# The digital management of structural complex systems in economics

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**Abstract:** As a result of the analysis, we establish throughout the world – there is a critical situation in economic management. A way out of the critical situation, based on new knowledge, solving new tasks and event-based digital management of structural complex systems in economics, is proposed. The new objects in management of economics are chosen: public authorities, socio-economic systems, processes of quality management of the socio-economic life of a person, safe living space. The management criteria are safety and quality of objects and systems. The new knowledge for management in economics is introduced: new types of Boolean event-propositions, risk scenarios for system failure, new types of logical and probabilistic risk models. We propose to solve the following new tasks in economics: modelling, analysis and management of one system and a group of logically unified systems (models); management of the State and development of systems; quality assessment of control systems. The special software for event-related managing economics is described. The content of the training course of additional education for economists and teachers is given.

**Keywords:** digital management; event-related management; structurally complex systems; government departments; economics; business; the safe space of mankind; knowledge; logical-probabilistic models; safety criterion; quality criterion.

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## 1 Introduction

Many foreign and Russian articles note the poor condition of state and economics management. All over the world economists are trying to find a way of dealing with this critical situation.

The present-day theory of economic management is inadequate. There are no fundamental achievements in state and economics management. Economics management is performed without mathematical methods and models on the basis of ephemeral concepts and aims, using 'unwritten rules', 'manual management', or the principle 'give me more money', promises, ephemeral programs of economic growth and reviving industry.

After analysing the ephemeral methods of management, management objects, state officials, strong structure (army and policy), the education system, economic and academic sciences, a conclusion was made about impossibility to remedy the situation without a new outlook, new knowledge and solving new tasks in economics management.

The presented study outlines the scientific foundations of a new breakthrough direction in managing safety and quality of structurally complex systems in economics.

*Aim* is the creation of a new breakthrough scientific direction in economics 'event-related management of safety and quality in economics' on the basis of new knowledge, solving new tasks and technology of event-related digital management.

*New objects and criteria of management* are state authorities, socioeconomic systems and projects, quality management processes of the socio-economic life of a person and the safe living space. Safety and quality of system have been selected as management criteria.

*New knowledge***.** For management in economics, the new knowledge is introduced: the methodological foundations of safety and quality management, new types of Boolean events-propositions, scenarios of systems failure, new types of logical-probabilistic (LP) models.

*New tasks*. For management in economics the new tasks are proposed: modelling, analysis and management of one system and a group of logically connected systems (models); management of the condition and evolution of systems; assessment of management systems quality.

*Digital management in economics* is defined as a technology of wide introduction of innovations and solving new tasks on the basis of the unified set of new knowledge, models, tasks and software. Digital management has been connected with innovations and investments.

*Scientific novelty*. The new breakthrough scientific direction 'event-related management of safety and quality of structurally complex systems in economics' is created. In management of economics we introduce: the methodological foundation, new objects and criteria of management, new knowledge and tasks, special software and the set of LP-models for the management of safety and quality of systems.

*Practical value*. We offered the way out of critical situations for economies of countries. Countries have to develop and use new knowledge and solve new tasks in economics. We have created the LP-models for the state analysis and development management of economic systems on safety and quality criteria. Special software was adapted for management purposes. A further education course of economists was developed. We proposed a unified system of knowledge, models, tasks and software for event-related digital management.

*Concepts and statements of eminent scientists about managing economics*. The study was performed for the first time. When developing a scientific direction in economics, choosing a mathematical apparatus and building risk models of systems, separate concepts, principles and statements of eminent scientists about management in economics were used.

Norbert Wiener and John von Neumann, founders of cybernetics, believed that mathematical methods for managing socio-economic systems should be based on logic, set theory and combinatorics.

Albert Einstein, the world-famous scientist, wrote that no problem can be solved at the same level at which it appeared.

Rudolf Kalman, the author of the Kalman filter, believed that the problem 'data → model, which explain data' should be considered as basic for any branch of science.

Nobel laureate James Buchanan considered the relationship of government, corruption and public opinion in the state.

Nobel Prize winner J. Heckman proposed an analytical apparatus of mathematical statistics for the analysis of socio-economic processes in the state.

The Nobel dynasty was guided by the principle of social justice. The Nobels spent a significant part of their profits on workers: they paid decent wages, built houses, kindergartens and schools, provided free medical services.

Li Keqiang, the Prime Minister of China, supposed new technology and innovation in management are the same.

Kate Raworth, Professor at Oxford University, proposed a new economic model in the form of a 'safe living space' ring. Above the ring – going beyond the ecological limits of the Earth: dangerous climate change, water pollution, etc. Below the ring are resources for a good life: food, clean water, housing, energy, education, etc.

Albert S., Wentz J., Ulyams T., American lawyers, believed that everyone was capable to make fraudulent action if circumstances put pressure and values are taken stock badly.

Isaac Newton, the great English scientist, believed that concrete examples are no less instructive than theory.

Williams Ockham, an English philosopher, believed that one should not complicate the model unnecessarily. A simple model is more likely to be correct. Sets and logic allow you to build the most simple and transparent models.

Robert Stevenson, an American scientist, believed that errors in projects (development programs) of complex systems and projects are inevitable and operational tests are necessary to identify and eliminate errors.

Stephen Robins and Meri Coulter, authors of the textbook *Management*, set out the components of system management, which include the functions of planning, organisation, management and control, which can be the basis for assessing the quality of management systems.

Ryabinin (2007) proposed the logical and probabilistic calculus for theory of the reliability of structural complex systems in engineering. We applied this theory to economic systems by introducing multi-states of the system instead of two states (refusal/failure) in technology.

Hovanov et al. (2009) developed a method of randomised summary indicators for ranking systems and synthesising the probability of events for non-numerical, incomplete and inaccurate expert information, which is used to construct safety and quality models in economics.

The author defended his doctoral thesis *Fundamentals of Building Systems for Automated Development of Complex Machines* in the USSR, Institute of Cybernetics, Academy of Sciences of Ukraine, Kiev (Solozhentsev, 1982). The theory and results of the thesis are developed to manage economic systems.

## 2 Main definitions and concepts

Let us give the main definitions and concepts regarding the digital management of structurally complex systems in economics.

The event-related approach has been adopted in order to build models, analyse and manage the structurally complex systems in economics.

Logical operations *OR, AND, NOT* are used for linking events. For the purposes of quantitative assessment logical risk functions are transformed into probabilistic risk functions. Logical variables are independent. Logical variables become dependent when

they fall into one L-function. Therefore, we must perform the orthogonalisation of L-functions so that the terms in the L-function are independent.

The term ‘ephemeral management’ has the following synonyms: phantom, illusory, invalid, non-transparent.

Digital management is understood as quantitative management of structurally complex systems in economics on the basis of the new knowledge, solving new tasks and using the special software.

