УДК 330.4:338.124.4

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PROGNOSTICS OF ECONOMIC PROCESSES UNDER THE CONDITIONS OF FINANCIAL CRISIS

In this paper the forecasting problem for economic indicators is considered. It is shown that processes in economics can be divided into such groups: having stable dynamics; corresponding to crises of various type; the combined processes. In the first case retrospective base is known and on its basis technologies of data in formativeness increase are offered. For crisis processes the necessity of elements application from the accidents theory is defined. For processes having long stable dynamics and containing the short-term crisis phenomena, the use composition advantages of discrete-continuous forecasting methods are shown.

***Keywords**: economics, economics processes, indicators, forecasting, preprocessing, technology, discrete-continuous models and methods.*

Problem definition. The dynamics of modern social and economic processes indicates a need of new technologies introduction into the research, analysis and processes, and also prognosis of behavior and functioning of both, social institutions and manufacturing ventures. Traditionally tabulation procedures and data conversion approaches were used for solving such problems and they are conventially subdivided into the following classes:

1.Heurism, its rational application is possible only in cases of information insufficiency and inability of boundaries definition and formal approaches, to estimate the error (example – brainstorming technique).

2.Conventional methods (example – method of relative and comparative numbers).

3.Determining factor approach (example – method of relative margins)

4.Method of stochastic component analysis (example – correlation-regression analysis).

5.Methods of optimized factors (example – economic and mathematical method).

Such classification analysis indicates descriptive orientation of the stated above methods upon presentation of economic units and processes. At the same time it becomes evident that the research methods shouldn't report to "passive", descriptive character of results. Economy development supposes elaboration and usage of approaches, the application of which will help get answers about future (meaning of economic criteria, nature of economic processes), will point out the ways of choosing optimal strategies, as well as an alleged opportunity of analysis and choice of optimal values of economic criteria on the basis of models building on the principle of "If …., then ….".

Why application of economic-mathematic modeling is the reason of economic analysis improvement and ventures activity analysis improvement, and of their organizational units? The reduction of terms of the analysis performance, the realization of a complex consideration possibility of factors impact on the results of economic activity, obtainment of specified results, task solutions with the problem attributes of curse of dimensionality and others speak in favor of such a conclusion.

Many authors, such as Zgurovsky M.Z., Moiseev N.N., Pankratova N.D. emphasize the necessity of mathematic methods application in the economic analysis on the basis of systemic approach and systemic analysis. This kind of paradigm in their interpretation suggests complex research of ventures to detect connections both with the external environment and intrasystem communication. We'll comment that this method type simplifies both the systemic method elements and systemic analysis as of scientific-applied methodologies. In particular, at the mentioned above consideration such constituents of systemic approach as systematization, formalization and system orientation, being the fundamental conceptual units of complicated problems solving process are missing.

It goes without saying, that the development of mathematical model complexes, describing venture activity is the task of primary importance. However, it must include interaction models with the external environment, reproducing the interinfluence of venture process functioning and the social sphere, medicine, education, etc. Another important condition is the body of colleagues consisting of industrial economists, professionals in economic and mathematical modeling, mathematicians, operator-programmers.

Let's examine the aspects accompanying modern processes of economic and mathematical modeling. It's obvious that almost all practical tasks, solved by means of relevant methods application, must lead to the prognostics of future characteristics and on their basis to the forecasting and development of possible scenarios, for example, ventures behavior at the market.

Note, that presently at the conferences scientists and chartists are reproached for their inability to predict the crisis of 2008. And in fact these rebukes are right. We approve, that the crisis was not actus Dei. It could have been and had to be predicted, especially by professionals in macro economy. The production curtailing took place because of banking-system collapse. The last one, in its turn, could be assumed, predicting the dynamics of major financial indicators. The very exceedance of criticalities of such indicators caused the bankruptcy of banks and their liquidity decrease. One of the reasons, because of which the crisis had not been predicted, was the application of the method appropriate for the stationary economy without shocks and functioning according to the certain laws for homogeneous steady environments.

