Intellectual system of the complex analysis of economic dynamics on time series

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ABSTRACT

Because the explained issues posses great importance for Azerbaijan experiencing its transition period, creation and implementation of the System of Economic Analysis (SEA) accepted as a non-linear dynamic system, fractal analysis of factors which can influence on the purpose of investment in the region and are stipulated with importance of solving of following problems:

- concrete and systematic analysis of the information;
- capacity of complex and visual usage of the data necessary for decision making;
- operative control over dynamics of progress of processes;
- operative analysis in the cases of emergency;
- quick investigation-information system.

Scientific-technical progress makes a basis for economic development in the XXI century, known as the century of information technologies. So, by analyzing the complicated dynamic processes using modern information technologies, there appear opportunities of foreseeing the probability of emergence of any nonstandard situation and taking certain preliminary measures [2].

Since the statistic indices served only to planning in the period of centralized economy, in the conditions of market economy, operative and effective analysis of these indicators accepted as an effect of facts that are evident and not evident, play very important role in strengthening the state that has already started intensive development, in making optimal decisions for getting new achievements and in directing the economic policy. Because, under the conditions of market economy statistic indicators are used as an aggregate of the primary data for satisfying the demands of users for information through changing into crucial information infrastructure of the society as a fundamental source of information about the past, for analyzing implemented works, obtained results and forthcoming processes and for prediction [1].

Investigations show that, the effective analysis of processes, which might happen under the influence of following factors, can be achieved by implementing Nero network, fuzzy logic, the synergetic analysis methods, which have successfully been experienced in learning and analyzing the formation of market infrastructure of developed countries through systematic approach in the condition of market economy [11, 9].

It is undeniable fact that, the main factors influencing the economic development in the countries with transition economy are as following: objective terms and subjective decisions, reforms, social-political factors, geographical situation of the region, ecological factors, international relations, etc. During the analysis of economic processes, oversight or incorrect assessment of influence of any of these factors will certainly show itself as an ultimate result.

On the other side, it is very necessary to research the existing condition of our economy on the framework of global changes taking place in the world economy. So, barriers between the countries are being removed, global economic area is being formed against the background of scientific-technical progress. The changes in this economic area is so intensive, their quality features are so unexpected that there arises a need for new analytic and calculation methods for the purpose of analyzing and forecasting the processes occurring here.

For that reason, the systematic analysis of transition economy should be made in the following main directions by using mathematical methods of nonlinear dynamics, modern information technologies, and technical means on the base of macroeconomic indicators:

- analyzing the influence of the objective terms and subjective decisions on dynamics of economic development;
- analyzing the influence of the reforms on dynamics of development;
- analyzing the influence of the socio-political factors on dynamics of development;
- analyzing the influence of the geographical location on dynamics of development;
- analyzing the influence of the ecological factors on dynamics of development;
- analyzing the influence of the international relations on dynamics of development.

These processes mainly characterize counter related nonlinear complicated systems and output information is reused as input information here. We cannot automatically include market economy into these systems, but market reflects many effects specific for counter related nonlinear systems. The main elements of these kinds of systems are such concepts as crisis, disaster, bifurcation, cyclic period, running wave, and so on [12]. Because the processes are inconvertible in nonlinear dynamic systems, time factor plays special role there. But the inconvertibleness is the result of complicated and collective actions of internal elements of the object. Because of that, it is very necessary to use experienced synergetic analysis methods widely in systematic analysis of countries with transition economies in which the probability of occurrence of these cases is very high.

Synergetic economy develops on the base of traditional economy. By contradicting some ideas of the traditional economy it explains them as a special case. At the same time, synergetic economy states hopeful directions for explanation and forecast of complicated economic processes [11, 12].

Classical methods are not used anymore and fractal analysis, more productive mathematical method, is widely applied in the western countries at present. Numerous statistic data covering several decades of capitalist markets is investigated by this method. Gained results are very hopeful and it is proved that grounded forecast is not just possible, but also very decisive factor for conducting the economic processes, which is the nucleus of economic upsurge in the countries with transition economies [4].

As transition period is a component of market economy, the following factors considered as characteristic features of dynamic systems, should be taken into account in the systematic analysis of transition economy:

- long-term correlation and counter-relation effect;
- crises in exact time and within exact terms;
- repetition of the process in a short period (fractal structure);
- increase or decrease of the reliance of given forecast (sensitivity to initial conditions);

These stated cases happen only when the system is far from equilibrium. But that belongs to only market economy and doesn't comply with effective market notion.

Along with the natural disasters, the scope of artificial disasters has been widening in the recent years. Now a little mistake can lead to the destruction of the whole world infrastructure. Preventing such kind of disasters is not required from the science yet. But forecasting the further development of the processes remains one of the crucial matters in agenda.

Any change occurring in the environment affects us. Our feelings about the future are formed on the base of experience gained in a long period of time. This is the above stated counter-relation form and shows itself more actively in the market relations. Because, the market economy considered as a real system, posses a very wide memory diapason and the elements of this memory strongly influences the existing situation of market. All these factors make the market to disorder and that's why, the accuracy, optimal decisions are unacceptable here.

Econometrics is mainly related with linear equations. But evidentially, they accept simple number decisions. For that reason, they are mostly implemented in technical fields. Unlike these, non-linear equations are many-valued, disordered, and their results are far from the reality. But as time passes, it becomes clear that major complicated natural processes are successfully modeled by differential equations [2, 6].

Life is disordered. A question may have more than one answer according to the circumstance here. That's why, during the solving of certain problem, there arises a need for having models which can make various decisions according to the circumstance.

Because the explained issues posses great importance for Azerbaijan experiencing its transition period, creation and implementation of the System of Economic Analysis (SEA) accepted as a non-linear dynamic system, aiming at analysis of today's some problems on the base of quantity and quality indicators of the previous years and creating effective visual working environment by statistic-space data assume very great importance for solving of social-economic problems, economic-geographical investigation of area naturality, fractal analysis of factors which can influence on the purpose of investment in the region and are stipulated with importance of solving of following problems:

- concrete and systematic analysis of the information;
- capacity of complex and visual usage of the data necessary for decision making;
- operative control over dynamics of progress of processes;
- operative analysis in the cases of emergency;
- quick investigation-information system.

