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Analysis of the change in the volume of electricity production

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Abstract: In the article, the prediction model of the change in the volume of electricity production in the Republic of Uzbekistan was studied. At the present time, it is important to change the volume of electricity production in the Republic of Uzbekistan. First of all, an econometric analysis of the changes in the volume of electricity production in the period 2010-2022 was carried out. The analysis was carried out on the basis of the MINITAB package. In the analysis, the main statistical indicators were calculated based on the data. A graph is constructed, and periods of changes in the volume of electricity production are studied based on the graph. Based on the statistical data, several trend models were built and a prediction model was selected based on the residuals. Based on the selected model equation, the change in the volume of electricity production for the next 3 years was predicted.

Keywords: Changes in the volume of electricity production, main statistical indicators, trend model equation

1. Introduction

In the development of humanity, the needs of people for various energy sources make them natural sources–wood, coal, peat and other fuels, wind, water flow energy (wind and water mills). Later, due to the progress of science and technology, the revolution in science and technology, from the second half of the 20th century, the need for electricity increased. These factors required rapid development of energy industry. The development of science and technology is expressed through the development of new methods of energy production and its transformation, the creation of new efficient equipment and technologies, the centralization of energy distribution, etc. Scientific research works on energy were focused on solving priority complex issues and practical problems of energy. The issue related to the long-distance transmission of electric energy - theory of transforming alternating current into fixed current, methods for calculating the maintenance of spontaneous awakening of magnetic currents of asynchronous and synchronous machines, development of the theory of complex types of damage in electronic devices, and solving the efficient distribution of power of hydroelectric power plants were dealt with. related works have been completed. In the late 1940s and 1950s, scientific research was focused on improving the operation of power plants, electrical systems and equipment, improving their accuracy, increasing their efficiency, and creating a compact theory and methods of calculating electrical systems. The problems of solving large-scale nonlinear equations representing the mode of electrical systems, creating schemes for extracting small power from high-voltage power lines, developing calculation theory and methods were studied [1]-[4].

Currently, the volume of electricity production is increasing from year to year. Based on this change, 2010-2022 annual data was studied to make a forecast for the next future years. Based on identified data, a tred model was built and prediction the value for the next 3 years was calculated.

In forecasting, an analysis was conducted based on the time series in the econometric model analysis.

Two types of data can be used to build an econometric model:

• a set of data describing various objects at a certain time;
• information describing one object in different time series.

2. Research methodology

A time series is a sequence of data collected, recorded, or observed over the same period of time. A time series consists of the observed values of a property of the studied object at different times. For example, in medicine, it can be a cardiogram, in geology, a graph of vibrations caused by an earthquake or underground explosion, in astronomy, a graph of solar activity, or signals from distant galaxies received by radio telescopes, etc. In the economy, the unemployment rate or the change in the interest rate, the dynamics of the exchange rate and the share price can be given as an example. The observed time interval can be continuous, one minute, one hour, day, month or year.

The overall trend of time series values over time is called the trend and denoted as T_t.

The most common way to model a trend in a time series is to find an analytical function that shows the change of its considered value over time, that is, to construct a trend. This method is called ***the analytical method of time series smoothing***.

A simple exponential smoothing algorithm provides a stable prediction for all future values of the time series. However, the trend of increase or decrease in the values of some lines is clearly observed. In such cases, it is necessary to pay attention to the trend and study it. Naturally, the trend model is expected to perform better.

In 1957, Holt proposed an exponential smoothing algorithm that incorporates the simplest linear trend model.

Autocorrelation is the correlation between variables and the correlation between one or more lags.

Formula:

$$r_1 = \frac{\sum_{t=1}^{n-1}(Y_{t-1} - \bar{Y})(Y_t - \bar{Y})}{\sum_{t=1}^{n}(Y_{t-1} - \bar{Y})^2}$$

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A graphical representation of the autocorrelation function is called a correlogram.

A trend is a long-term component that shows how a time series changes over a specified period of time. That is, the trend is an analytical function of time, which can be in the following forms:

- Linear trend $T_t = at + b$;
- Parabolic trend $T_t = at^2 + bt + c$;
- Exponential trend $T_t = exp(at + b)$,

where a, b, c are parameters.