New intellectual knowledge in management is represented as events-propositions, scenarios of system failure and LP-risk models.

A scenario is a textual, informative, brief and structured description of the failure risk of a system or an event. Scenarios are used for building structural and LP system risk models and expert estimations of probabilities of initiating events-propositions.

Management objects of economics are SCS. In digital management we use events and logical variables for systems.

For generality we called management all objects as systems. Digital management has a unified system of methods, models, technologies and software for the management of SCS in economics.

The requirement of safety and quality is essential for all systems of economics. Digital management is performed by the criterion of safety and quality. System safety is determined with the help of the notions ‘risk’ and ‘acceptable safety’. The quality is determined by the evaluation of the system’s invalidity. The criterion of safety and quality are the main ones for systems.

Effective management of the country’s SCS in economics should be based on a comprehensive study of the criteria for the safety and quality of socioeconomic systems and projects, business and government departments using the set of logic-probabilistic risk models.

Management has the following characteristics: the presence of the subject and the object of management, commitment to achieving a goal, supplying means of management. Management and optimisation are close concepts. Optimisation by criteria of safety and quality is management; management by criteria of safety or quality is optimisation

Digital management presupposes calculation significances of initiating events (IEs) and changing criteria of safety and quality by making investments, retraining staff, changing the structure of a system and implementing reforms.

The theory and technology of digital management of SCS in economics are common and invariant for all countries.

## 3 The critical situation of management of structurally complex systems in economics

Main components of the management of the SCS in economics are management methods, management objects, managers (state officials), the educational system, economic science and academic science. Management of the SCS in economics is in critical condition all over the world. The economic science does not guarantee the development of countries and their economies.

Below we will deal in detail with the following components of management of the SCS in economics: the ephemeral management methods and the ephemeral objects of management (Solozhentsev, 2018n).

*Ephemeral management methods* employ ephemeral concepts and targets, management of 'unwritten rules', 'manual management', management on the principle 'give more money', management based on promises and slogans, appeals, ephemeral programs of economic growth, increasing labour efficiency and industrial revival, regulation and adjustment based on intuition.

*Ephemeral objects of management* include aims, objectives, processes, stereotypes of economy, safety and quality factors. For example, the following factors as criteria are ephemeral in management of economics:

- GDP per capita, percentage of worldwide average
- share of manufacturing industry in industrial output
- share of machine building in industrial output
- investment volume, percentage of GDP
- expenses on science, percentage of GDP, etc.

These factors-objects in relative or absolute values make the management problem of optimisation a multi-criteria one, which is impossible to decide. Each of these factors as a sole management criterion depends on lots of other various factors. The set of factors-objects can be used for assessing the ratings of different countries, and not the management of a country's economics. If we build the time series for such factors for several years, as well as correlating and approximating functions for several years, we will not get an answer what and how we are going to manage. At the same time the event-related LP approach reduces all the factors to a single aggregate: the safety criterion or the system quality criterion.

*The way out from the critical situation*, we considered the ephemeral system of management of economics of Russia. However, such management system components as management methods and management objects are ephemeral in all countries. It is kind explains the unsatisfactory critical state of the economics throughout the world.

Ephemeral management methods and ephemeral management objects cannot change the management of the structurally complex systems in economics of Russia and other countries.

The fate of Russia depends on the development of new knowledge in the management of the structurally complex systems in economics that can change the critical situation.

Fundamental science can find a way out of the critical state of the management of the SCS in economics, using the theory of the reliability of structural complex systems and LP-calculus (Ryabinin, 2007), synthesis of probabilities by the randomised summarised indexes method (Hovanov et al., 2009), the software for structurally logical system modelling (Mozhaev, 2008), the theory and methodology of assessment trials of complex technical systems and socio-economic systems (Solozhentsev, 1982, 2015, 2017c, 2017a, 2018b).

Ephemeral methods and ephemeral objects of management in economics exist both in Russia and abroad. The digital management of the SCS in economics is considered as an alternative to the existing management which employs ephemeral methods and ephemeral objects of management.

## 4 The digital management of the structurally complex systems in economics

Nicholas Negroponte (Massachusetts University), the American IT scientist, introduced the term ‘digital economy’ in 1995. This term is used all over the world now. However, this concept still remains vague. The Russian Information Agency ‘Science’ offers some materials concerning digital economics. Traditional economics is the business function of the society, as well as the complex of relations in the system of production, distribution, exchange and consumption. Digital economics is understood as a kind of economic relations via the internet, mobile communications.

Having studied a host of literature sources, we found out that digital management of the SCS in economics has not been touched upon**.** This can be explained by the fact that there are no mathematical models and algorithms in management of the SCS in economics. Management is performed on the basis of ‘certain notions’, ‘manual approach’, or by the principle ‘give me more money’, which inevitably leads to corruption. Mathematical models and corresponding software are needed for digital management of the structurally complex systems in economics.

*Definition of digital management*: we should introduce digital management due to the following reasons:

1 the tasks of management of structural complex systems in economics are the most relevant and prevalent both at the top level of management, and at the level of regions, cities and enterprises

2 the tasks of management differ in the complexity, novelty of the mathematical methods, the use of new knowledge

3 management tasks have great arithmetic and logical computational complexity and without special software are not solved

4 ensuring the possibility of broad and rapid implementation of solution of new tasks in the country’s economy.

Digital management of the SCS in economics can be defined by the following features:

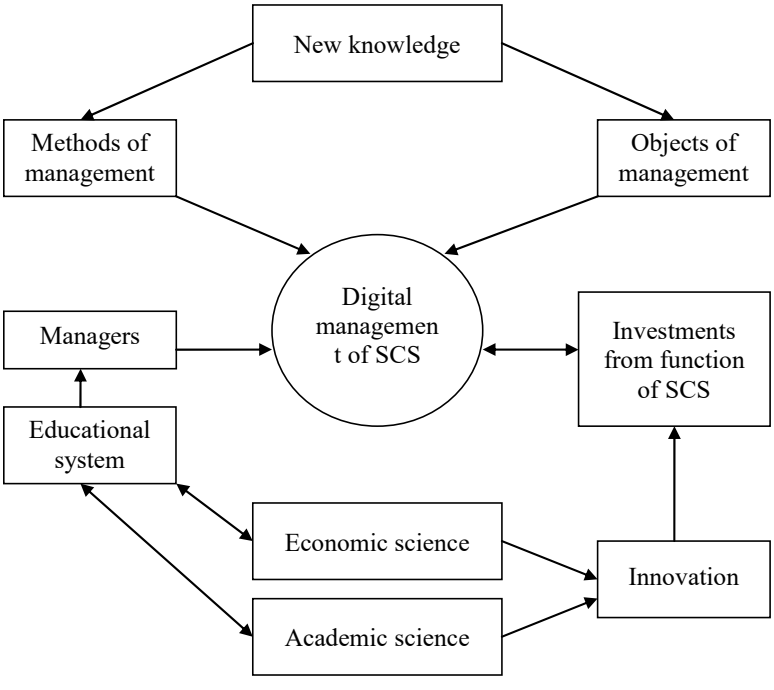
- *aim* is maximum of the safety and quality criterion
- *use of new knowledge* – Boolean events-propositions, risk scenarios of failure of systems and events, LP risk models
- *objects of management:*
  1 socio-economic systems and projects (of the country, region, city, enterprise)
  2 business
  3 safe space for population (of the country, region, city)
  4 government departments (ministries, state agencies and departments, state corporations, extra-budgetary funds, the State Duma, the Federation Council)
- *special software* for building LP risk models (orthogonalisation of logical risk functions, synthesis of event probabilities)

- *the computer network* for transmitting scenarios of the failure of systems and events, LP risk models of systems and the results of analysis and management.