The creation of such an analysis system creates a possibility to prevent various undesirable outcomes that can occur during dynamics of progress of economical processes, and to predict performance models for a short period of time of forthcoming processes on the basis of quantity and quality indicators of the previous years. As a result of fantastic progress of information technologies and efficient usage of mathematical methods of non-linear dynamics in the solution of complex dynamic system, possibility of directly observing the unique processes of transition period of economy in a computer monitor supports the creation of such a system.

Functional software of SEA consists of program packet, which has been made in C++ Builder algorithmic language. This packet includes functions and tools for information holding, analysis, decision-making and visual appearance. These are divided into three main groups:

- - operations on the data and input-output tools;
- - management systems of data and information bases;
- - analysis and visualization of inquiry and decision making operations.

The primary data of SEA, first of all consist of information, which characterize the space position of economic objects and the data tables related with them. These data can either be prepared by user using recourses of system, or received from outside in an appropriate form.

The bank of information is one of the significant elements of SEA. Because, its comprehensiveness determines in which extent the ultimately made decision is close to the reality. The information, which is the element of this bank – the quality indicators obtained as a result of technological operations composed by user using algorithms that are made on the base of mathematical methods of non-

liner dynamics from quantity indicators assembled in the data bank and included to SEA in the forms of functions - is a verbal expression of economic situation.

Generally, the implementation effectiveness of SEA depends on correct creation and choice of algorithms that are main tools in the formation of information base and decision-making. That's why, these algorithms should be able to ensure the closeness of the decision, and made for a short time period to the reality when not all the primary data are known. To achieve this, the following mathematical methods of non-liner dynamics, that give opportunity to obtain results based on above-mentioned conditions, are used [2, 6, 12]:

- - fractal dimension;
- - Hertz R/S analysis;
- - correlation Integral;
- - chaos theory methods;
- - fuzzy sets;
- - Nero network methods.

Algorithms created by using these methods are applied systematically in the processes of analysis and decision-making and each of them has its function.

Fractal dimension reflects how the object (time series) fills up the space in which it is located. For this reason, the value of fractal dimension is always less than the space in which the system is located. In other words, fractal dimension is the item created by those factors, which their influence to the system creates this object (time series) [3,6].

While random time series is accepted as a result of many events of equal probability, non-random time series reflects non-casual nature of influences on the system. The jumps that are faced in the series are result of the influence of objective and subjective factors. But this is an indication of correlation among the elements. In other words, such time series have fractal features [3,6,12].

Time series with fractal features are also characterized by long-term indication of correlation. So, events happened today influence tomorrow. The new time factor assumes an important significance. In the processes of market economy, especially in the transition period, this factor plays a great role.

The exponents of effective market hypotheses declare that, investors react instantly to the new information and deny relationship between past and future. And its purpose is to ground the use of liner models. But, what is in reality? Yes, some people react instantly, but majority wait for the confirmation of the information. But for this, grounded information approved by time is necessary. But this is a long-term memory effect specific for the non-liner dynamic system. The method of Hertz R/S analysis is very reliable for analyzing this memory. This method is directly related with Hertz indicator [6,12].

The following results reflecting the reality were obtained through analyzing the dynamics of growth of exchange rate of American dollar to Azerbaijani manat by Hertz R/S analysis for the time period 01.01.1995-31.03.2001- the years of transition period.

During the given cycle, the time series made by quantity indicators of exchange rate occurred as a result of various influences has been divided into 15 cycles with five months to each. Totally this cycle consist of 77 months (Figure 1). This time series was analyzed by R/S analysis (Figure 2) and Hertz indicator was- H=0.65 and fractal dimension was – D=1.35.

According to the logic of R/S analysis, the last graphic is characterized as below [9]:

- - exchange rate is not random;
- - there is no natural cycle in exchange rate;
- - exchange rate is a non-liner dynamic system. There is a rise in present case and in a future the rise will continue in this way up to a certain point in corresponding circumstance;
- - there are no random jumps during process and the system is far from chaos circumstance.

For grounding the obtained results, elements of time series were arrayed in any style, the structure of system was broken and R/S analysis was reused for obtained time series and the corresponding values of Hertz indicators were calculated. If the series indeed doesn't reflect random events, i.e. there is a long-term memory effect, then the value of Hertz indicator has to change and decrease significantly. Otherwise, the value has to remain unchanged. As a result of calculation it was obtained that H=0.69. But this is the symptom of short-term memory effect. That is, the relation among the elements of observed series is too weak.

Although this memory is long-term in natural systems, it is not infinite. That is, such a moment comes in the dynamics of progress of system that, the sensitiveness to initial conditions decreases and completely disappears and the time series in a certain instant reflects random events.

This period is called average length of natural cycle in the non-linear dynamic systems and the memory about primary conditions is lost during this period. In the economic systems, especially in the transition period the length of the memory varies depending on the structure of the system. The values of Hertz indexes of the exchange rate of U.S. dollar to Azeri manat (AZM) for both mixed and non-mixed cases are close to 0.50 and each other. And this proves that the memory effect is multiperiodic.

This kind of result is not unexpected for an exchange rate. Because, unexpected changes are peculiar to the foreign exchange markets. This is mainly related with the government regulation of the exchange rates through Central Bank, unlike pure market processes. But not existence of natural cycle is explained with being unacceptable of six-years time interval.

