Use of mathematical methods at determining of South Kazakhstan energy consumption

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Abstract: Mathematical methods, including econometric approaches, take a ranking place in the study of economic events and processes. Models determining quantitative connections between studied figures and factors influencing on them by using their available values in the period under review for forecasting of the future period can be related to the econometric.

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1. Introduction

A process of construction and intake of the econometric models involves following principal stages:

– determination of the research objective;

– construction of figures system and logical selection of factors mostly influencing on every figure;

– choice of connection form of the studied figures between themselves and selected figures, i.e. choice of the econometric model type;

– primary acquisition and analysis of information;

– construction of the econometric model, i.e. determination of its parameters;

– quality control of the constructed model, first of all its adequacy to the studied economic process;

– use of the model for economic analysis and forecasting.

The research objective is determination of energy consumption in the region in terms of using mathematical methods of optimum relationship formulation for energy distribution between branches of economy.

The aim - development of methodology for ranking of territorially-administrative formations units according to the level of entrepreneurship development.

2. Material and Methods. Mathematical apparatus base of the econometric approaches and models is mathematical statistics, particularly correlation and regression analysis. Methods of the correlation-regression analysis offer solution of three primal problems such as connection forms between performance and factorial features, closeness of connections between them, influence of separate factorial features.

Theoretical and methodological principles of the research are the works of foreign and domestic scientists and economists in the field of theory and practice in the field of mathematical modeling of the economy, as well as legal acts, decrees of the President of the Republic of Kazakhstan, the government regulations on energy consumption.

Information base of the research is materials of RK Agency for statistics, data of the regional administrating authorities, reports of scientific-research institutes, normative-reference materials.

3. Discussion.

Depending on number of factors included into the regression equation there are simple (paired) and multiple regression. The simple regression is a regression between two variables y and x, i.e. model of the following type

$$y = f(x), \quad (1)$$

where y is a dependent variable (performance feature),

x is an independent, or explanatory variable (feature-factor).

The multiple regression is a regression of performance feature with two and more factors, i.e. model of the following type

$$y = f(x_1, x_2, \ldots, x_n). \quad (2)$$

Any econometric research begins from definition of a model type on the assumption of associate connections between variables [1].

The most significant influencing factors can be separated out from the whole circle of factors influencing on the performance feature. The paired regression will be sufficient, if there is a dominant factor which is used in the quality of explanatory variable.

The paired regression shall give a good result at modeling if there is a possibility to ignore influence of other factors influencing on the research object. However, the researcher can never be sure of the validity of this assumption. In this situation we should try to identify the influence of other factors introducing them to the model.

The multiple regression is widely used in solution of problems of demand, returns on equity, costs of production, in macroeconomic values, and a number of other questions of the econometric theory. Nowadays the multiple regression is one of the most routine methods in the econometric theory. The main objective of the multiple regression is to develop a model with a great number of factors determining at that influence of each of them separately, and also their additive influence on the simulated figure.

In series of the econometric models the great attention is paid to the modeling of temporal (or dynamic) series. The temporal series is a set of values of some figures for several consequent moments or time intervals. Every level of the temporal series is formed under the influence of a great number of factors which can be conventionally divided into three groups:

- factors forming tendency of the series;
- factors forming cyclical changes of the series;
- random factors.

At different combinations in the studied event or process of these factors the temporal influence of the series levels can take different forms. Firstly, most of the economic figures temporal series has tendency characterizing additive long-term influence of a set of factors on dynamics of the studied figure. It is clear that these factors single can make differently directed influence on the studied figure. However, as a whole they form its growing or decreasing tendency. Secondly, the studied figure can be subjected to the cyclical changes. These changes can have seasonal nature, by virtue of the fact that economic activity of series of economy branches depends on time of year. In the presence of mass data during long-term spaces of time it is possible to identify cyclical changes connected with general dynamics of market conditions, and also with business-cycle phase wherein national economy is situated. Some time series do not involve tendencies and cyclical components, and every its level is formed as a sum of mean series level and some random component. It is clear that the actual data do not appear entirely and completely from any one model. More often they contain all three components. Its every level is formed under the influence of the tendency, seasonal fluctuations, and random component.

One of the most accepted methods for modeling of the temporal series tendency is a construction of analytical function characterizing dependence of the series levels on time, or trend. This method is known as an analytic graduation of the temporal series. By virtue of the fact that the time dependence can take different forms, various functions both linear and non-linear are used for its formal characterization. Parameters of these functions are determined by method of least squares using time in the quality of independent variable, and actual levels of the temporal series in the quality of dependent variable. A standard procedure of linearization is carried out preliminary for the non-linear trends.