Digital management of economics (unlike the existing ephemeral management, based on ephemeral methods and ephemeral objects), solves new tasks in economics management, uses new knowledge, unified techniques, mathematical models and special Software. In the digital management of system safety, significances of IEs and the changes of the values of the probabilities of these events are calculated to make investments, retraining personnel, changing the system structure and conducting reforms in economics, science и education.

*The concept of digital management* of economics and the interaction of components is shown in Figure 1. We assume, digital management is used completely in a country with a market economy, that is, in objects of economics, business, socio-economic systems and government departments. Components of the digital management system, as already noted, are: management methods, management objects, managers, the education system, economic science, academic science. For each object, criterion of safety and quality are calculated. You can calculate the entropy of the objects of each industry or the country as a whole. If the safety criteria for all objects are approximately equal, it means the death of competition in the industry or country and the exclusion of the country from the world market.

**Figure 1** The concept of digital management in economics




For the system of digital management of economics, funds and highly qualified specialists are needed. The education system prepares specialists for economic objects, government department and economic and academic science.

Economic and academic sciences are the part of the education of students in the educational system. They also develop and research innovations for objects of economics, business and government departments. Objects, using innovations, increase their criterion of safety or quality, thus causing competition between objects.

Investments come from innovations in industry and management of systems, leading to a reduction losses and additional income in structurally complex systems in economics.

In the concept of digital management, first of all, we have investments from the SES-1[1] group, aimed at reducing losses of funds and increasing their revenues:

- management of innovations in the country, regions and companies
- management of the risk of banks and reserve capital by Basel requirements
- management of production quality by WTO requirements
- counteraction bribes and corruption
- counteraction narcotisation of the country
- management of the crediting process in banks
- assessment the management system quality.

*The digital economics and the digital management.* The foundations of the new scientific direction in economics 'management of SCS in economics' were formed ten years before the recognition of the urgency of development of the 'digital economics' at the state level.

In the new scientific direction, managed objects are government departments, socioeconomic systems, the safe space of mankind, business. All tasks are solved on the basis of the unified system of methods, models, technologies, knowledge and software.

With the beginning of the recognition of the 'digital economics' as the technology for the development of economics, it became necessary to define the place of the new scientific direction in the digital economics called 'event-related digital management of SCS in economics'.

The new scientific direction 'event-related digital management of SCS in economics' is a complex problem and deals with various aspects of economics, management, safety, new knowledge, computer network, LP calculus and special software. The tasks of analysis and management of SCS in economics have a great logical and arithmetical computational complexity and without special software are practically not solved. Due to the novelty of the scientific direction, complexity and computational complexity, the prospects for its widespread introduction were practically absent. The situation changed when decisions on the development of the digital economy were declared. Now the new scientific direction 'event-related digital management of SCS in economics' has a real opportunity for widespread implementation.

## 5 Objects of management of structurally complex systems in economics

In the work, unlike the existing management of SCS in economics, event-related digital management of real structural and complex objects is considered without ephemeral goals, processes and economic stereotypes. Let us consider these SCS in economics.

### *5.1 Government departments*

Functions of the state are the maintenance of public order and stability, the use of available opportunities for economic development, and the increasing the country's safety. The state as a political system manages the society in all spheres. The body of state power is an independent subdivision of the state power, as well as a legally formalised, economically and organisationally separate part of the state mechanism that is endowed with state-power authorities and has all the necessary means to solve tasks and perform functions.

Government departments include: ministries (21), state agencies (35), services agencies (15), state corporations (2), state extra-budgetary funds (3) (in brackets – the number of objects), the State Duma, the Federation Council and, correspondingly, the governments and the legislative assemblies of the regions and cities). The Federation Council and the State Duma as a system are the objects of digital management.

### *5.2 Socioeconomic systems and projects of the country and regions*

The state allocates the budget to socioeconomic systems (SESs) and projects. The state incurs losses in SES and projects due to corruption, drug addiction of the population, bribery, embezzlement, decisions taken by unwritten rules and not by law, excessive expenses on social and military projects. *The following SES groups can be identified (Solozhentsev, 2016, 2017b):*

- *Group SES-1 contains SESs* of the highest importance for the state, aimed at reducing the loss of funds and increasing revenues:
  1 the system of management of innovations in the country, regions and companies
  2 the system of management of the banks risk and capital reservation by 'Basel' requirements
  3 the system of production quality management by *WTO* requirements
  4 the system of monitoring and management of crediting process in banks
  5 the system of management of counteraction to bribery and corruption
  6 the system of management counteraction to drug addiction in the country
  7 the system of assessment of system management quality.
- *Group SES-2 includes SESs* which are complex for the state and the regions and depend on a number of ministries, departments and agencies (systems of education, healthcare; agriculture, ecology, industry, finances, economic development, energy).
- *Group SES-3 includes* local SESs for companies and firms whose success depends mainly on their desires and capabilities (management of the risk and efficiency in a restaurant, control of a company's management, etc).