Here one of the main factors is the length of time series. How many does the number of elements forming the series have to be? The scientists conducting researches in this field don't show any etalon magnitude for getting an adequate result. It is possible to get

numerous practical values during the investigations under the circumstances managed on the base of exact sciences. But economic systems are expressed by the short time series of relatively fractal dimension and subjected to the various influences of market environment. That's why it's necessary to be more attentive during the investigation of economic processes using time factor. Experience shows that, in such systems the aggregate of the data can be considered acceptable for the adequate analyses and results corresponding to the definition of natural cycle without alternatives. That's why, for determination of natural cycle in the growth dynamics of exchange rate of U.S. dollar to Azerbaijani manat it is necessary to wait for the certain period of time.

Thus, Hertz R/S analysis from the side of software gives us 2 main indicators for analyzing the economic processes: Hertz indicator (H) and average length of natural cycle. The cycle periodicity and also fractal property of the series are determined by virtue of the value of the first indicator. But the second indicator allows us to visually estimate the inertia of growth dynamics of the system. As seen, although the fractal analysis describes the real situation well, it doesn't explicate it. Chaos theory solves this problem [5, 6]. The main elements of this theory are attractor, phase space, Lyapunov indexes, information periods and above mentioned fractal dimension concepts. Chaos theory allows us to study dynamics of uncertainty and to find an order in its non-uniformity. It's possible to find the followings through analyzing the state of system by virtue of this theory,

- the length of natural cycle in the growth dynamics;
- the period of prediction or sensibility to primary conditions;
- the shape of the set of solution (attractor);
- the size of phase space;
- the fractal dimension of phase space;
- Lyapunov indexes and etc.

Visual estimation of the process in non-linear dynamics assumes special significance for determination of the given elements. Because, there may be many, sometimes numerous possible solutions, as in real life.

In this case Lyapunov indexes showing the dependence degree of the system on primary conditions are widely used [7, 12]. Though the sign of Lyapunov index is an indicator of quality, its numerical value expresses the level of information about current situation of the system.

Fractal dimension is also used as a main factor in the multidimensional case. Fractal dimension of phase space is determined by correlation integral. Correlation integral defines at which distance two random points are located in the attractor (set of solution) [2,12].

Experience shows that, as the size of phase space increases, fractal dimension (D) approaches to its real value ultimately. Usually convergence occurs when fractal dimension is more than 2-3 times of the size of phase space. Despite of such a dimensional difference, fractal dimension keeps its real value among the elements of system according to the correlation ratio. That's why; correlation dimension is a proper item for determination of the fractal dimension. All variables belonging to the system have to be known for constructing real phase space. But it is almost impossible in a real life. That's why, restoring of phase space using one known dynamic parameter is considered as the best way. Ruelle mathematically proved that, phase space restored by this rule possesses both the fractal dimension of "real" phase space and Lyapunov indexes' spectrum. [5]

Thus, it is possible to explain the real situation properly by virtue of the elements of Chaos theory. Reestablishment of the phase space of the inflation process existing in the state (Azerbaijan Republic) economy, calculation of its fractal dimension and the determination process of the period of prediction are examples of practical explanation.

Generally, the main factors that can influence the inflation process in the transition period are followings:

- budget deficit;
- monetary policy pursued in the country;
- the effects of change in the foreign prices to the domestic market;
- the effects of future expectations about inflation (physiological factor);
- the attempts of market monopolists to increase the prices artificially, etc.

The inflation rate for months, quarters or years forms the time series of this non-linear dynamic system in the time period of the existence of the process in the result of the effects of this and other subjective and objective factors. In this case, there occurs the process with the certain effect showing only the state of system. But this process doesn't make known how these factors influence and which of these factors influence more.

In a case the time series of inflation rate for the months during 1992-2002 years was chosen as primary dynamic series for the reestablishment of phase space of non-linear process (Table 1). The phase space was restored (Figure 6) and its fractal dimension (D) was determined: D=2,463 (Figure 5) in the result of analysis conducted by virtue of above explained non-linear rules. The dimension of phase space was 15. This means that at present it's necessary to use at least three of 15 variables for modeling the growth dynamics of inflation process in Azerbaijan Republic. But the visual analysis of the set of solution shows that chaotic or strange attractor is typical for this system. Lets calculate the greatest Lyapunov index (λ_1) for confirming this fact. Thus, if λ_1 is greater than zero, then there is high sensibility to the primary conditions and this system has chaotic attractor. This means that, a little alteration in parameters can cause to the fundamental changes of performance. Also, there exists a factor that forces active variable to remain in the set of attractor and there is maximum extent of deviation from real value of the current inflation indicator.

Wolf algorithm [7] is widely applied for calculating the greatest Lyapunov index λ_1. The algorithm is schematically shown in the Figure 3. The process begins with the selection of $z_0(t_0)$, the nearest point in the phase space and primary y (t_0) point from the main

dynamic series used in restoring of the phase space. After a certain period of time the first point converted into $y(t_1)$ is held , $z_1(t_1)$, its nearest point in the phase space is found and substitutes the second point converted into $z_0(t_1)$. The process is continued up to the end of the time series along the trajectory of y(t).

The greatest Lyapunov index λ_1 is calculated using the formula below:

$$\lambda_1 = \frac{1}{m \bullet \Delta t} \sum_{k=0}^{L-1} \ln \frac{r'_k}{r_k} \qquad (1)$$

L-the number of steps of substitution, m-the aggregate number of steps over time, -the length of time period, r_k- distance between the points $y(t_k)$ and $z_k(t_k)$. $\mathbf{r'_k}$- distance between the points $y(t_{k+1})$ and $z_k(t_{k+1})$.

In the result of calculations by this scheme, λ_1 was equal to 0.107339 (bit/month) for the time series of inflation rates for the months during 1992-2002 years (Figure 7). If we measure the current situation with the accuracy of one bit, then today's information will be useless after 9 (1/0.107339) months for giving any opinion about future, i.e. the length of natural cycle is 9 months (Figure 8).