Object of the article. Thus the object of the article is the technology construction for the preparation of the retrospective information of the economic processes prediction, which improves the prediction quality, especially under the conditions of crisis. Thus the following problems must be solved:

-it's necessary to develop prediction technologies under quickly changing, often critical conditions;

-as the prediction is carried out on the basis of identified dependences of combined characteristics from entering factors it is necessary to put to use hybrid functions, as a dependence, allowing predicting for the economic system functioning under changing conditions;

-it's important to realize that the vital condition for the obtaining of the component hybrid functions is the economic processes clustering, because the task of identification can be solved adequately only for homogeneous processes;

-it's necessary to develop methods for definition of critical points, i. e. meanings of economic process parameter vectors, the exceedance of which proves the crisis and the points after which crisis prevention is impossible;

-solving the prediction problem and possible scenarios development; it's rational to aim for the decline of the inclusion criteria and for the increase of their information value.

Statement of Basic materials.

We are going to deal with the stated above conclusions in details and to show how their realization can make the background of new technologies for the analysis and prediction of economic processes and indicators.

Recession and ascendancy as an integral part of economic processes and aspects of their prediction

Let's deal with several arguments. According to the first one a stationary economy evolves on the linear law and can be easily anticipated. The second argument means that economic processes in developing countries can in a short period progress exponentially and then decline rapidly. The first and the second types of economy are interdependent in the global world. In the majority of cases the production growth can be explained by the logistic function dependence and the period of decline is inevitable for the qualitative changes for the better to occur. The final mentioned statement corresponds to the concept of catastrophism [1]. The dynamics of a venture efficiency criterion in a stationary economy is presented in fig. 1. The efficiency criterion diagram in the case of crisis phenomena is given above. Venture operating benefits were rising before a certain moment, then due to some reasons they began to decline. Having achieved a certain point, called critical, further effective activity of the venture is impossible without its restructuring (e.g. the reorientation to new products). It should be noted, it could be possible to keep on the same production, having accomplished certain arrangements but without its structure reorganization. Having passed the point of no return it's possible to do it in no way. In the processes of restructuring, venture effective activity inevitably moves downwards to some border, after that it starts to ascend. Such processes are of cyclic nature. Therefore this fact must be taken into account. Apparently, the environment influences the cyclicality and primarily, the equation of demand and supply law.

Hybrid functions as economic processes models.

Let's consider venture activity Ω in some time length $[t_0, t_n]$. Let us call $X = \{X_1, X_2, ..., X_m\}$ is the multitude of entering factors for Ω, in particular, material, power and information resources, Y is the criterion of functioning effectiveness. Y is a certain combined characteristic: income, profit, cost value, etc.

