Enterprise Competition and Cooperation Processes Imitation Modeling

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***Abstract*— The paper provides the software module as a part of a united decision support system framework, developed in order to simulate enterprises competition and cooperation processes within the biological species models. Innovative systems economic development aspects are considered. The economic systems characteristics analysis allows estimating small, medium-sized enterprises and corporations influence on the innovative technologies development process.**

Keywords*— *imitation modeling; competition; cooperation; innovation; predator-prey model; decision support system

I. INTRODUCTION

Simulation modeling is aimed at model formation, helps to formalize system's elements relationships, reveal new qualitative characteristics of the system under investigation that could not initially be envisaged, eliminating the existing shortcomings in management and strategic planning.

Enterprises' competition and cooperation processes modeling complexity is determined by the specific properties, which are inherent to economic systems. The economic system is a complex system, the distinctive qualities of which are:

emergence – system's properties presence, which aren't inherent to its individual elements;

self-organization – the structure of the system in the process of its functioning could be changed;

polystructural – different-quality subsystems mutual influence, that form several connected hierarchical structures.

The fundamental principle of the economic systems analysis, development and management is the system approach towards models development. Each element is considered as a structural part of a more complex system, the role of each investigated object in the economic system functioning general process is revealed. The system considered to be as interacting and interdependent components forming a single whole. The study of the systems' elements and their interrelations, processes functioning description, economy possible states analysis are the main prerequisites for effective planning and management.

II. SIMULATION MODEL JUSTIFICATION

Speaking of economic systems, there is a hierarchical model: corporations, medium-sized enterprises, small enterprises form the subsystem elements. Each element is highly connected with consumers. The application of the Lotka-Volterra model, taking into account the statistical data on enterprises, makes it possible to evaluate processes dynamics in each industry and for the production ecosystem as a whole. Lotka-Volterra model is scalable and applicable in both tasks: small enterprises goods consumers' demands and corporations' enterprises acquiring processes assessment. For example, the 'predator' could be a small business company and 'victims' could be customers. In modeling, the following assumptions can be used: in the absence of the required number of companies producing demanded products, the number of potential consumers grows exponentially. In the absence of the company consumers, the producers die exponentially. These assumptions are obvious for economic systems, however, birth and death processes are most often analyzed for the ecological systems populations number. Competition processes simulation modeling using the predator-prey model makes it possible to evaluate the dependence of the economic subsystem elements.

One of the up-to-date, issues is the enterprises modernization [1]. In order to reach competitive products, the company has to know the expectations and implement in practice offers, needed by the market. The ability to build and develop an innovative component, in many ways is determined by the information usage effectiveness. The emergence of new technologies and innovative solutions is affected by a variety of economic factors. A number of measures, developed with the support of the state: research and development, additional financing, targeted investments, state orders, tax incentives, etc., can be considered as significant factors. Enterprises strive for their own purposes to use regional and state legislation and measures taken at the state level to improve the economy and develop science and technology. Mutual influence factor analysis allows to build strategic plans and introduce innovative technologies in various sectors of the economy, create knowledge-intensive and innovative products, with the support of the state.

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Accordingly, competitiveness for medium and small businesses can ensure the availability of innovative technologies. For medium-sized enterprises there is a need to evaluate whether it is more preferable either to fund the researches directly, or absorb small businesses, for instance, in a form of startups purchases. Obviously, corporations have to produce technologies and absorb innovative small and medium-sized businesses. At present the simulation methods set allows to assess various complex systems development dynamics characteristics. In order to find problems' solutions, which were described above, the module aimed for economic systems dynamics analysis had been developed within the DSS STEP framework [2].

III. LOGISTICS DEPARTMENT THROUGHPUT AND RESILIENCY PARAMETERS SIMULATION

It is highly advisable to assess the competitiveness for strategic planning of enterprise development. Interpretation of the model of competition and cooperation will be presented for small and medium-sized enterprises:

$$\begin{cases} \frac{dx}{dt} = (a - \beta y)x - \psi x^2; \\ \frac{dy}{dt} = (-\gamma + \delta x)y - \varphi y^2; \end{cases}$$

where:

x stands for small enterprises number;

y represents medium-sized enterprises number;

a is small enterprises birth rate;

β – small enterprises absorption coefficient by means of averages;

γ – medium-sized enterprises mortality rate;

δ – medium-sized enterprises birth rate;

t stands for time;

ψ – small enterprises intraspecific competition coefficient;

φ – medium-sized intraspecific competition enterprises coefficient.

Statistical data analysis makes it possible to determine the companies' birth and death rates and on its basis to determine development dynamics.