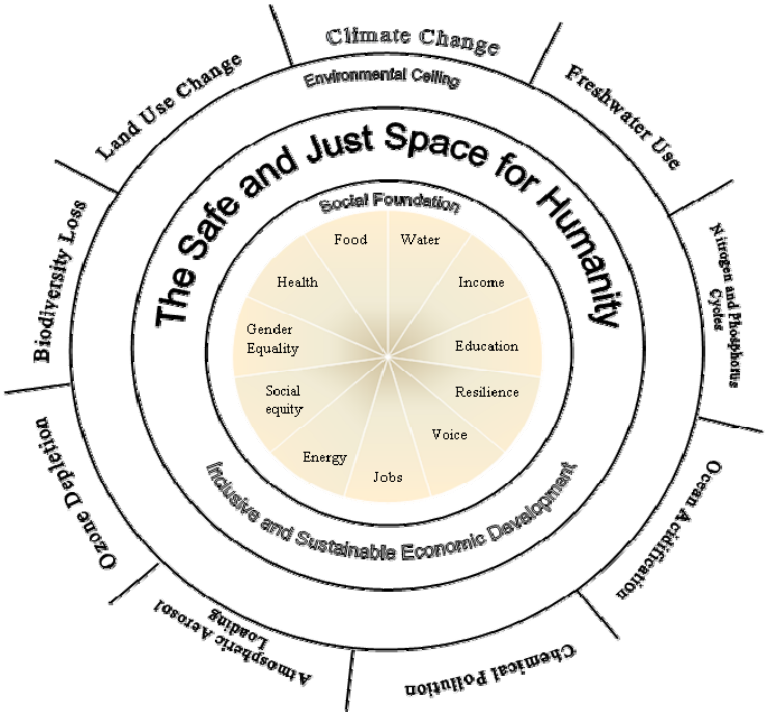
### *5.3 Safe space of humanity, countries, regions and cities*

Raworth (2017) from the Oxford University's Environmental Institute studied the system of humanity safe space. She points out that in the 20th century economics lost objectives. Economics strived to be a science based on a totally erroneous picture of humanity. The

dominating model – 'rational homo economicus', self-interested, isolated, calculating tells us about economists mainly rather than about other people. The loss of the obvious goal encouraged the main task as achievement permanent economic growth.

The existing economic model, according to Kate Raworth, is the closed flow of periodic revenues circulating between the state, enterprises, banks and trade in a social and ecological vacuum. This model lacks energy, materials, wildlife, human society, power and wealth. Economic activity does not reflect the reality.

**Figure 2** Kate Raworth's economics model (see online version for colours)




Raworth (2017) reconsiders foundations of economics at Figure 2. She incorporates the systems of the Earth and society into the diagram and obtains a new graphic representation of her idea. The diagram consists of two rings. If we go beyond the outer ring, we will leave the ecological boundaries of the Earth and face drastic climate change, depletion of the ozone layer and water. If we go beyond the inner ring, we will not have enough resources for good life: food, clean water, accommodation, sanitary conditions, energy, education, healthcare, democracy – our life will be full of deprivations.

## *5.4 Quality management processes of the socio-economic life of a person*

Such processes include: treatment of diseases, training at the institute, raising children, and others. A characteristic feature of these processes is the participation of several subjects and their respective infrastructures. For example, the process of cataract eye

surgery is reviewed and analysed with the aim of improving its quality. Management is carried out according to the criterion of quality, taking into account the following event factors:

1 medical personnel qualifications and hospital infrastructure

2 the patient's condition and the infrastructure outside the hospital in the postoperative period

3 the qualification of 'managers' of the state and the infrastructure of the state in the field of healthcare.

Evaluation, analysis and quality management of a cataract surgery-treatment process is performed on an event-related LP model. Structural, logical and probabilistic models of the quality of eye cataract surgery are built. The estimation of the probabilities of IE – factors is performed by the method of randomised summary indicators for non-numeric, inaccurate and incomplete expert information by the method of identifying statistical data on the results of the success of surgery-treatment.

## 6 New knowledge for management of SCS in economics

We have introduced events-propositions by analogy with events in reliability in engineering, scenarios of system failure and LP-models of the risk of system failure.

### *6.1 New types of events-propositions for management*

P.S. Poretsky, the Russian mathematician and logician, was the pioneer of LP-analysis. In 1886, he shaped Boole's idea about the applicability of mathematical logics to the probability theory. In 1917, Bernstein published a paper in which he applied the proposition axiomatic of Boolean logic to events axiomatic. Ryabinin in 2007 summarised the contribution of outstanding scientists G. Boole, P. Poretsky, S. Bernstein, A.N. Kolmogorov and V. Glivenko to the foundations of LP-calculus. For building LP-risk models of reliability in engineering he used the basic axiomatic of logic, events, probabilities and sets.

In Solozhentsev (2016, 2017a, 2017b) we extended the notion of 'an event-proposition' on the basis of axioms and ideas of mathematical logic. New types of Boolean events-propositions for economy were introduced**:** about the failure of subjects and objects, signal events, invalidity events, conceptual and indicative events, latent and repeated events, groups of incompatible events.

The sum-total of propositions forms a scenario of system failure and a complex derivative event. In management of state and economic safety by risk and efficiency criteria, probabilities of success/failure, danger/safety, validity/invalidity of events are used. The probabilities of events-propositions are evaluated by non-numerical, inexact and incomplete expert information.

Some events-propositions can be described and used as follows:

1 *Events-propositions concerning subjects' failure.* For the purposes of assessment, analysis, forecast and management we propose risk models which are built as logical functions of events-propositions concerning the failure of events-subjects and events-objects. Subjects solve a problem; objects constitute the core of the problem. An event-subject is an event of the subject's failure to solve a difficult problem. Subjects include the government, business, academics, public opinion.

2 *Signal events-propositions* are treated by us as significant events-propositions in management of structurally complex systems, in the world market, in politics, laws, innovations, natural disasters and wars. They serve as a signal for changing the probabilities of IEs in LP-models of system risk. The probabilities of IEs in risk models are adjusted by non-numerical, inexact and incomplete expert information, using signal events.

3 *Events-propositions about invalidity.* An invalid event-proposition is a deviation of a factor from a value, set by the specifications, technical conditions or the standard. The factors are normalised and are within the interval [0, 1]. The proposition that the value of factor $q_i > 0$ is an event-proposition about invalidity and *i*ts probability equal to the value of the factor.

4 *Conceptual events-propositions.* Conceptual events-propositions forecast a state or development. Probabilities of conceptual events-propositions are probabilities of the genuineness of propositions or forecasts which we will assess using expert information. It should be stressed that the notion of conceptual events-propositions is the first one in Boolean logic.

5 *Indicative events-propositions about* system danger are treated as invalid events. Their measure is the deviation of a parameter from a set value. The probability of indicative events-propositions is the measure of the danger of the parameter for the system.

6 *Events-propositions about latency* are revealed on the basis of public opinion polls and social networks analysis.

7 *Repeated events-propositions* can be found in different systems.

8 *Groups of incompatible events* are introduced for the gradations of parameters of systems. A set of events-propositions is a scenario of system failure risk or a complex derivative event.

## 6.2 Scenarios of failure of structural complex systems in economics

A system failure scenario is a meaningful description of factors (events-propositions) affecting system failure, their logical interconnection and the failure of the whole system by *OR, AND, NOT* operations. System failure scenarios are considered as intellectual knowledge.

In a scenario there are a large number of factors that affect a failure. These factors or events-propositions are called initiating. In a scenario, these events-propositions are logically combined into groups or derived events. Scenarios for derived events are also logically combined into a finite event of system failure. Let us give examples of building scenarios of systems failure.