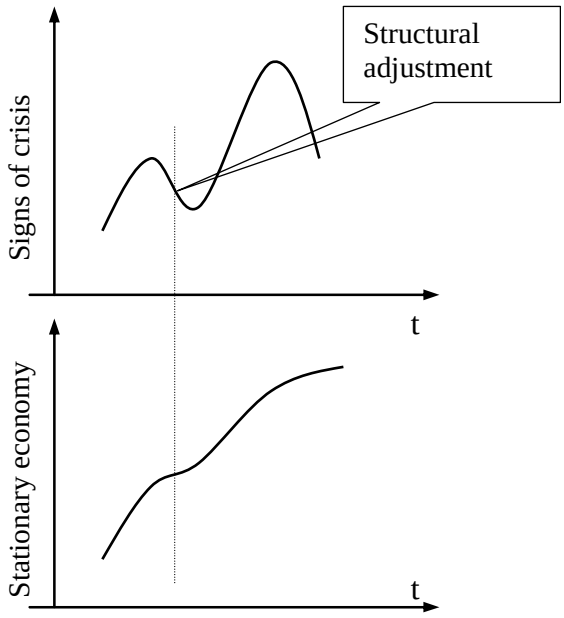

Fig.1. Dynamics of processes

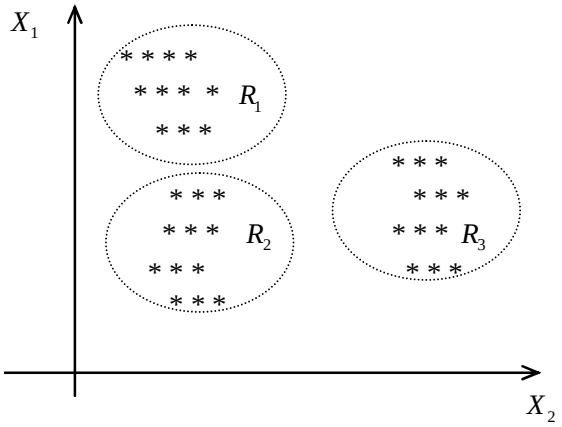

Fig. 2. Clusterization problem solving

An integral factor can serve as a combined characteristic and it presents, in most instances, additive or multiplicative function.

Let's define hybrid reaction as

$$G(X,t) = h(X,t) \cdot F(X,t), \quad (1)$$

where $h(X,t) = H(X_1, X_2, ..., X_m, t)$ is a logical function, assuming one of two values out of multitude $\{0,1\}$, $F(X,t)=F(X_1,X_2,...,X_m,t)$ is a vector function. Thus, in details

$$G(X,t)=\begin{cases} f_1(X,t), \text{ if } \bigcap_{i=1}^{m}\left(X_i \in \Theta_i^1\right) \text{ and } t \in T^2, \\ f_2(X,t), \text{ if } \bigcap_{i=1}^{m}\left(X_i \in \Theta_i^2\right) \text{ and } t \in T^2, \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots, \\ f_k(X,t), \text{ if } \bigcap_{i=1}^{m}\left(X_i \in \Theta_i^k\right) \text{ and } t \in T^2, \end{cases}$$

where Θ_i^j - variation range of factor X_i changes at j-м variant of economic situations an interval $T^j \subset [t_0, t_n], i=\overline{1,m},\ j=\overline{1,k}.$

Thus, in relation to the value of the outcoming factors, defining the type or state of the economic process, function *G* is a model for prediction and getting answers to the questions, «If $X_1 \in \Theta_1$, $X_2 \in \Theta_2$, and…and $X_n \in \Theta_n$, what field does Y belong to?», that enables scenario analysis and determination of optimal properties of entering factors. We point out the hybrid function as a model of a combined characteristic allows responding to the changing economic situation, but its identification is based on the information about precedent situations.

Clustering is a base element for identification problem solving.

It has already been stated that the obtaining of the combined characteristic from entering factors can be adequate only for the homogeneous processes. There is an idea of mean-root square error minimization in the majority of dependences identification methods. It results in the "rough" consideration of a given data structure causing the averaging-out and, as a consequence, inaccurate definition of the initial dependence and inaccurate prediction.

Fig.2 shows the structure of the data in the space of two factors X_1 and X_2. It's necessary to find the dependence $Y = G(X_1, X_2)$. Having solved clusterization problem beforehand, we'll obtain the stated data structure with three fields. The capacity of the multitude of the given data being enough, the required dependence after clusterization is obtained in the following form:

$$Y = G(X_1, X_2) = \begin{cases} f_1(X_1, X_2), (X_1, X_2) \in R_1, \\ f_2(X_1, X_2), (X_1, X_2) \in R_2, \\ f_3(X_1, X_2), (X_1, X_2) \in R_3. \end{cases}$$

The generation of the model type $Y = G(X_1, X_2)$ makes the prediction more precise according to the values of the entering factors.