Under the conditions of uncertainty, it's impossible to define with simple digit the cases that the behavioral dynamics of process suits in complex systems at the current moment, including in market economy, in other words, to find exact boundary [8, 10]. Some indicators, characterizing different fields of economic state are becoming well known. It includes profitability, durability, capital circulation, income and some other indexes. In addition to these indices, there are also certain norms that characterize the situation from good or bad viewpoint. But in most cases, it's impossible to define these indexes with simple digit during the decision-making process. The specific character of these appropriate economic fields is related with current economic –political conditions and other objective and subjective factors. That's why; the decision-maker is not satisfied with simple quantitative indices. He is looking forward to forming conscious connection among several complex indices that characterize the economic state as a whole. All these show that, decision-maker can not be satisfied with binary "Good"-"Bad", or "Yes"-"No" answers, he is interested in economic interpretation of condition. That is why the main purpose of decision -making is to "unite" all the economic indices, which characterize the current situation in unit complex index, and determine the "state" of the process referring to this index. The main duty here is not forecasting the probability of the crises case but defining the time distance up to the crises and assessing the current situation. There is not any place for statistical probability now. Because, the purpose here is not to find similarity, but make decision discovering the unique features of the process.

The point here is about fuzzy sets explaining complexity and analysis methods of Nero net for decision-making [8, 9, 10]. There is subjectivity in final decision-making and it comes from the complexity of the system. That's why, the adequacy of decision made depends on how the user perceives the problem .In this case; linguistic variables characterizing the process qualitatively are helpful. For example "high ", "low", "more preferable", "expected", "probable","unique".

As well as known, the relationship between the quantitative measure of one factor and quality index is determined by means of belonging function in fuzzy sets theory. The value of this function expresses the extent of comparability of the condition. Its value changes throughout [0;1] and this value does not depend on the density of elements characterizing the process. This value is not also a probability, because the process is not repeated here [8, 10].

In the System of Economic Analysis (SEA) that we analyze, belonging function is constructed on the basis of followings:

Results of analysis of macroeconomic indicators of appropriate field, by means of mathematical methods of non-linear dynamics on the purpose of determination of unique features of dynamical economic process. -Hertz index (H), Fractal dimension (D), and average length of natural period;

Intuitive expert imaginations formed from visual assessment of growth model of dynamical economic process by using modern technical means.

So, on the base of above-mentioned data, new complex indicator is defined as a following outline for assessment of the economic state:

P – set, expressing the current condition at non-linear dynamical process is divided into fuzzy sub-sets:

P_1 – sub-set, expressing "extremum" in a current situation – economic growth experiences deep crisis. The probability of improvement of the situation even due to radical reforms is very low;

P_2 – sub-set, expressing "relative extremum " in a current situation – economic growth tends to crisis, some symptoms of it have already been seen (observed), but the condition is still not dilemmatic, urgent measures have to be taken;

P_3 – sub-set, expressing "stagnation" in a current situation – economic growth is not sustainable, "unfortunate" event may happen any time, urgent reforms have to be carried out, investment calls for a great risk;

P_4 – sub-set, expressing "relative growth" in a current situation – economic development is satisfactory, separate indices make trouble, system is not sustained enough against market conditions;

P_5 – sub-set, expressing "stable growth" in a current situation, - there is high growth in economic development, it is stable enough and has the best opportunities for future development.

In other words, P – term-set, of "Current Economic state" linguistic variable, consists of 4 components. Here, V – is the complex index of current state in growth dynamics.

Fuzzy classification of values of X_i (i = 1, 2, …, N) parameters necessary for the modeling of the growth dynamics is carried out. For that purpose, "level of Xi index" linguistic variable defined by means of the following {B} – is included:

B_1 – "The lowest level of X_i index" fuzzy subset.

B_2 – "Low level of X_i index" fuzzy sub-set.

B_3 – "Average (mean) level of X_i index" fuzzy set.

B_4 – "High level of X_i index" fuzzy set.

B_5 – "The highest level of X_i index" fuzzy set.

Assessment of importance of X_i (i =1, 2, …, N) parameters in complex evaluation. Individual W_i – Weight coefficient of appropriate X_i index is defined in assessment of economic state (information level about the state of index). So, each of the indices able to radically influence to the economic development in the translation period, as investment, export, exchange rate, deposits, import, interest rate, GDP, tax, salary, consumption, employment and inflation, has its own "weight". On the other hand, there are also 3 possible types of contacts among these indices: direct functional, counter functional and indirect contact. These contact relations also make impact on the value of W_1 – weight coefficient of index.

Constructing a complex index. V – complex index is defined with help of X_i – indices and Wi – weight coefficients as following.

$$V=\sum_{i=1}^{N} w_i X_i \qquad (2)$$

Determination of current state of economic growth dynamics. The level of the comparability of the current situation in economic growth is determined by means of M (V) belonging function dependent on V complex index.

The name of index	Value interval	Classification of the level of parameters	Confidence level of assessment (belonging function)
V	0<V<0.15	"Extremum"	1
	0.15<V<0.25	"Extremum" "Relative extremum"	M (V)
	0.25<V<0.35	"Relative extremum"	1
	0.35<V<0.45	"Relative extremum" "Stagnation"	M (V)
	0.45<V<0.55	"Stagnation"	1
	0.55<V<0.65	"Stagnation" "Relative growth"	M (V)
	0.65<V<0.75	"Relative growth"	1
	0.75<V<0.85	"Relative growth" "Stable growth"	M (V)
	0.85<V<1	"Stable growth"	1

Thus, evidentially, complex assessment of current situation in reality is artificial intellectual process referring to subjective judgments and it's not expedient to solve it without the ideology of fuzzy sets. Because, it's necessary to differentiate these subjective quality indices before saying whether it is "Good" or "Bad". And its most effective solution is possible in the framework of fuzzy sets theory and methods of Nero network [9].

Thus, by means of above-explained synergetic methods, Economic Analysis System, which aims systematic analysis of economic processes in Azerbaijan Republic and creates effective visual work environment with statistic space data on the base of quantity and quality indices of past years, makes the construction of technological operations chain possible as following outline (plan):

- discovery of specific symptoms of transition period;
- synergetic analysis of transition economy on the base of symptomatic information carriers;
- visual assessment of the behavioral model of economic development for short time period and decision making.