*Example.* Based on the descriptions of factors influencing on birth rate, a failure scenario of fertility was developed (Solozhentsev, 2016). Events that affect fertility are logically connected (in parentheses) for following derivatives of failure events: legal support (legal protection of mothers or legal protection of the family), social programs (housing, or assistance to low-income families, or health programs), provision of pre-school education (state support or increase salaries of workers or building new kindergartens), improvement of medical services (improving the quality of life and free medical care, or economic stability in the country), strengthening of family relations (leisure or permanent family income).

Fertility failure is a conjunctive combination of derivative events: legal provision, the implementation of social programs, provision of preschool education, improvement of health services and strengthening of family relations. Scenarios use events in economy, politics, law, that is, the solution of a problem depends on different ministries, departments and authorities.

Thus, describing scenarios of system failure, events-propositions, that influence on system failure, and indicate logical connections between initiating and derived events-propositions (logic operations *OR, AND, NOT*) are used. Probabilities of events-propositions are estimated by expert non-numerical, incomplete and inaccurate information (Hovanov et al., 2009).

### *6.3 New types of LP-risk models for systems failure*

At present management of SCS in economics is performed by adjustments, by unwritten rules (and not by law), by the 'give me more money' principle, which inevitably leads to corruption.

For the purposes of digital management of SCS in economics we use *decomposition* – the division of a big system into several smaller ones. For example, the state is represented by numerous ministries, departments and agencies.

Also we suggest the *structuring* – this is a process of dividing each system into elements and establishing the logical connection (*AND, OR, NOT*) of elements with the aim of this system. New types of LP-risk models have been proposed (Solozhentsev, 2016, 2017b, 2012):

1 structural-logical system models

2 hybrid LP-models of system failure; they are built on the basis of the risk scenario for subjects, taking part in the solution of the problem, and the failure scenario for objects (tasks and projects), constituting the essence of the problem

3 LP risk models of invalidity are built by invalid events

4 conceptual LP-models of forecasting the condition or the development of a system are built by descriptions of the specialists, who understand the essence of the problem

5 indicative LP-models of system state danger

6 LP-models for invalidity management

7 LP-models for the management of system state and development

8 LP-models for assessment the management system quality.

These LP-risk models can be used for one system for purposes of comprehensive analysis and management. Different systems are connected by repeated events-propositions, which can be found in different systems. Management criteria in economy based on LP-models are the criteria of system safety and efficiency. Risk knowledge unequivocally determines efficiency as a mathematical expectation of losses or profits.

The dynamic character of LP-risk models of systems is achieved by the adjustment of the probabilities of events-propositions with the emergence of signal events. Signal events indicate the necessity of changing probabilities of IEs in LP- risk models. The probabilities of LP-risk models are adjusted by non-numerical, inexact and incomplete expert information (Hovanov et al., 2009; Karaseva and Alexeev, 2015).

In this paper we propose a set of LP-models for management of SCS in economics of the country. Models have different scenarios, describe different properties of systems and are used to manage safety and quality criteria.

LP risk models and their criteria for digital management in economics are presented in Table 1.

**Table 1** The set of models for management of SCS in economics

| *No* | *LP-risk models* | *The meaning of the criterion* |
|---|---|---|
| 1 | Structural and logical models | Risk of system failure |
| 2 | Hybrid LP-models of management failure | Risk of problem solution failure |
| 3 | LP risk models of invalidity | Risk of system invalidity (quality) |
| 4 | Conceptual LP-models | Risk of forecasting |
| 5 | Indicative LP-models | Risk of system danger |
| 6 | LP-models of state management | Risk of system state |
| 7 | LP-models of development management | Risk of system development |
| 8 | LP-models of management system quality | Risk of management system quality |

The criteria of management for all these LP-models are the criterion of safety and quality, with the formally probabilistic interpretation and features.

They are simply computed and analysed on a probabilistic (arithmetic) model obtained after orthogonalisation of the logical risk model of the system. The problem is solved for any complexity of the logical risk model.

A comprehensive study of socioeconomic systems and projects, business and government departments on the basis of criteria of safety and quality with use LP-models is the basis for effective management.

## 7 New tasks in management of economics

The created and adapted special software *Arbiter* and *Expa* allow to solve the following new and previously unknown management tasks in economics:

1 modelling, analysis and control (MAC) of the safety and quality of one system

2 MAC of safety and quality of several systems combined into one common system (L-model)

3 MAC on common L-model of safety and quality of systems connected by logic operations *OR, AND, NOT,* with different outcomes

4 MAC on common L-model of different systems with the correct account of repeated IEs.

## 8 LP-analysis of risk of the structural complex systems in economics

Quantitative system risk analysis is performed by significances and contributions of IEs into the probability of the final and derivative events (Solozhentsev, 2012).

*Structural significance* takes into account the number of different paths with the *i*-event, leading to the final event; risk is determined by the probabilistic function:

$$\Delta P_i = P_y\big|_{Pi=1} - P_y\big|_{Pi=0}, \quad i = 1, 2, \ldots, n, \tag{1}$$

where $P_y$ is the final event probability; $P_i$ is the IE probability, and the probabilities values of other IEs $P_1 = P_2 = \ldots = P_n = 0.5$.

*The probabilistic significance* of an *i*-event takes into account its position in the structure and its probability. P-significances and contributions are calculated with the real values of IEs probabilities. The contributions of events to the minus and to the plus into the final event probability are determined by giving values 0 and 1 to probabilities in the risk P-function.

*i*-event significance:

$$\Delta P_i = P_y\big|_{Pi=1} - P_y\big|_{Pi=0}, \quad i = 1, 2, \ldots, n. \tag{2}$$

*i*-event contribution to the minus:

$$\Delta P_i^- = P_y\big|_{Pi} - P_y\big|_{Pi=0}, \quad i = 1, 2, \ldots, n. \tag{3}$$

*i*-event contribution to the plus:

$$\Delta P_i^+ = P_y\big|_{Pi} - P_y\big|_{Pi=1}, \quad i = 1, 2, \ldots, n. \tag{4}$$

The simplicity and transparence of risk analysis are one of the main advantages of LP-risk models for management of SCS in economics.