4. Results.

In the present work the economic and mathematical models are considered to be used for forecasting by the temporal trend of South Kazakhstan energy consumption key figures. The key figures have been studied by methods of the temporal series investigations, and also there have been carried out their forecasting for the future period. Modeling of the specified figures and their forecasting for the future period (2013 – 2015) have been carried out by using one of the most accepted and safe methods, the temporal trend.

Values of the energy consumption key figures in the base period (2007 – 2012) [2] are given in Table 1.

Table 1. Structure of South Kazakhstan energy consumption (in millions of kilowatt-hours)

Consumers	2007	2008	2009	2010	2011	2012
1. Industrial sector	5335	5428	5532	5722	5876	5862
2. Agriculture and Building Industry	396	410	422	430	453	479
3. Transport, Communication, Service Industry	2275	2302	2309	2317	2342	2355
4. Human population	2175	2215	2236	2264	2301	2345
5. Other (needs of energetics, losses, etc.)	2795	2812	2829	2857	2883	2911
Total demand for electric energy	12976	13167	13328	13590	13855	13952

The further variables have been introduced for using of the appropriate methods:

- x1 – energy consumption of South Kazakhstan industrial sector, in millions of kilowatt-hours
- x2 – energy consumption of South Kazakhstan agriculture and building industry, in millions of kilowatt-hours
- x3 – energy consumption of South Kazakhstan transport, communication, and service industry, in millions of kilowatt-hours

- x4 – energy consumption of South Kazakhstan human population, in millions of kilowatt-hours

x5 – energy consumption of South Kazakhstan internal needs of energetics, in millions of kilowatt-hours

The further types of functions have been used for determination of the temporal series parameters: linear, logarithmic, degree, and exponential.

In the case of linear regression model it is supposed that dependent variable linearly depends on independent variable (of time):

$$x_i = a_i + b_i t \qquad (3)$$

The constants a and b are determined from the temporal series by using method of least squares, whereby values of these constants affording a minimum to the sum of squared difference between observed and calculated values are found. The values a and b are determined as solutions of the next normal system of equations:

$$\begin{cases} na + b\sum t = \sum x, \\ a\sum t + b\sum t^2 = \sum xt. \end{cases} \qquad (4)$$

In the case of non-linear regression model the initial equation (logarithmic, degree, exponential) is primarily linearized by taking the logarithm and introduction of new variables, and then it is solved in a similar way to the linear model.

Modeling of the temporal series according to several industrial trend lines, linear logarithmic, degree, and exponential, is listed in Diagram 1. According to the other consumers diagrams are composed in a similar way to the Diagram 1.

Selection of the optimal trend line has been carried out on the base of value for squared determination R^2 and collating of appropriate diagrams. Equations of the temporal trend for variables x1 – x5 shall take the next form:

$$x1 = 5219{,}6e^{0{,}0212t}, \qquad (5)$$

$$x2 = 379{,}45e^{0{,}0363t}, \qquad (6)$$

$$x3 = 15{,}086t + 2263{,}9, \qquad (7)$$

$$x4 = 2144{,}7e^{0{,}0144t}, \qquad (8)$$

$$x5 = 2766{,}7e^{0{,}0082t}. \qquad (9)$$

Numeric values of the temporal trend parameters on different consumers are given in Table 2.

Forecasting for 2013 – 2015 years has been made on the base of the optimal trend line.

Results of the forecasting are given in Table 3.

Table 2. Parameters of the temporal trend of South Kazakhstan energy consumption

Consumers	Optimal equation	Trend methods			
		Linear	Logarithmic	Degree	Exponential
1. Industrial sector	X_1=5219,6e^ ·(0,02121)	y=119,11x+5208,9 R^2=0,9545	y=327,44 ln(x)+5266,8 R^2=0,9049	y = 5272,7· · x 0,0585 R^2=0,9105	y = 5219,6· · e 0,0212x R^2=0,9551
2. Agriculture and Building Industry	X_2=379,45e^ · (0,0363t)	y =15,771x+376,47 R^2=0,9602	y=41,538 ln(x)+386,12 R^2=0,9049	y = 387,67 · · x 0,0962 R^2=0,9105	y = 379,45· · e 0,0363x R^2=0,9694
3. Transport, Communication, Service Industry	X_3=15,086t + 2263,9	y=15,086x+2263,9 R^2=0,9663	y=41,599 ln(x)+2271,1 R^2=0,9218	y = 2271,3· · x 0,018 R^2=0,9243	y = 2264,3· · e 0,0065x R^2=0,9661
4. Human population	X_4=2144,7e^ · (0,0144t)	y=32,457x+2142,4 R^2=0,9884	y=87,721 ln(x)+2159,8 R^2=0,9058	y = 2161,0 · · x 0,039 R^2=0,9124	y = 2144,7· · e 0,0144x R^2=0,9898
5. Other (needs of energetics, losses, etc.)	X_5=2766,7e^ · (0,00821)	y=23,457x+2765,7 R^2=0,9885	y=62,381 ln(x)+2779,4 R^2=0,8771	y = 2779,9· · x 0,0219 R^2=0,8804	y = 2766,7 · · e 0,0082x R^2=0,9896