Generally, estimates for trend parameters are found using the least squares method. Non-linear trends are first transformed into a linear trend by some shape transformation, and then the appropriate calculations are performed. Using computer programs, it does not take long to do this. To select the best model, their coefficient of determination and errors are considered. We calculate errors using MAPE, MAD, MSE, MPE and MSD methods. We calculate the coefficient of determination from its formula.

Statement of the problem: the amount of electricity production in the Republic of Uzbekistan is given for the years 2010-2022, to determine the dependence of this data during the unit of time and to build the best model for this, and through it to generate the average electricity in the following periods is to predict output volume with low error.

№	Years	Electricity production volume
1	2010	51976,3
2	2011	52806,2
3	2012	52999,6
4	2013	54618,6
5	2014	55766,0
6	2015	57658,1
7	2016	59100,5
8	2017	60820,1
9	2018	62896,6
10	2019	63531,6
11	2020	66500,7

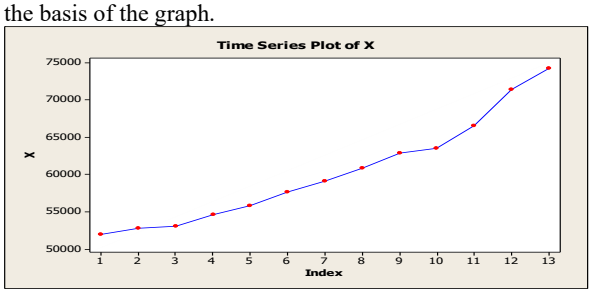
First of all, the main statistical indicators are calculated using the MINITAB package program.

Descriptive Statistics: Y

Variable	Mean	StDev	Variance	Minimum	Median	Maximum
Y	60331	7150	51120784	51976	59101	74269

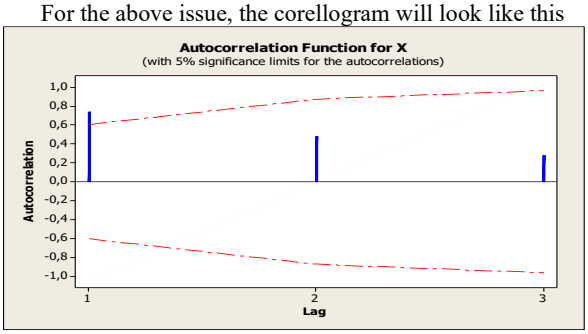
As we can see from the main statistics, the volume of electricity production during the given period reached its maximum point in 2022, which was 74 269. This point was not reached in the period after that. The lowest point corresponds to 2010 and it was 51 976. The average volume of electricity production for the whole year was 60 331. In this place, the median was equal to 59 101. The average squared deviation was 7 105. How far the given values are scattered around the regression line shows 51 120 784.

The next task will be to give preliminary conclusions on the basis of the graph.



From the graph, we can observe the trend of changes in the volume of electricity production in each period. In general, it is advisable to study the graph in several parts. As can be seen from the graph, initially, the value of electricity production has a tendency to increase, and this situation continued until the 2nd period. A slight downward trend was observed from period 2 to period 3. From the 3rd period, the value of the volume of electricity production has a general upward trend. In general, the value of the volume of electricity production has an almost increasing tendency. So, **there is a trend.** You can easily see from the graph that there is no seasonality and cyclicality

For the above issue, the corellogram will look like this



From the autocorrelation graph we can make the following conclusions:

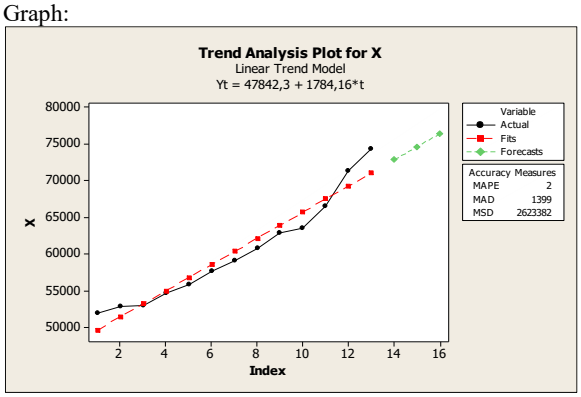
As a rule of thumb, a series must be non-stationary for a trend to exist. For the series to be non-stationary, the first few values in the correlogram must lie outside the boundary line. Since one lag in the correlogram is out of bounds, our model has a trend and by itself the series is non-stationary. We also conclude that the autocorrelation function has no seasonality or cyclicity, since the values of the autocorrelation function are decreasing and do not return to the same value.