Front-end processing as a condition of effective prediction.

Quite often the chartist has not the important information but the one he/she can get at the moment. It's a well known truth that if factors in many cases are interdependent, their meanings contain various mistakes. Thus these reasons prevent from model correct specification and its further application. Here are the basic reasons of the given data preprocessing:

-different measuring scales of factors [6];

-existing linear and non-linear dependence among factors;

-the low entropy of entering factors (insignificant informational content);

-a great number of insignificant factors.

The obtained through the preprocessing data allows a more effective identification of the required dependences. It's for a scientist to choose one of the

variants of a problem solving: either to fulfill the clusterization before the data reprocessing procedures or after but before identification problem solving.

Therefore, the first step is the given data standartization. The transformation of the following type is used most commonly

$$x' = \frac{x - x_{\min}}{x_{\max} - x_{\min}}, \qquad (2)$$

with the help of which the given data becomes non-dimensional and is situated on interval $[0,1]$.

Next step is multicollinearity testing according to Farrar-Glober criterion [7]. It enables linear dependent factors revelation. Then the greater part of them is deleted.

The third step is the significant factors determination. The theoretical methods of argumentation of their choice being unknown presently, different heuristic procedures are applied instead. One of them is the technology of box-counting [10]. The concept of cross-entropy lies in its basis, which for two variables U and V is quantitively equal to the logarithm of typical dispersion of values of the variable *U* ratio to the dispersion of this variable, but at the stated value of variable *V*:

$$H(U,V) = \log \frac{N_U \cdot N_V}{N_{UV}}, \quad (3)$$

where N_U is the amount of vertical lines, containing values of factor U; N_V is the amount of horizontal lines with the values of factor *V;* N_{UV} is the number of nonempty cell entries (fig. 3). For example given in fig. 3, $N_U = 9$, $N_V = 6$, $N_{UV} = 17$. Taking the logarithm base equal two, we'll obtain that the cross-entropy is $H(U,V) = 1,67.$

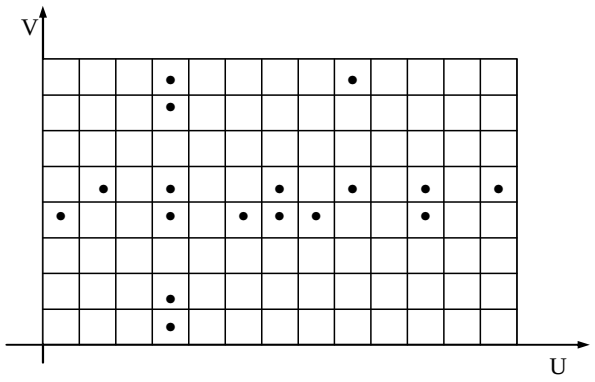

Fig. 3. Data for cross-entropy calculation

In the general case, calculating cross-entropies $H(X_i, Y),\ i = \overline{1,m}$ and comparing them, we leave the factors where the cross-entropy has a greater value.

Therefore, due to the box-counting technology it's possible to determine the factors, the values of which have more certainty in the prediction of the values of the combined characteristic. No supplementary assumptions are used for the box-counting method.

Before using identification methods it's necessary to make another step due to which the accuracy of the obtained dependency and further prediction with its help can be significantly increased. With this purpose we level the given data by means of "entries whitening". In the consequence of its realization the given factors become decorrelatable with the zero mathematical expectation and ordinary mean-square deviation. The following development lies in the basis of the "entries whitening" method

$$X_k^{'} = (X_k - \bar{X}_k) \cdot U_k / \sqrt{\lambda_k}, k = \overline{1, m}, \quad (4)$$

where U_k is the matrix latent vector of the entering factors; λ_k is an eigenvalue; m is the amount of factors.

