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# The Method of Cliodinamik Monitoring

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***Abstract* — This article describes the process of using information technology of multi-level monitoring in the research of the similarity of historical periods. The results of inductive modeling are used to explain historical processes. The methods of clusterization and expert evaluation of the obtained results are combined. The results of experimental research of revealing similar periods of the history of Ukraine are presented.**

***Keywords— history, monitoring information systems, modeling, historical processes, cliodinamik studies.***

## I. INTRODUCTION

Monitoring is a technology for providing information about decision-making processes by providing continuous monitoring and processing of their results. The processing of the results of the observation is carried out in order to identify the properties of the objects and processes that are subject to research.

In accordance with the methodology for the establishment of multi-level monitoring information systems (MLM) [1], the processing of monitoring results is carried out through the consistent application of statistical processing methods, inductive and other methods for synthesizing models that solve local data transformation tasks at each of the levels of monitoring. Stratification of the structure of the multi-level monitoring information systems allow solving tasks of identifying functional dependencies, classifying, forecasting and some others by constructing multilayered models [2]. The hierarchical combination of these models form a global functional dependence (GFD) [3]. For the synthesis of multilayered models that form the structure of GFD, the basic algorithms of the GMDH [4], genetic and other evolutionary methods of synthesis of models, neural networks with various topologies, and hybrid algorithms, which are formed by combining several methods into a single process of designing the algorithm of model synthesis is used. Today MLM is used in many subject areas. In particular, information socioecological [5], sociogeygenic [6], medical monitoring [7] have already been created. Monitoring systems are used in public administration [8], in pedagogy [9, 10].

The variety of tools of historical science [11, 12] opens up wide opportunities for using information technology of multilevel monitoring based on inductive modeling methods.

Application of such methods allows realizing the prognostic function of historical science, which aims at predicting ways of development of historical processes, various variants of historical events. The prognostic function answers the question: what the historical reality will be and when certain events will take place. The result of this function is, above all, the hypothesis, historical forecasting, which is based on objective scientific data.

## II. ANALYSIS OF RESEARCH AND PUBLICATIONS

In practice, mathematical modeling in historical science has been used for more than 40 years. I. D. Kovalchenko, the founder of the Klimometric School in the USSR and the co-chairman of the International Commission on Quantitative History (INTERQUANT) widely applied mathematical modeling [13]. The scientist believed that this method makes it possible to analyze the historical process that could be implemented, but by virtue of some reasons has not happened. An American economist, one of the founders of the cliometriya and Nobel Laureate of the Year 1993, Robert William Fogel applied counter-factual modeling and proved that small innovations in industry contribute more to its evolution than large-scale technological discoveries [14]. The scientist conducted a fundamental study on what would be the US transport system if the railways were not invented.

At the beginning of the twenty-first century, especially during periods of social chaos, when the predictability of the course of history is significantly weakened and the possibility of unexpected variants of development increases, the relevance of multi-parametric modeling as a study of historical alternatives increases. Within this approach, the principle of synergetics as an interdisciplinary science that deals with the study of the processes of self-organization and the emergence, support of the stability and decomposition of structures (systems) of different nature is realized. Synergetics allows the historian to determine in which conditions small influences cause a complex system of large-scale changes and avalanche-like processes.

A new direction of modeling in historical research is the study of nonlinear processes. professor L. Borodkin introduces the direction - the cliodinamik that study the models of unstable historical processes [15, 16]. Under the guidance of L. Borodkin, the project was released which is devoted to the analysis of alternatives to historical development in 1929, when the so-called "big change" began in the USSR (the transition from the new economic policy to the beginning of the course on industrialization and collectivization).

Thus, for the identification and research of historical laws on the basis of the analysis of long-term social processes methods of cliodinamik are used by various scientific schools [17].



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It is proposed to use data processing tools in the information technology of multi-level monitoring of cliodinamik.

The purpose of this study is to develop a method of cliodinamik monitoring, which will provide the identification of similar historical periods by clustering the vectors of their numerical features.

## III. USING THE TEMPLATE

The method of cliodinamical monitoring combines the use of processes of clustering historical periods with their numerical features and expert justification of clustering results. It involves the following steps:

1. The list of features that are significant for making decisions based on the results of monitoring of historical processes is determined.
2. An array of numerical characteristics is formed for meaningful signs. The point of observation is numerical characteristics within one year.
3. The clustering of monitoring points by modeling results is carried out.
4. The hypothesis about the similarity of historical processes that took place over the years that formed separate clusters is proposed.
5. Examination of hypotheses is carried out by their expert justification using historical research methods. If an expert way has succeeded in substantiating the given hypotheses, the historical periods included in one cluster are considered to be similar. If this does not work - the following research is conducted and conclusions about the similarity of historical periods are not announced.