Because of existing disarray in micro and macro levels, not fitting of bilateral relationships to the real context, lack of the legal base determining the exact limits of government intervention to economic processes, intentions of artificial regulation, incomplete formation of real market and such objective and subjective factors specific to the system, under the conditions of more broadened uncertainty and realization of unit-economic space due to fantastic development at modern information technologies, the great

importance of the creation, implementation and the development of intellectual system allowing to the visual assessment of growth dynamics of economic processes by using the time series of quantity indices and fuzzy set of quality indices of effects that formed in the result of different impacts, like SEA to Azerbaijan Republic is beyond a shadow of a doubt.

LITERATURE

2001. The aggregate of economic indicators of Azerbaijan Republic. Baku.
Beltrami E., 1987. Mathematics for Dynamic Modeling. Boston: Academic Press.
Mandelbrot B., 1982. The Fractal Geometry of Nature. New York: W.H.Freeman.
Peters E., 1994. Fraktal Market Analysis. New York: Wiley.
Ruelle D., 1989. Chaotic Evolution and Strange Attractors. Cambridge University Press.
Schroeder M., Fractals, 1991. Chaos, Power Laws. New York: W.H.Freeman.
Wolff R., 1992. Local Lyapunov Exponents: Looking Closely at Chaos. Journal of the Royal Statiscal Society 54.
Zadeh L., 1965. Fuzzy Sets. Information and Control 6.
Ежов А., Шумский С., 1998. Нейрокомпьютинг и его применение в экономике и бизнесе. М., ЭАИ МИФИ.
Заде Л., 1976. Понятие лингвистической переменной и его применение к принятию приближенных решений. М., «Мир».
Занг В.Б., 2000. Синергетическая экономика: Время и перемены в нелинейной экономической теории. М., «Мир».
Петерс Э., 2000. Хаос и порядок на рынках капитала. М., «Мир».
Федер Е., 1991. Фракталы. М., «Мир».
Холодниок М., Клич А., Кубичек М., Марек М., 1991. Методы анализа нелинейных динамических моделей. М., «Мир».
Хэссард Б., Казаринов Н., Вэн И., 1985. Теория и приложения бифуркации рождения цикла. М., «Мир».

ANNEX

Figure 1. Average monthly indicators of the exchange rate of dollar to manat.

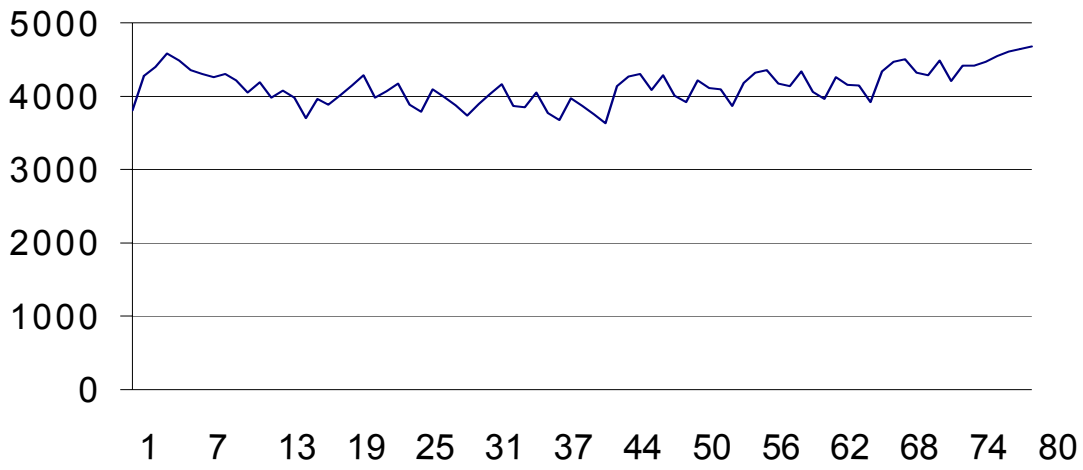


Figure 2. R/S analysis of the exchange rate of dollar to manat.

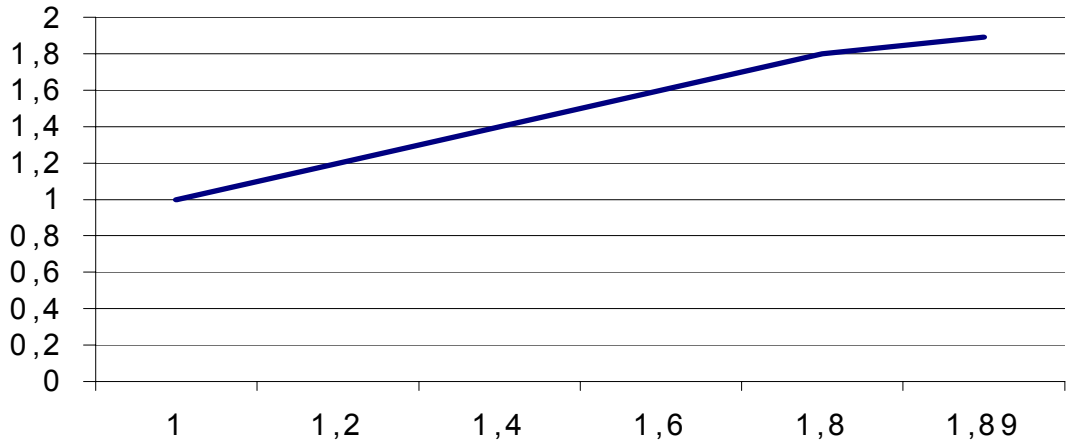
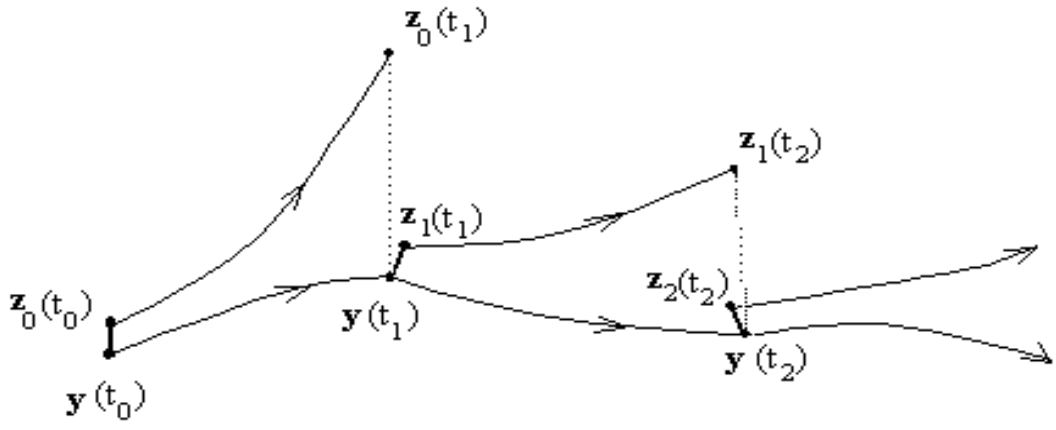