Offered above steps make up the technology, the realization of which will help improve the prediction quality and obtain more precise results. It should be noted that this approach is not the only one. The technology based on the neural network is closely adjacent to the stated above technology [9]. However the majority of neural network methods include the already stated approaches and models. We shall deal with the example of the offered technology realization further.

Identification of the tabular given dependence.

Let's solve the problem where one has to identify the dependence $Y = G(X_1, X_2, ..., X_{13}),$

where Y is a combined characteristic - nominal gross domestic product (GDP), factors $X_1, X_2, ..., X_{13}$ are stated in table 1.

By this example we shall follow the steps of the proposed technology, point out the particularities of their realization and carry out a comparative analysis of the results obtained.

On the basis of Farrar-Glober algorithm we shall accomplish the multicollinearity testing. On the first stage we establish rate fixing and given data standardization. We find the correlation matrix for them and calculate the value $\chi^2 = 565,$ which is significantly higher than that in the table at $\frac{1}{2} m(m-1) = 68$ the degree of freedom and confidence level 0.05 proving the multicollinearity in the massif of the entering factors. Then we find the matrix contrary to the correlation one and the values of *F*-criterion. We draw the conclusion that all factors are multicollinear with other factors. Performing further calculations of *t*-criterion and comparing the obtained results, we come to the conclusion about the necessity of receding factors 1, 3, 5, 6, 7, corresponding to the value of industrial sales, size of industrial engineering, passenger turnover, imports and exports. On the basis of *t*-criterion values some more factors could be deleted, but we leave them to provide the representation in the required dependence of the different-type data.

To check in what way multicollinearity elimination influences the precision of the identification problem solving two models have been developed: the first linear dependence for all thirteen factors and the second is for eight factors, the ones left after the elimination. To obtain the linear multiregression we included data for the previous eight years and the quality of the obtained dependence was determined on the basis of the predicted value for 2009. Thus, in the first case the relative error constituted 89.9%, in the second case it lowered to 26% proving a significant

influence of the linear dependence in the factors massif to the accuracy of the identification problem solving and its further effective use. However, it should be noted, that the prediction accuracy remains low.

Next step is the cross-entropy calculation for each of eight factors. With this purpose we standardize them and present the corresponding points in a unit square. The square itself is divided be the vertical and horizontal lines with the discreteness of 0.2. The discreteness value is determined through the quantity of the statistics data and the desired precision of the result. The obtained values of the cross-entropy:

$$H(X_1,Y)\approx 2,\ H(X_2,Y)\approx 1,\ H(X_3,Y)\approx \log 3,\ H(X_4,Y)\approx \log 3,5,\ H(X_5,Y)\approx \log 3,\ H(X_6,Y)\approx 2,$$
$$H(X_7,Y)\approx 2,\ H(X_8,Y)\approx 2.$$

Therefore, we draw the conclusion about the greatest informational content of the factors with the greatest entropy (the information content appears to be factor property, allowing value reconstruction of the combined characteristic on the basis of its values), namely: the first factor is the volume of agricultural products sales, the second is the average nominal wages, the third is wage arrears, the fourth is unemployment rate. Developing the model on the basis of these four factors and verifying it, we obtain the result that the relative error of the prediction of the GDP value in 2009 constituted 6,5% that is four times more precise that in the previous case. However this kind of accuracy still remains low. The obtained model is presented as follows:

$$Y = 28501 + 1,2Z_1 + 425Z_2 + 5Z_3 - 50Z_4,$$

where Z_1, Z_2, Z_3, Z_4 are factors with the greatest cross-entropy, coefficient values are approximated.

The precision can be increased by means of “entry whitening” method. Necessity and actuality of its application is caused by the unsteady allocation of the entering factor values. Having standardized data and having done diagrammatic formulation we draw the conclusion about their greater density closer to the borders of the unit hypercube. This kind of allocation will allow getting the required dependence but the prediction precision, especially for the values in the middle of the hypercube with its application, will remain low.