## 9 LP-management of the risk of state and development of systems in economics

*LP-management of system state risk* is performed on the basis of quantitative LP-analysis of significance and contributions of IEs in the following manner:

1 risk analysis by contributions of IEs to system risk is performed

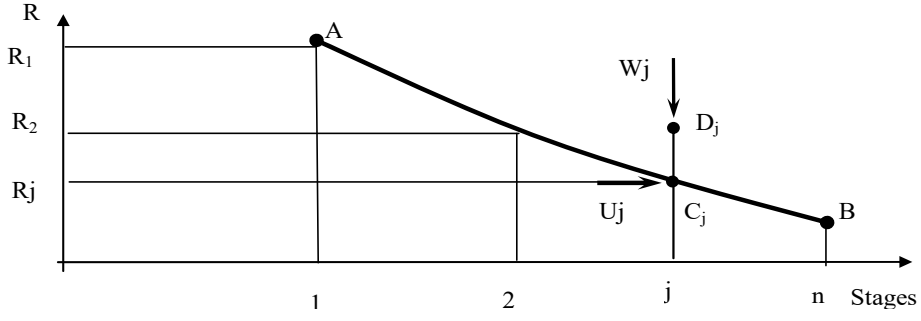
2 a decision is taken about changes in the probabilities of events

3 resources are distributed for change probabilities of the selected events.

*LP-management of system development risk*. We suggest managing the risk of system development failure according to the principle of management a complex system (Solozhentsev, 2016, 2012). We can manage the system movement along the prescribed trajectory and make corrections in case of deviations (Figure 3). Here: $j = 1, 2, \ldots, n$ – are stages of development; $R_j$ – the risk of system failure, $U_j$ – are control actions (resources), $W_j$ – are correcting actions (resources). A system is transferred from its initial state *A* into the final state *B* along the chosen trajectory *A* – *B*.

Structural, logical and probabilistic risk models are developed for a system. System risk *R* is calculated at each stage, contributions of IEs into system risk are analysed. While developing the program of system development management, the values of *R*, *W*, *U* at stages *n* are determined. Resources are required for the realisation of *R*, *W*, *U*, *n*.

**Figure 3** The scheme of system development management




The LP model of the development process failure is built by the logical addition of failure at development stages:

$$Y = Y_1 \vee Y_2 \vee \ldots \vee Y_n. \tag{5}$$

In order to choose optimal *R*, *W*, *U*, *n* we have to know expenses for their introduction: *Qr* – for calculating risks, *Qu* – for control actions, *Qw* – for correcting actions, *Qn* – for the organisation of the stages. And possible losses if we don't incur these expenses: *Sr* – when risk is not calculated, *Su* – when there are no control actions, *Sw* – when there are no correcting actions and *Sn* – when there are no organisation of stages.

## 10 Assessment of management system quality in economics

The management of the state, regions and companies will be considered as structurally complex systems, which have to be managed. For example, let us build the LP-model of management system quality by the structural management of the planning, organisation and control functions (Robbins and Coulter, 2002) (Figure 4), which includes events-propositions regarding the invalidity (quality). Events-propositions about invalidity have the measure of invalidity within the interval [0, 1]. Each function consists of events-propositions for sub-functions. The structural model of the management system quality includes events about invalidity (Solozhentsev, 2017a):

- $Y_1$ – functions of planning: $Y_{11}$ – concepts and principles of planning, $Y_{12}$ – strategic management, $Y_{13}$ – instruments and methods of planning
- $Y_2$ – functions of an organisation: $Y_{21}$ – structures and schemes of organisation, $Y_{22}$ –management of personnel, $Y_{23}$ – reforms and innovations;
- $Y_3$ – functions of management: $Y_{31}$ – behaviour management principles, $Y_{32}$ – rules of management in teams, $Y_{33}$ – employees' motivation, $Y_{34}$ – management of managers;
- $Y_4$ – functions of control: $Y_{41}$ – principles of control, $Y_{42}$ – operations management, $Y_{44}$ –instruments and methods of control.

The logical model of the invalidity (quality) of the management system:

$$Y = Y_1 \vee Y_2 \vee Y_3 \vee Y_4. \tag{6}$$

Logical models of management system invalidity in the equivalent orthogonal form:

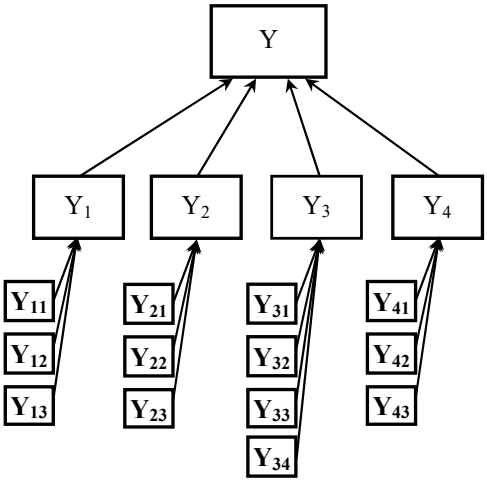
$$Y = Y_1 \vee Y_2\overline{Y_1} \vee Y_3\overline{Y_2}\,\overline{Y_1} \vee Y_4\overline{Y_3}\,\overline{Y_2}\,\overline{Y_1}. \tag{7}$$

Probabilistic models (polynomial) of management system invalidity:

$$R = R_1 + R_2(1-R_1) + R_3(1-R_1)(1-R_2) + R_4(1-R_1)(1-R_2)(1-R_3), \tag{8}$$

where $R_1$, $R_2$, $R_3$, $R_4$ are probabilities of parameters' invalidity.

**Figure 4** Structural model of management system quality




## 11 Examples of studies of structurally complex systems

Brief descriptions of the contents of some studies are given below.

- *LP-management of economic safety in Russia (Solozhentsev, 2017b).* The core of the system contains the combination of two systems and the corresponding LP risk models: the LP-model of the risk of the birth rate and the LP-model of the risk of

housing construction. The combined scenario contains 33 initiating and derived events, connected by logical connections *OR, AND, NOT*. The LP-model of the risk can logically include other models and scenarios, for example, LP-models of counteraction bribes and corruption, counteraction drug addiction, innovation system management, etc. We constructing LP-model of the country's economic risk and perform LP-analysis of the economic risk, review the LP-management of the country's economic risk, economic wars with sanctions and the LP-risk management of economic development.