Trend Equation: $Y_t = 47842,3 + 1784,16 \cdot t$

Errors:

MAPE	2
MAD	1399
MSD	2623382

Graph:



Period	Forecast
2023	72820,5
2024	74604,7
2025	76388,8

The volume of electricity production predicted for the following years was calculated using the linear trend model. Based on the residuals of the linear trend model, the correct selection of the model equation is based. Other model

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equations are also considered to justify the correct model selection.

Now let's look at the parabolic trend pattern:

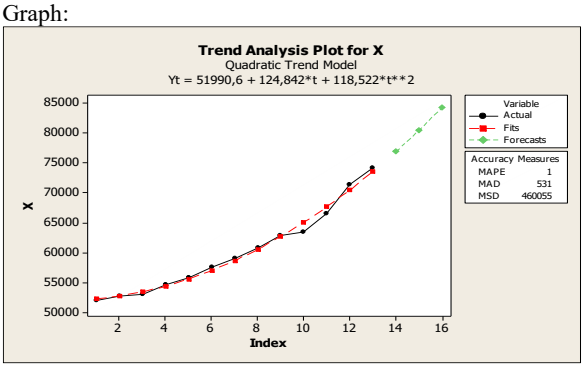
Trend model equation:

$$Y_t = 51990{,}6 + 124{,}842 \cdot t + 118{,}522 \cdot t^2$$

Errors:

MAPE	1
MAD	531
MSD	460055

Graph:



Period	Forecast
2023	76968,8
2024	80530,8
2025	84329,8

Therefore, the electricity production volume predicted by our parabolic model in the following years is more accurate than our prediction made by the linear trend model.

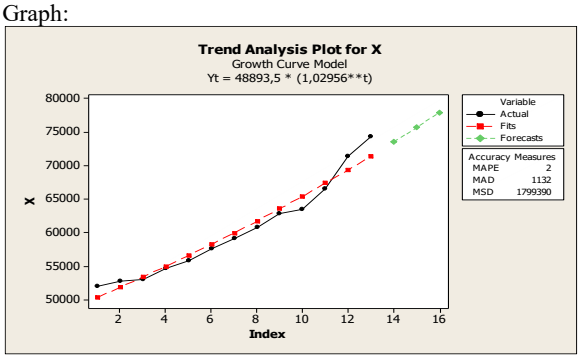
Now let's look at the exponential trend model:

Trend model equation: $Y_t = 48893{,}5 \cdot 1{,}02956^t$

Errors:

MAPE	2
MAD	1132
MSD	1799390

Graph:



Period	Forecast
2023	73518,4
2024	75691,8
2025	77929,6

Let's compare the models by errors:

Model type	MSD
Linear	2623382
Parabolic	**460055**
Exponential growth	1799390

The parabolic model most accurately describes the available data because it has the smallest standard deviation (MSD). The trend equation describing this time series is:

First, annual basic statistics of electricity generation volume were determined and confidence intervals were found for them. At the next stage, a graph of the model was built and it was concluded that there is an increasing trend. Nevertheless, an autocorrelation analysis was performed to test whether there was indeed a trend in the model and whether there was seasonality in the model. According to him, there is a real trend in the model and

$$Y_t = 51990{,}6 + 124{,}842 \cdot t + 118{,}522 \cdot t^2$$

3. Conclusion

There is no seasonality. Then the analysis of linear, parabolic and exponential growth trend models was performed, and the parabolic model was chosen because the coefficient of determination of the parabolic model is large and its errors are small. In the analysis, a forecast of the volume of electricity production for the next 3 years was obtained.

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