“Entry whitening” starts with the search for the eigenvalues and eigen vectors. Eigenvalues help draw the conclusion about dispersion meaning of different factors and its contribution into the combined characteristic prediction. In our case $\lambda_{\max} = \lambda_1 = 4,43$, that points at the greater information content of Z_1 factor. Eigenvalues, corresponding to other factors, appeared to be much smaller. After “whitewashed entries” calculation we build dependence, where they serve as arguments. The particularity of this method is the necessity to re-compute the obtained predicted results from the “whitewashed” form into an ordinary one. The computation process ends on the results destandartization. The relative error in this case constituted 1.2%. It proves to be a good result, if to take into consideration nonstationarity of economic processes in the given time period.

The discussed retrospective includes the years of 2001 – 2009. The previous two years are the crisis years and the identification of the GDP dependence from many factors during the discussed period does not correspond to the real economic processes adequately. At the same time the amount of the information given for the

Table 1. Retrospective data about Ukrainian economy

year	volume of industrial sales mln.hrn	volume of agricultural sales, mln.hrn	size of industrial engineering, mln.hrn.	haulage, mlrd.km	passenger turnover mlrd.pass. km	exports, mln. dollars.	imports, mln. dollars.	volume of retail, mln. hrn.	personal income, mln. hrn.	personal expenses, mln. hrn.	average nominal wages, hrn.	wage arrears mln. hrn.	unemployment rate, thousand persons	nominal GDP., mln. hrn
A	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2001	155891,1	65100	12323,2	384,5	85,5	14948,4	14286,9	56103,3	160342	15342	304,9	2996,7	1008,1	204190
2002	171206,7	64380	16873,3	398,1	89,1	16143,4	15103.6	65592,5	171731	175765	370,33	2389	1034,2	225810
2003	220605,1	64473	21560,3	450,7	95,8	20679,4	20344,3	82805,8	188145	178861	454,56	2123,6	988.9	267344
2004	294239,4	83500	31499,2	469,4	104,7	29482,7	26070,3	114086,4	233825	222412	589,63	817,6	981,8	345113
2005	348840,9	92536	40024,9	460,6	111,4	31140,6	32480,8	157502,1	322995	296794	806,18	959,7	881,5	441452
2006	413082,9	94300	38030,8	477,2	116,3	34676,7	39899,6	226918,4	420240	378423	1041,44	806,4	759,5	544153
2007	537377,6	109850	53524,6	496,4	144,4	44448,9	54041,1	318725,3	551817	505457	1351	668,7	642,3	720731
2008	718941	150845	64362,6	491,7	147,3	63046,2	80757,1	449307,5	760353	701753	1806	1123,5	844,9	948056
2009	591965,4	153800	37886,8	380	130	35602,9	40417,9	442793,2	235345	204203	1906	1473,3	531,6	912563

particularities accounting in pre-crisis and crisis periods appears to be insufficient for the hybrid function creation. Thus the obtained results are rational only for the preliminary analysis and prediction. If there is a need for more precise conclusions, it's advisable to deal with the statistic data during one month.

Conclusions. Analysis and prediction methods, used in modern economy, are focused on its stable dynamics [2, 4]. Gradient methods underlie their basis. They allow finding optimal values of the economic parameters on the assumption of persistence and smoothness of functions determining income, profit, prime cost capital and energy intensiveness, etc. In the developing countries, Ukraine being one of them, the use of such methods is complicated, and often impossible because of the nonstationarity and instability of economic processes.

The proposed technology does not restrict the scientist by the requirements used in traditional methods, based on the integro-differential calculation and is an invariant one to the identification method choice. Such methods can include the method of group consideration of arguments (polynomial identification) [5], Brandon method (production of nonlinear functions) [10], neural networks [9, 3, 8]. Each of these methods has its own particular characteristics defining its application, but the proposed technology of pre-processing of the given data is general and doesn't depend on any method. Its application helps obtain more precise results both at the required dependences creation and at prediction with their usage and, as a consequence, determine strategies of effective economic development, work up possible scenarios of behavior of business units.