- *LP-management of the country's innovation system*. We used statistical data on the Global Innovative Index (GII), adopted in international practice (Solozhentsev, 2016, 2015). This GII considers: seven groups of derived indicators of the first level, 21 group of derived indicators of the second level and 84 initial indicators of the lower level. Five groups of indicators evaluate capabilities of the innovation system and two groups of indicators evaluate the results of the innovation system. We developed the Global Logical Innovation Index (GLII) and compared it with the Global Innovation Index for ten countries. We analysed the development of one innovation in Russia, built a hybrid LP-model of the failure risk to solve the problem of innovation. LP-model of LII provides an effective methodology for assessment, analysis and management the country's innovation system. In the GII procedure, all derived indicators at all levels have approximately the same scores (in points), equal to the average score of the initial indicators. The effect of the baseline is averaged. It is impossible to correctly analyse and manage individual indicators.
- *LP-models of counteraction to bribes and corruption*. We set forth axioms of counteraction to bribes and corruption, construct a hybrid LP-model of counteraction failure. We developed LP-models: counteraction to bribes in the institution, LP-model of the risk of bribes based on the behaviour of officials, LP-model of the risk of bribes on the basis of analysis of service parameters (Solozhentsev, 2016).
- *LP-models of counteraction to narcotisation of country*. We justified the choice of the LP-model of failure to counteract drug addiction, built a conceptual LP-model of the risk of drug addiction in the region, gave characteristics of the drug situation in the region, built the LP model of the danger of drug situation on indicators, and carried out studies (Solozhentsev, 2017b).
- *LP-model of the operational risk of the bank and the reservation of capital by Basel*. We built the LP-model of the operational risk of the bank, which allows us to determine the reservation capital volume and research the integration of models and the impact of repeated events (Solozhentsev, 2016, 2017b).
- *LP-models for quality management for systems and products by WTO requirements*. LP models of the system's non-validity have been constructed, and invalid events have been described (Solozhentsev, 2016, 2017b).
- *LP models, monitoring and management of the bank crediting process* (Solozhentsev, 2016, 2017b). We used real data on loans of several banks, built an LP model of credit risk, outlined the methodology and algorithm for identifying the LP model of credit risk according to the bank's statistical data. We outlined the methodology of LP-analysis of credit risk and justified the inability to create a

testing sample. The technology of monitoring and clarification of the LP-model of risk on the signal set of credits is expounded. The management of the lending process is described.

- *LP-management of the risk and efficiency of the restaurant 'Prestige'* (Solozhentsev, 2012, 2017b). We examined the initiating parameters and their gradations, resulted in databases and knowledge base of the restaurant conditions performed a frequency analysis of risk and effectiveness, and LP analysis and forecasting of the restaurant's risk and efficiency, as well as risk and efficiency analysis of parameter contributions.
- *LP-model of the management failure in 'Transas' company*. We described the problem and parameters of the company, outlined methods and models for assessment the failure risk in management in terms of functions, business areas, achievement of target groups. The models for the estimation and management of company's operation quality are presented (Solozhentsev, 2017b).
- *The LP model 'doughnut economy'*. As example of an LP-risk model let consider (Raworth, 2017) 'doughnut economy'. The economic concept of the 21st century, proposed by Kate, has attracted our attention. We propose the LP-model of the invalidity of the mankind's safe space by the invalidity of parameters which can go beyond the inner and outer boundaries of the mankind's safe space (Figure 2).

Let us focus on two consequences of the analysis of parameters which can go beyond the inner and outer boundaries of the system. First of all, our approach and LP-risk models can also be used for assessment, analysis and management of countries, regions, cities, industrial enterprises and companies, as their states is described by a number of parameters which can be invalid and go beyond internal and external boundaries of the free space. Secondly, external invalid parameters are, as a rule, repeated events and they ensure the connection of LP-models of different systems when building a global LP-risk model of a system, for example, a region. We have to take into account repeated events if we want to assess the risk of a large system, as well as the probabilities of IEs.

Proceeding from the subjectivity and objectivity of the definition of invalidity (Solozhentsev, 2016; Ryabinin, 2007), it will be different in different countries and regions and will change depending on the condition of the environment and the standard of population living.

The model of mankind's safe space invalidity is presented as a graph (Figure 5), usual for top-economy and LP-calculus. Invalid parameters, as IEs and, correspondingly, logical variables beyond the outer ring of the safe space are as follows $Y_1$: $Y_{11}$ – change in land utilisation, $Y_{12}$ –fresh water utilisation, $Y_{13}$ – nitrogen and phosphorus cycles, $Y_{14}$ – ocean souring, $Y_{15}$ – chemical waste, $Y_{16}$ – atmospheric aerosol load, $Y_{17}$ – depletion of the ozone layer, $Y_{18}$ – loss of biodiversity.

Invalid parameters as events and, correspondingly, logical variables beyond the inner ring are as follows $Y_2$: $Y_{21}$ – food, $Y_{22}$ – water, $Y_{23}$ – income, $Y_{24}$ – education, $Y_{25}$ – stability, $Y_{26}$ – right to vote, $Y_{27}$ – employment.

The logical model of the invalidity of mankind's safe space looks as follows:

$$Y = Y_1 \vee Y_2, \tag{9}$$

where

$$Y_1 = Y_{11} \vee Y_{12} \vee Y_{13} \vee \ldots \vee Y_{18}; \quad Y_2 = Y_{21} \vee Y_{22} \vee Y_{23} \vee \ldots \vee Y_{211}. \tag{10}$$

The logical model of safe space invalidity in the orthogonal form:

$$Y = Y_1 \vee Y_2 \overline{Y_1}, \tag{11}$$

where $\overline{Y_1} = Y_{11} \vee Y_{12}\overline{Y_{11}} \vee Y_{13}\overline{Y_{11}}\overline{Y_{12}} \vee \ldots$; $\overline{Y_2} = Y_{21} \vee Y_{22}\overline{Y_{21}} \vee Y_{23}\overline{Y_{21}}\overline{Y_{22}} \vee \ldots$

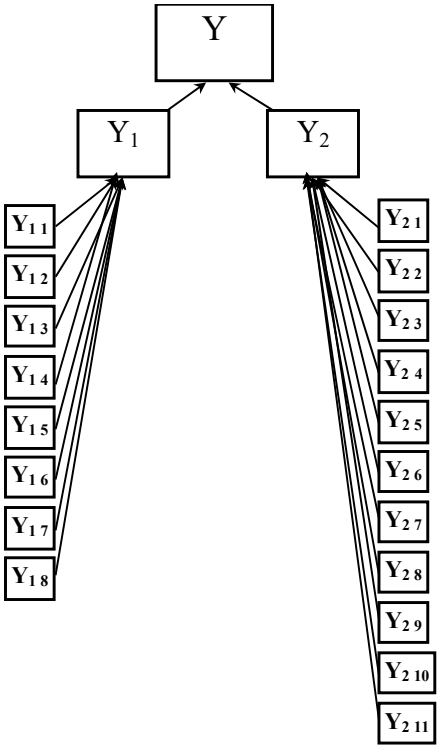
The probabilistic model of mankind's safe space invalidity:

$$P(Y) = P_1 . + P_2 (1 - P_2), \tag{12}$$

$$P_1 = P_{11} + P_{12}(1 - P_{11}) + P_{13}(1 - P_{11})(1 - P_{12}) + \ldots,$$
$$P_2 = P_{21} + P_{22}(1 - P_{21}) + P_{23}(1 - P_{21})(1 - P_{22}) + \ldots$$

Here $P_{11}$, $P_{12}$, …, $P_{18}$; …, $P_{21}$, $P_{22}$, …, $P_{2\ 11}$ are probabilities of the invalidity of parameters.