Let's consider statistical data regarding small and medium-sized companies number in Russia in the period from 2010 to 2016. Table 1 presents small and medium-sized enterprises total number (at the end of the year, thousands), according to the data published by the Federal Tax Service of the Russian Federation [3].

TABLE I. SMALL AND MEDIUM-SIZED ENTERPRISES IN RUSSIA 2010-2016

	2010	2011	2012	2013	2014	2015	2016
Small enterprises (thousands)	1644,3	1836,4	2003,0	2063,1	2103,8	2222,4	2777,6
Medium-sized enterprises (thousands)	25,2	15,9	13,8	13,7	13,7	19,3	13,3

Let's analyze economic system dynamics development process using software module DSS "STEP". Fig. 1 shows the interface of the module and gives the initial data, based on statistical values (Table 1).

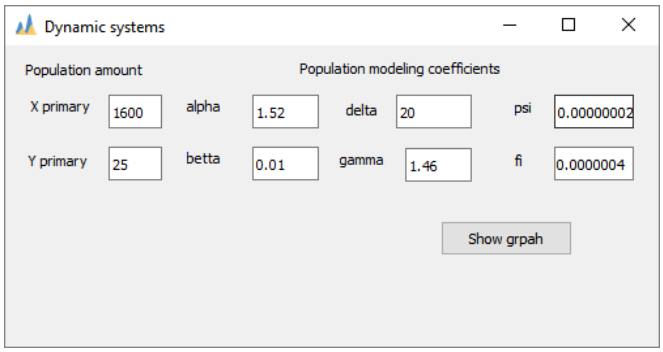

Fig. 1. Dynamic systems main window

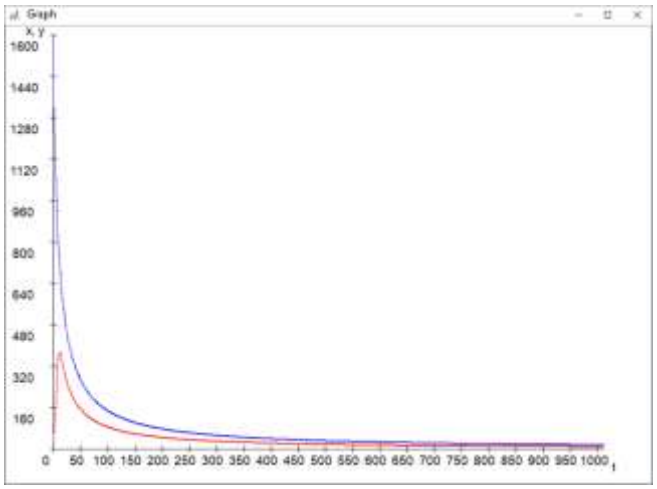

Fig. 2. The number of small and medium-sized enterprises (thousands)

The analysis shows a decrease in the number of companies taking into account competitive relations (acquisitions and intraspecific competition) and allows us to conclude that it is necessary to develop measures aimed to stimulate the small companies' number growth.

Consider innovations statistics in Russia [4]. Innovation is understood as the end result of an innovative activity, embodied in the form of a completely new or improved product (work, service), production process, marketing or organizational method in conducting business, workplace organization, external relations [5]. According to the Federal State Statistics Service, the number of organizations with innovative capacity is growing (Table 2).

TABLE II. SMALL ETERPRISES INNOVATIONS IN RUSSIA 2012-2015

	2012	2013	2014	2015
Number of organizations performing research and development (thousands)	3566	3605	3604	4175
Developed advanced manufacturing technologies (thousands)	1323	1429	1409	1398
Research and development internal costs (billion rubles)		749,8	847,5	914,7
Innovative goods, works, services volume (billion rubles.)		3072,5	3037,4	3258,3

According the data given in Table 2, let us analyze R&D organizations number interaction with advanced technologies developed number (Fig. 2).

Fig. 3. Initial data input window

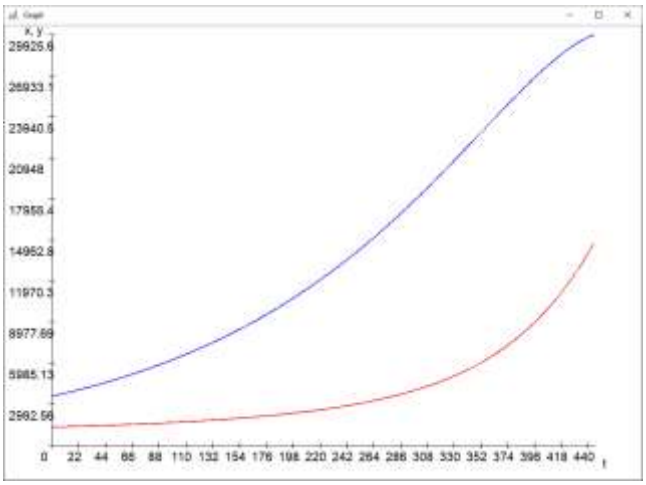

Fig. 4. R&D organizations and technologies numbers (thousands)

Simulation modeling research presents the innovative economic systems development positive dynamics in the Russian Federation. However, if it's taken into account intraspecific competition and acquiring companies peculiarities, it is necessary to stimulate the development of research and development projects, including small businesses (start-ups) at the state level.