List of sources used

1. Arnold V.I. Catastrophe Theory. – Moscow: Phismatlit, 1990. – 128 p.
2. Bidyuk P.I., Zvorygina T.F. Structural Analysis of the Design Methods of Creation Methods Regression Models on Observation Temporal Series // USiM. – 2003. – № 2. – P.93-99.
3. Barsky A.B. Neural Networks: identification, management, decision making. − M.: Finance and Statistics, 2003. − 176 p.
4. Vitkovsky T. Multistep Processes of Decision Making at Plant Management // Problems of Management and Informatics. – 1998. – № 3. – P. 124-138.
5. Ivakhnenko A.G., Yurachkovsky Y.P. Modeling of Complex Systems according to Experimental Data. – M.: Radio and Signal, 1987. – 120 p.
6. Lbov G.S. Methods of Diverse Experimental Data Processing. − Novosibirsk: Nauka, 1981. − 160 p.
7. Lukyanenko I.G., Krasnikova L.I. – Econometrics. – Kiev: Znanie, 1998. – 494 p.
8. Osovsky S. Neural networks for Data Processing. − M.: Finance and Statistics, 2002. – 344 p.
9. Snityuk O.I. Synthetic Models and Methods of Optimization of Farm Structure Production. – Thesis of Candidate of economic sciences: 08.03.02. – Kiev, 2004. – 205 p.
10. Chavkin A.M. Methods and Models of Rational Management in Market Economy. – M.: Finance and Statistics, 2001. – 320 p.

***Подано до редакції** 7 лютого 2011 року*

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Прогнозування економічних процесів в умовах фінансової кризи

У статті розглянута проблема прогнозування економічних показників. Показано, що процеси в економіці можна розділити на такі групи: ті, що мають стабільну динаміку; ті, що відповідають кризам різного типу; комбіновані процеси. У першому випадку ретроспективний базис відомий, і на його основі запропоновані технології підвищення інформативності даних. Визначено, що для опису кризових процесів необхідно застосування елементів теорії катастроф. Для процесів, що мають стійку динаміку і містять короткострокові кризові явища, показано переваги використання дискретно-неперервних методів прогнозування. В статті відмічено, що економічні процеси в Україні є нестаціонарними і нестабільними. Запропонована технологія не обмежує дослідника вимогами, що властиві інтегро-диференційним методам. Її застосування дозволяє визначати стратегії ефективного економічного розвитку й розробляти можливі сценарії поведінки економічних суб'єктів.

***Ключові слова**: економічні процеси, прогнозування, ідентифікація, препроцесинг, технологія, дискретно-неперервні моделі й методи.*

Снитюк О.И., Бережная Л.В.

Прогнозирование экономических процессов в условиях кризиса

В статье рассмотрена проблема прогнозирования экономических показателей. Показано, что процессы в экономике могут быть разделены на такие группы: имеющие устойчивую динамику; соответствующие кризисам различного типа; комбинированные процессы. В первом случае ретроспективный базис известен, и на его основе предложены технологии увеличения информативности данных. Определено, что для описания кризисных процессов необходимо применение элементов теории катастроф. Для процессов, имеющих устойчивую динамику и содержащих краткосрочные кризисные явления, показано преимущества использования дискретно-непрерывных методов прогнозирования. В статье отмечено, что экономические процессы в Украине являются нестационарными и нестабильными. Предложенная технология не ограничивает исследователя требованиями, которые свойственны интегро-дифференциальным методам. Ее применение позволяет определять стратегии эффективного экономического развития и разрабатывать возможные сценарии поведения экономических субъектов.

***Ключевые слова:** экономические процессы, прогнозирование, идентификация, препроцессинг, технология, дискретно – непрерывные модели и методы.*

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