At the initial stage, it is necessary to solve the problem of clustering historical periods, which are presented in the form of vectors of their numerical features. Moreover, each historical period is represented by one vector of numerical characteristics of these attributes. The list and limits of historical periods, as well as the list of characteristics, are determined by expert means. The results are presented as an array of data (1):

$$\begin{pmatrix} x_{11} & x_{12} & \dots & x_{1n} & y_{11} & y_{12} & \dots & y_{1m} \\ x_{21} & x_{22} & \dots & x_{2n} & y_{21} & y_{22} & \dots & y_{2m} \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ x_{k1} & x_{l2} & \dots & x_{kn} & y_{k1} & y_{k2} & \dots & y_{km} \end{pmatrix} \quad (1)$$

where xij is the j-th independent index of the i-th historical period, yij is the j-th dependent index of the i-th historical period, k is the number of vectors; n - the number of indicators, m - the number of historical periods.

It is necessary to create a method of clustering historical periods, which allows you to obtain an array of input data in the form of a matrix (2):

$$\begin{pmatrix} x_{11} & x_{12} & \dots & x_{1n} & y_1 \\ \dots & \dots & \dots & \dots & y_2 \\ x_{k1} & x_{k2} & \dots & x_{kn} & y_k \end{pmatrix}, \quad (2)$$

which contains the sequence of vectors of the indices (Xi, yj), Xi × Xχ, i = 1, k, where Xi = {xi1, xi2, ..., xin} is the array of independent indicators of the i-th historical period

It is necessary to develop a method of clustering historical periods in the form of a function

$$a : (X_i, y_i) \to r, \quad (3)$$

where r is the cluster number that forms the set of clusters R.

The process of clusterization for each vector of the signs of the historical period sets the cluster number r є R. In this case, the power of the set R is not known in advance.

Table I lists the features of the historical period that make up the vector.

TABLE I. LIST OF FEATURES.

| Feature | Variable | Feature | Variable | Feature | Variable |
|---|---|---|---|---|---|
| Time of observation | $x_1$ | Unemployed population (according to ILO methodology) at working age, ths | $x_8$ | Budget (consolidated), UAH billions. Income | $x_{15}$ |
| Income population, billion UAH. | $x_2$ | Economically inactive population of working age, ths | $x_9$ | Budget (consolidated), UAH billions. Expenditures | $x_{16}$ |
| Average monthly salary, UAH | $x_3$ | The level of economic activity, the percentage of the total population of the corresponding age group of working age | $x_{10}$ | Financial result of ordinary activity before taxation, UAH billions. | $x_{17}$ |
| The average monthly retirement pension, UAH | $x_4$ | Number of births, ths. | $x_{11}$ | Investments in fixed assets *, UAH billions. | $x_{18}$ |
| The average size of assistance to low-income groups of population per capita, monetary, UAH | $x_5$ | Number of deceased, ths | $x_{12}$ | Exports of goods and services, billion dollars. USA | $x_{19}$ |
| The average size of assistance to low-income groups of population per capita, natural | $x_6$ | Natural population growth, ths. | $x_{13}$ | Imports of goods and services, billion dollars USA | $x_{20}$ |
| Economically active population of able-bodied age, ths | $x_7$ | Fixed assets *, billion UAH | $x_{14}$ | Direct foreign investment in Ukraine (at the end of the year), mln. USA | $x_{21}$ |



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To solve the clustering problem, the method proposed in [16] was used.

Socio-economic and demographic development of Ukraine was investigated during 1998-2012 based on the technology of multi-level monitoring.

The dependence of the gross domestic product of the country from the indicators presented in Table I was modeled. For synthesis of models, multi-row algorithm of GMDH [4] was used. A set of models was synthesized. After the tests, models were selected that met the criteria of accuracy, adequacy and stability, and the influence of the indicators from Table I that were included in the structure of these models was estimated. The impact of indicators was determined by the weighting factors calculated by the formula:

$$W_i = \frac{F'_{x_i}}{\sum_{i=1}^{n} F'_{x_i}}, \quad (4)$$

where $F'_{x_i}$ is a partial derivative of the model on its i-th variable, n - number of indicators Table I that entered into the structure of the model.