Figure 3. Finding algorithm (Wolf) of the greatest Lyapunov index.



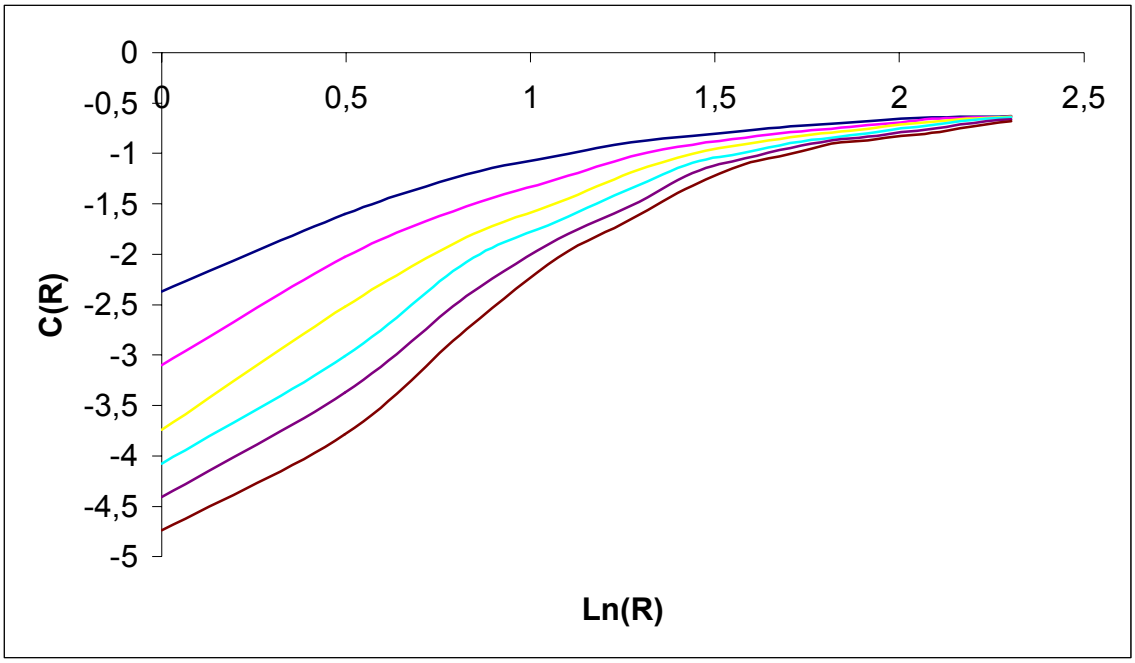


Figure 4. Correlation integrals.

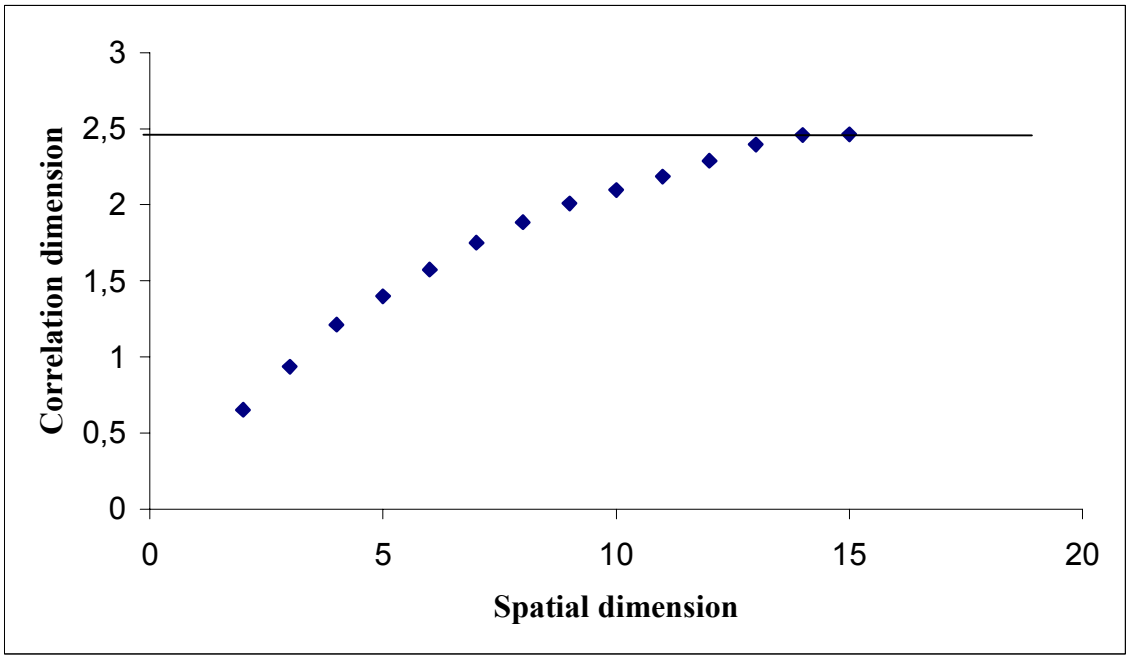


Figure 5. The convergence of fractal dimension.

