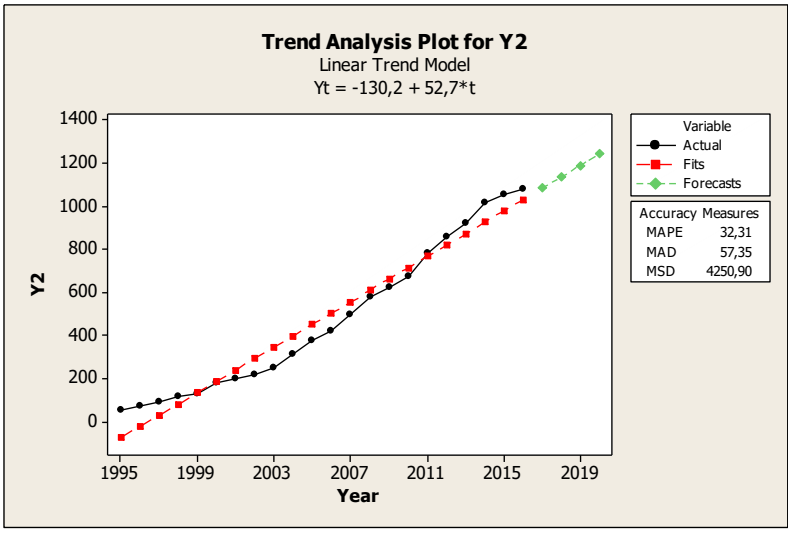
Analysis of Variance

	F	P
Regression	1832,85	0,000

Having constructed polynomial models, we obtained that for all trend models the corrected determination coefficient is significantly high ($R^2 = 0.95$).

Analyzing the remains, they revealed that all prerequisites for regression analysis are met. Therefore, we can conclude that the theoretical values are close to the actual values.





You can see that the forecast values do not match the actual values. However, the forecast caught the trend of further development. You cannot build a model that has the same forecast as the actual data. This is due to the fact that the investigated indicator is annually affected by many external factors.

Conclusions

To conclude with, we can state that two models were constructed, during the study of the dynamics of the main indicators.

In dynamics, there was a change in the trend for the period from 1995 to 2016, which was caused by the instability of Artsakh is economy. After checked the structural stability of the investigated indicators, it has been found out that it is necessary to build a piecewise-continuous model. Therefore, polynomial models were constructed. The models approximate the investigated indicators fairly well.

Making predictions for the best models led us to the idea that all the models constructed guessed the development trend. However, the predicted values do not coincide with the actual ones.

Summing up, we can say that it is very difficult to predict the behavior of the indicators under study, since external factors influence economic indicators as well.

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