**Figure 5** Structural model of safe space invalidity




The following logical functions of invalidity $Y$ should be analysed in the model of safe space invalidity (Figure 5) in order to take decisions:

1 logical function of the realisation of at least one criterion ($Y_1 \vee Y_2$)

2 logical function of non-realisation of any criterion ($\overline{Y_1} \wedge \overline{Y_2}$)

3 logical function of the realisation of both criteria ($Y_1 \wedge Y_2$)

4 logical function of the realisation of only the first criterion $(Y_1 \wedge \overline{Y}_2)$

5 logical function of the realisation of only the second criterion $(\overline{Y}_1 \wedge Y_2)$.

## 12 Software for digital management of SCS in economics

A computer can solve all problems which did not exist before computer's invention. Systems of the state and economy have a lot of factors and combinations of possible solutions. The orthogonalisation of the logical function of system risk in order to obtain probabilistic risk functions or the algebraic risk polynom for real systems is impossible without a special software. The potential of computers for management in economics is not used due to the lack of formalisation of economic problems and, correspondingly, the lack of mathematical models. We cannot manage risk and efficiency without risk models. Risk and efficiency are connected: mathematical expectation of losses is equal to risk multiplied by system assets.

The following special certified software was used for digital management (Solozhentsev, 2016; Hovanov et al., 2009; Karaseva and Alexeev, 2015; Mozhaev, 2008):

- *Arbiter* – for structural logical modelling
- *Expa* – for the synthesis of probabilities of events-propositions and assessment of objects' ratings.

Examples of systems management are discussed in Solozhentsev (2016, 2017b, 2018a). The results of system management with real data help us establish following facts: difficult socio-economic problems cannot be solved without scientists and public opinion, reforms in education, science and economics that are needed in order to increase the efficiency of the country's innovations system.

## 13 The further education course for economists

The program of the course of additional education 'management safety and quality in economics' for economists has been developed, tested and licensed. The course program is as follows.

Lecture topics

1 The problem of management in economics:
   - the state of management in economics
   - ephemeral management in economics
   - the exit of economics from the state of a systemic crisis.

2 New objects in management in economics:
   - structurally complex objects in economics
   - government departments
   - socio-economic systems and enterprises

- quality management processes of a person's social and economic life
- safe population living space
- quality and safety criteria in economics.

3 New knowledge in management in economics:

- methodological foundations of management in economics
- methodical foundations of management in economics
- new types of event-propositions in management
- risk scenarios of systems failure in economics
- new types of LP-models of failure in economics.

4 New tasks in management in economics:

- modelling, analysis and control (MAC) of safety and quality of one system
- MAC of safety and quality of a joint system, built from the logical connection of several systems
- MAC of safety and quality of a joint system with different outcomes of success/failure of separate systems
- study of the connection of different systems in joint system with the correct account of repeated IEs
- logical and probabilistic management of the system state
- logical and probabilistic management of the system development
- evaluation of the quality of an management system.

5 Digital management in economics:

- digital economics and digital management
- computer network for event-related digital management in economics
- connection of event-related digital management with innovation and investment
- changes in the work of company personnel in digital management.

6 Information from the algebra of logic:

- truth table
- basic logical operations
- rules for two and three logical variables
- transition from the logical failure function to the probability failure function
- perfect disjunctive normal form
- the shortest paths to successful operation and minimal failure sections.

Laboratory work on special software

7 Software Expa:

- assessment of the probability of the event by one expert
- assessment of the probability of the event by a group of experts
- ranking of systems (objects) by one expert

- ranking of systems (objects) by a group of experts.

8 Software Arbiter:
- structural and logical modelling of system failure risk
- construction and study of a joint LP-model of the system consisting of two or more models of separate systems
- investigation of a joint LP-model of the system with possible outcomes of two separate systems
- investigation of the connections of separate systems in the joint system with the correct account of repeated events.

## 14 A computer network for digital management of SCS in economics

A computer network is a group of computers connected by information channels, as well as the necessary software and hardware for distributed data processing.

In such system any of connected devices can be used for transferring or receiving data. There are computer networks of different size: local and global ones. Local networks work at the distance of several metres to several kilometres. They usually include computers of one organisation or enterprise and are located within one building. Global computer networks connect a lot of computers on huge territories: whole regions, countries and continents, using fibre optic connectivity, satellite communication systems and switched telephone networks for data transfer. The internet is an example of global and local networks joined together.

To create a computer network of digital management we have to (Solozhentsev, 2017a):

1 create a computer network with LP-models of system risk, connecting government departments in regions, cities and enterprises

2 receive and transfer data as events-propositions, systems and events failure scenarios, LP-risk models, results of the assessment and analysis of system risk

3 to use LP-risk models for analysis and management of systems.

The computer network for the digital management of SCSs in economics consists of the following components:

- computers
- knowledge bases as events-propositions and scenarios of systems and events' failure risk
- LP-risk models of systems
- special software for building LP-models of risk and management
- access to the internet
- the education course for managers, economists and teachers.

The computer network for event-related digital management of SCSs in economics has a unified system of models, technologies and software.

## 15 Conclusions

The present work is devoted to the event-related digital management of SCS in economics. This problem is fundamental one for economics and economic science. A new breakthrough scientific direction of research in economics is being formed. New knowledge, tasks, LP-models and special software for management is offered. The event-related digital management of structural complex systems in economics under the criteria of safety and quality is proposed.

The main results of the work are following:

1 Analysis of publications showed the unsatisfactory situation in the management of SCS in economics in the world. They are searching for ways out of the current critical situation.

2 Currently, management of SCS in economics is performed on the basis of ephemeral concepts and goals, 'by concepts', 'manual management' and 'give more money' principles, by promises and appeals, ephemeral programs for economic growth, increase of labour productivity and the revival of the industry in the absence of mathematical models.

3 As a result of the analysis, we conclude that successful evolution depends on the development of new knowledge and new tasks in management of SCS in economics that can change the critical situation in the management.

4 The structural complex systems in economics are: socio-economic systems and projects; business enterprises, the safe space of mankind, government departments and quality management processes of the socio-economic life of a person.

5 The new knowledge for management in economics is introduced. This knowledge face with new types of Boolean event-propositions, risk scenarios for system failure, new types of logical and probabilistic risk models.

6 Safety and quality are necessary conditions for the existence of all systems in economics. The management of these systems by criteria of safety and quality is proposed for implementation.

7 The definition of digital management is given, the concept of digital management of SCS in economics is stated, the relationship of the digital economics and digital management of economics is established. Digital management gives a real opportunity for a wide introduction of the new scientific direction 'event-related digital management in economics'.

8 For the event-related digital management in economics special software and the course of additional education for economists and teachers have been created.

9 Digital event-related management in the economics in the centre and regions of the country is designed to develop annual and long-term evolution programs and for operative management and decision-making.

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## Notes

1 SES is a socio-economic system.