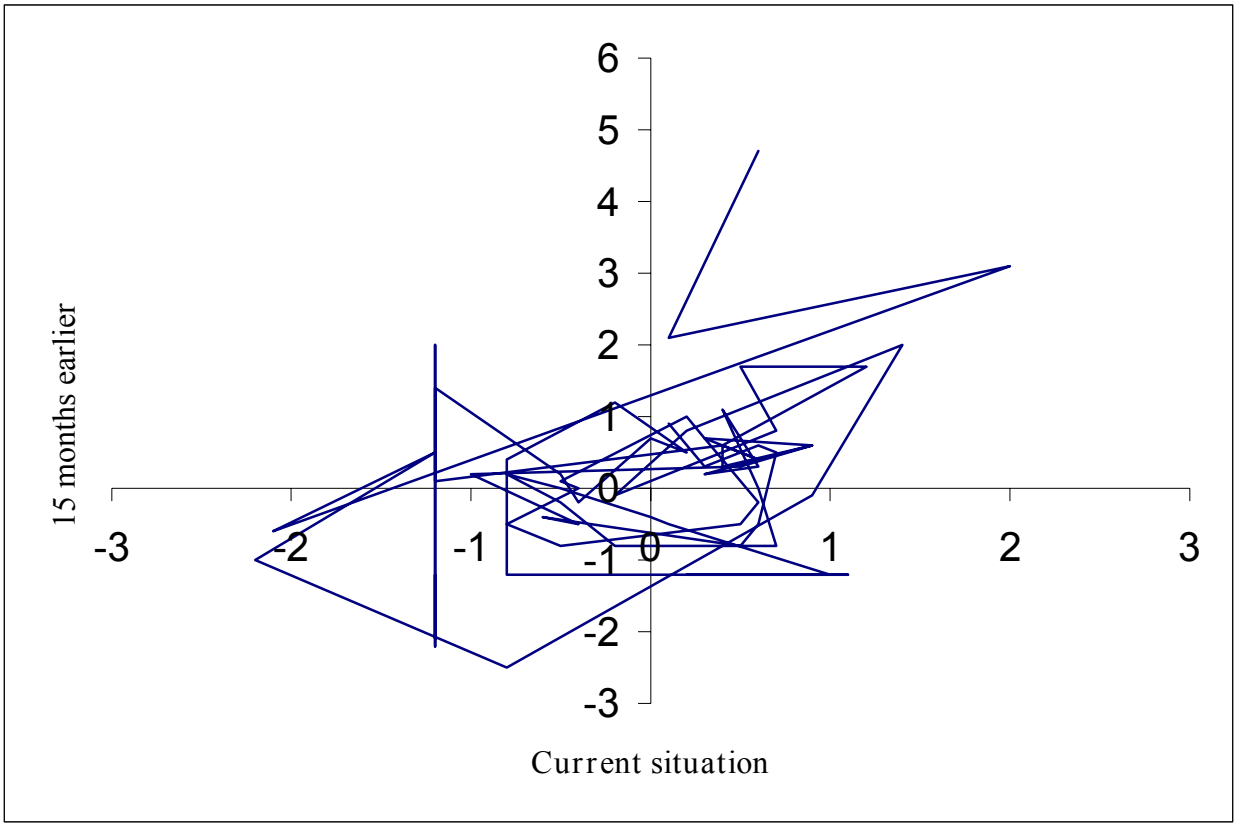


Figure 6. Two-dimensional phase space of restored inflation process.