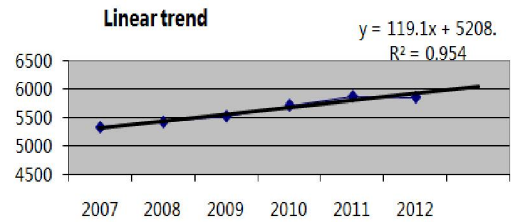
Table 3. Forecasting values of energy consumption figures for 2013 – 2015 years

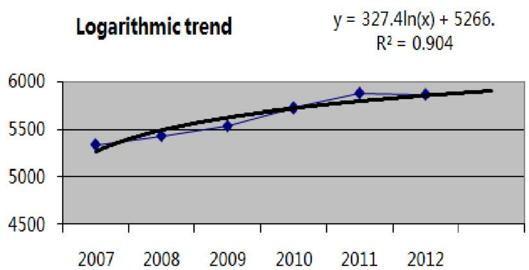
Consumers	**2013**	**2014**	**2015**
1. Industrial sector	6054,615	6184,343	6316,851
2. Agriculture and Building Industry	489,2252	507,3103	526,064
3. Transport, Communication, Service Industry	2369,502	2384,588	2399,674
4. Human population	2372,157	2406,563	2441,468
5. Other (needs of energetics, losses, etc.)	2930,155	2954,281	2978,606
Total demand for electric energy	14215,65	14437,09	14662,66

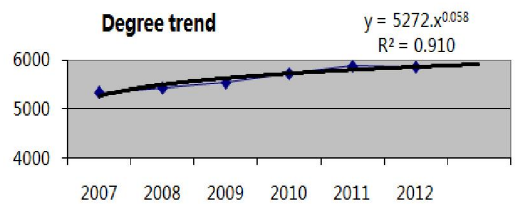
Millions of kilowatt-hours

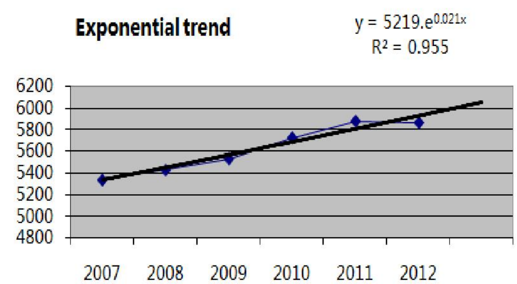
Diagram 1. Parameters of the temporal trend for energy consumption of South Kazakhstan industrial sector (x1)

Years	Number	Variable value (x1)
2007	1	5335
2008	2	5428
2009	3	5532
2010	4	5722
2011	5	5876
2012	6	5862









x1=5219,6e^(0,0212t)

5. Conclusions

By this means, based on the outcome of carried out calculations, it is possible to make the following conclusions:

- balanced and stable increase in all figures characterizing energy consumption in the forecasting period is expected;
- character of dependences on every variable $x_1,\ldots,x_5$ suggests that there will be relative growth of the energy consumption in all directions, besides transport, communication, and service industry, according to which there is expected linear stable and slight growth;
- exponential growth of the energy consumption almost by all consumers suggests that the energy consumption shall increase with higher rate in the nearest future, that makes introduction into the system of fresh capacity as significantly actual;
- similarity of the diagrams for actual and theoretical values and convergence of squared correlation coefficient to 1 (for all variables it is more than 0,96) suggests that the forecast accuracy from the point of initial data relation is quite high, and influence of random factors is negligible, that affords to make a conclusion about high quality of the selected econometric model.

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Declaration of Conflicting Interests

The author(s) stated no probable conflicts of interests with deference to the authorship and/or publication of this article.

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