The results of the study of these models are presented in Table II.

TABLE II. RESULTS OF CLUSTERIZATION

| Indicator | Cluster 1 (2001-2012) | | Cluster 2 (1999-2009) | | Cluster 3 (1998-2002) | |
|---|---|---|---|---|---|---|
| | *Weight coefficient., %* | *With indicator growth, GDP:* | *Weighty coef. %* | *With an increase in the indicator, GDP:* | *Weighty coef. %* | *With an increase in the indicator, GDP:* |
| $x_1$ | 99,88 | Decreasing | 0,00 | unchanged | 0,00 | unchanged |
| $x_2$ | 0,00 | unchanged | 20,60 | decreasing | 90,66 | increasing |
| $x_3$ | 0,06 | increasing | 19,50 | increasing | 0,00 | unchanged |
| $x_4$ | 0,00 | unchanged | 1,72 | increasing | 0,00 | unchanged |
| $x_6$ | 0,00 | unchanged | 22,86 | decreasing | 0,00 | unchanged |
| $x_9$ | 0,002 | increasing | 0,00 | unchanged | 0,00 | unchanged |
| $x_{14}$ | 0,00 | unchanged | 8,96 | decreasing | 0,00 | unchanged |
| $x_{15}$ | 0,00 | unchanged | 1,09 | decreasing | 0,00 | unchanged |
| $x_{16}$ | 0,00 | unchanged | 3,05 | increasing | 0,00 | unchanged |
| $x_{18}$ | $1 \cdot 10^{-6}$ | decreasing | 20,75 | increasing | 0,00 | unchanged |
| $x_{20}$ | 0,06 | decreasing | 0,00 | unchanged | 0,00 | unchanged |
| $x_{21}$ | 0,00 | unchanged | 1,46 | increasing | 9,34 | decreasing |

Expert estimation of historical periods is as follows:

**1 cluster of 2001-2012 :** decrease of investments into fixed capital; strengthening the processes of industrialization; crisis in mechanical engineering, chemical industry; growth in agriculture, trade, transport; according to sources of financing, bank loans and other loans play an essential role; negative balance of trade balance; lack of investment; the super-profits of the export industries fell into the pockets of the oligarchic circles in full; increase in the amount of social assistance; uncontrolled migration of the population; growth of demographic load.

**2 clusters of 1999-2009 :** the economic downturn, resulting in GDP declining to 40.8%; violation of macroeconomic equilibrium, correlation between wage level and gross income / mixed income in the structure of GDP, did not have the character of a stable trend; industry was the leading sector of the real economy, while retaining the largest share in its structure (in 2008, it accounted for 46.1% of the gross output of goods and services and 31.3% of gross value added); more than 2/3 of the total industrial output accounted for in the industry producing raw materials and energy resources; the share of products of social orientation is 1/5 of the total volume of industrial production. The light industry almost disappeared (1999: 1.6%, in 2008 - 0.9, in August 2009 - 0.8%); the machine-building industry even added in the rate of development during 1999-2007, but its share in the structure of industry through the crisis has fallen to 10.3%, which was 3-4 times lower than the level of developed countries.

**3 clusters of 1998-2002 :** growth of real incomes of citizens was 5-6 times higher than GDP; there was a rise in wages; the real GDP growth was 4.1-9%; recorded increase in production in industry; the growth rate of export of goods exceeded the growth rate of imports; increased competitiveness of Ukrainian goods; currency offer exceeded demand**.** Thus, we proved the closeness of the points included in each cluster. This means that during these years historical events in Ukraine were caused by close processes and research objects.

## IV. CONCLUSIONS

A new method of cliodinamic research has been developed, which combines clustering and expert evaluation processes. Experimentally confirmed its effectiveness. The use of powerful means of synthesis of models in the cliometry allows us to draw conclusions based on the results of scientific research with formalized metrics. It helps to identify historical patterns and use them to justify future decisions, using the experience of past years with similar events.

In the difficult conditions of the economic crisis and social transformations, the value of qualitative historical knowledge is constantly increasing, as it allows us to explain the patterns of socio-economic events, identify trends, models of the future. It is necessary to develop a mechanism for the rational organization of social processes, taking into account the resources of political power, especially its components and forms, such as authority, control, influence, coercion, etc.

The simulation results obtained using the new method of cliodinamic monitoring should be used to identify the same types of periods of Ukrainian history (according to the mechanisms of influence on the economy that creates GDP).

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