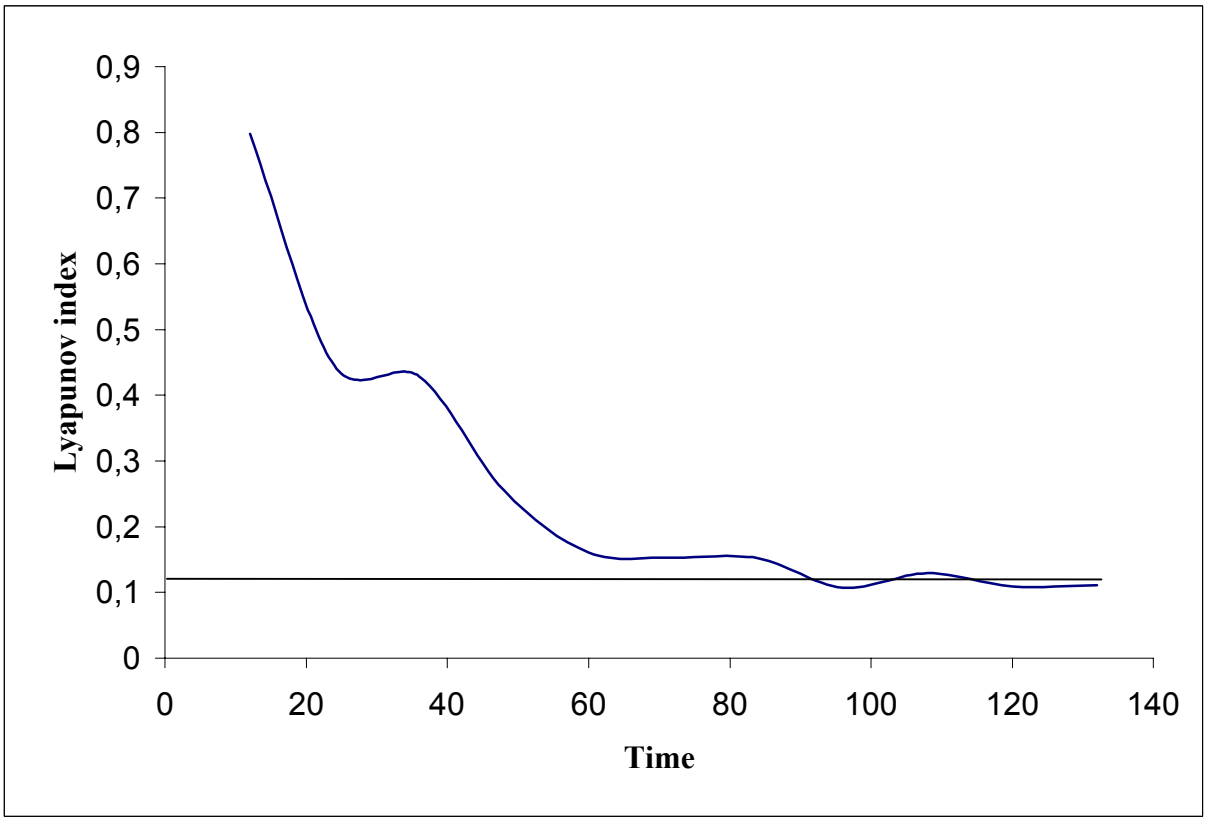


Figure 7. The convergence of the greatest Lyapunov index.

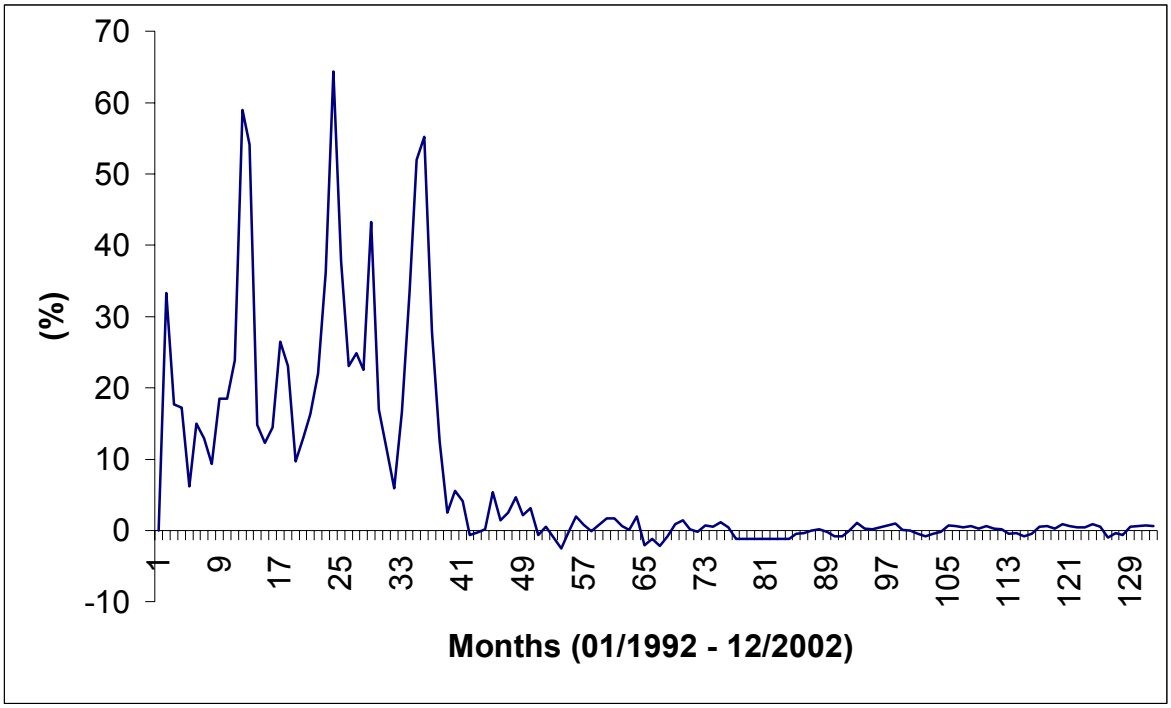


Figure 8. Growth dynamics of inflation.

Table 1. Inflation rates for previous months during 1992-2002.

Months	Years										
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
January	118.1	54.1	37.8	27.8	2.1	1.7	0.7	-0.5	0.7	0.3	0.6
February	33.3	14.8	23.1	12.5	3.1	0.6	0.5	-0.4	1.0	0.6	0.4
March	17.7	12.3	24.9	2.5	-0.6	0.1	1.2	0	0.1	0.3	0.4
April	17.2	14.4	22.5	5.6	0.5	2.0	0.4	0.2	0	0.2	0.9
May	6.2	26.5	43.3	4.1	-1.0	-2.1	-1.2	-0.2	-0.5	-0.5	0.5
Junky	15.0	23.1	17.0	-0.6	-2.5	-1.2	-1.2	-0.8	-0.8	-0.4	-1.0
July	12.9	9.7	11.5	-0.3	-0.1	-2.2	-1.2	-0.8	-0.5	-0.8	-0.4
August	9.3	13.0	5.9	0.2	2.0	-0.8	-1.2	0	-0.2	-0.5	-0.6
September	18.5	16.3	16.6	5.4	0.8	0.9	-1.2	1.1	0.7	0.5	0.5
October	18.5	22.0	33.5	1.4	-0.1	1.4	-1.2	0.3	0.6	0.6	0.6
November	23.9	36.2	52.0	2.5	0.8	0.2	-1.2	0.2	0.4	0.3	0.7
December	59.0	64.4	55.2	4.7	1.7	-0.2	-1.2	0.4	0.6	0.9	0.6

Table 2. The values of fractal dimension corresponding to phase space.

	2	3	4	5	6	7	8	9	10	11	12
D	0.653	0.937	1.211	1.398	1.751	1.885	2.009	2.098	2.186	2.288	2.397