IV. EXPERT EVALUATION METHOD IN COMPETITION ANALYSIS TASKS

In order to form enterprises' development strategy it is necessary to evaluate innovative projects. These problems are difficult to formalize and, usually, mathematical methods application is possible only, if expert opinions are taken into account. For example, in order to create innovative technologies that ensure competitiveness, it is necessary to evaluate numerous factors. Let us list some of them: technological development level, personnel qualification, information supplement level, self-financing possibility, investors available, infrastructure features, business environment, etc. The presented spectrum of heterogeneous factors influences economic systems and subsystems states. Accounting for innovations in the technologies being developed introduces additional uncertainty, complicating structural elements interaction processes and determining alternative approaches usage need.

Expert opinions can be processed using information processing systems. As a part of the DSS "STEP" there is a module expert information processing; the module takes into account opinions consistency and experts' competence coefficients [6]. Expert methods basis is a collective cognitive study aimed at projects priority identification. With regard to the tasks of evaluating innovative projects, the expertise collective methodology allows to a weighted conclusion on the competitive advantages evaluation. There are various approaches to expert opinions formation, one of them is object matrices construction and further estimating with M.J. Kendall's consistency coefficient. Let's consider an example of the innovative projects analysis with expert evaluations using the DSS "STEP" software module.

Fig. 5 shows model problem solution – innovation projects evaluation, formed as a result of an expert survey. Experts competence and reliability coefficients allow to determine the relevant opinions. Also experts agreement coefficients and most promising objects recommendations are displayed, calculated on the expert opinions analysis basis.

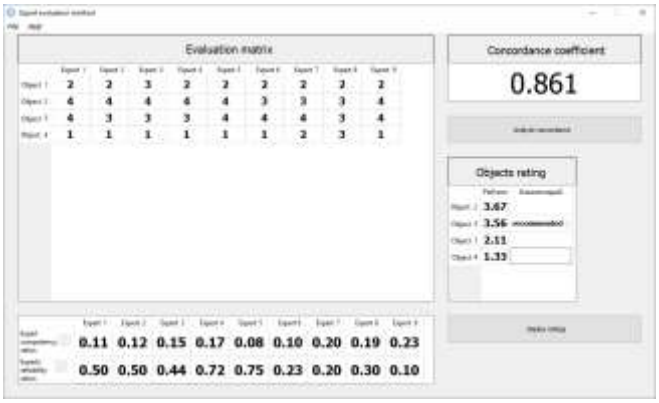

Fig. 5. Expert evaluation module

Despite the fact that the project number 2 has a higher score, the program recommends project number 3. The algorithm used in the software module takes into account experts' competence and reliability coefficients and in case several objects have similar average score, recommends that particular object, which received higher average score regarding most competent and reliable experts. Note that experts' consistency high degree ensures examination best accuracy. Acceptable values of the concordance coefficient are considered never the less 0.7, i.e. at least 70% of experts are unanimous in their assessments.

The presented approach to the innovative technologies analysis based on collective expertise methodology allows to identify most promising projects and highlight prior development areas.

V. CONCLUSION

Economical development can be defined as the consistent and continuous technologies improvement process. Economic systems planning and management processes are aimed at the initial state determination, development goals estimation and possible control actions formalization that implement goals' achievements. As already noted, the economic system is characterized by the hierarchical structure presence: lower level subsystems, as a rule, are aimed at reducing the development goals of a higher hierarchy level systems. This model of top-down management and planning is not always effective, because in many cases innovative technologies emergence occurs spontaneously, like an idea (start-up). In modern conditions of subsystems functioning, planning should be carried out not only taking into account state programs for financing development, but also aimed at developing mechanisms for transition to self-financing [7]. Bottom-up management from, increasing complex subsystems number, while modeling, leads to a positive dynamics and systems' characteristics changes, allowing small businesses to play a significant role in the innovation development. Simulation, aimed at complex systems' elements analysis, allows to identify development relationships and patterns. Decision support systems and economic systems dynamics simulation in conjunction with expert assessments allows the company to solve tasks beyond the power of most other market players, provides the owner with technological excellence and the potential for market leadership.

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