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DEVELOPMENT OF METHODS OF MANAGEMENT BY CLUSTER ECONOMIC SYSTEMS

ABSTRACT

THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PHD) IN THE SPECIALTY "6D070300 - INFORMATION SYSTEMS"

Relevance of the research topic. In practice, the existing methods for solving most applied and important tasks in the economy, such as improving competitiveness in the world market, globalizing economic processes, diversifying and modernizing all of its industries, are very complex and labor intensive. The search for solving such types of problems became the basis for the study of economic theories of mathematical modeling in the field of economics, decision-making, operations research, systems analysis, optimal control, and other methods and theories. Among such methods, special mention should be made of optimal control problems (OCP), which cover a wide range of problems. For example, the OCP in the economy considers such tasks as achieving a certain level of economic development at the scheduled time, creating a balance between producers and consumers, optimal distribution of labor resources and financing in the production process and optimal planning for their improvement, and in the space field, launching artificial earth satellites, manned spacecraft, soft landing on the moon, flights to other planets of the solar system, etc. It should be mentioned that such great mathematicians as L.S. Pontryagin, R. Bellman, V.F. Krotov are at the head of this direction, which arose in the 60s of the twentieth century.

However, at present time, decision-making methods using the theory of optimal control in the field of economics are lagging behind in theoretical and practical development. Despite the fact that many articles have been published on this topic, it can be noted that no new effective methods have been proposed specifically for the OCP in the economy. There are reasons for this. For example, in practice it is not always possible to find an analytical solution of the OCP. In such cases it becomes necessary to solve them on a computer. This, in turn, requires detailed studies of such problems as the development of separate computational algorithms, the creation of software systems and a knowledge base found on these algorithms, the creation and supply of technologies for developing software systems for implementing these processes in solving optimal decision making tasks and control. Therefore, the need to solve such classes of tasks requires the creation of new computational and intelligent information systems, the research and development of which is relevant.

Based on the above, it is possible to present the relevance of the dissertation work by the following points:

1. Development of an information system or module that implements algorithms for solving problems of the above type;

2. The construction of the algorithm for carrying out numerical calculations for the OCP in the economy;

3. Construction of the algorithm for solving problems of transferring the economic system from a given initial state $x(t_0) = x_0$ to the desired final state $x(T) = x_T$ or $x(T) = 0$.

The aim of the research is to create module «Modeling and planning of optimal allocation of labor and investment resources between sectors» for Economics Sectors Management Information System (MIS), which provides the optimal distribution of labor and investment resources and ensures balanced growth in the sectoral economy. Also, to provide an algorithm for constructing a synthesizing control for this module in a convenient form for implementation on a computer.

Objectives of the study. Based on the stated goals, the following tasks are considered in the thesis:

1. Research and analysis of existing technologies and MIS for solving OCP;
2. Development of a module «Modeling and planning of optimal allocation of labor and investment resources between sectors» for Economics Sectors MIS;
3. Development of algorithms for construction synthesizing controls for this module:

– Development of an algorithm for determining the stationary equilibrium state for three-sector economic model of a cluster (TSEMC);

– Development of a synthesis control search algorithm for a linear TSEMC model over a finite time interval without restrictions on the control values;

– Development of a synthesis control search algorithm for a linear TSEMC model over a finite time interval with restrictions on the control values;

– Development of a synthesis control search algorithm for a non-linear TSEMC model over a finite time interval with restrictions on the control values;

– Development of an optimal stabilization search algorithm for a non-linear TSEMC model on an infinite time interval with restrictions on the control values;

4. Creating software tools that implement these algorithms and the system;
5. Testing the performance of the proposed module based on experimental calculations.

The object of the research is the mathematical model of TSEMC, which is described by a system of ordinary differential equations and nonlinear algebraic equations.

Subject of study. Development of an algorithm for constructing synthesizing controls based on the feedback principle for dynamic systems with fixed ends of trajectories, as well as the module that implements this algorithm.

Scientific novelty.

1. Proposed module «Modeling and planning of optimal allocation of labor and investment resources between sectors» for Economics Sectors MIS;

2. Proposed of algorithms for searching the synthesizing control for TSEMC;

– Algorithm for determining the stationary equilibrium state for TSEMC;

– Algorithm of searching for synthesizing control for linear model TSEMC on a finite time interval without restrictions on the control values;

– Algorithm of search for synthesizing control for linear model TSEMC on a finite time interval with restrictions on control values;

– Algorithm of search for synthesizing control for non-linear model TSEMC on a finite time interval with restrictions on the control values;

– The algorithm for finding the optimal stabilization for the non-linear model TSEMC on an infinite time interval with restrictions on the control values;

Structure and scope of research. The thesis consists of an introduction, 4 chapters, a conclusion, a list of references and 4 applications. The thesis is a typewritten text with a volume of 122 pages, including 7 tables, 55 figures.

Theoretical and practical significance of the research. The use of the Lagrange multipliers method of a special type in the mathematical model of a TSEMC given by balance ratios makes it possible to plan and organize an economic cluster, to study the transition processes arising from changes in economic policy. The developed module provides an ability to make optimal decisions and makes it possible to interactively make decisions using existing information.

In this work, numerical calculations are performed that make it possible to determine the trajectories of the optimal distribution of resources between sectors based on data from the state statistical service of the Republic of Kazakhstan.

The dissertation research originates from a research grant project on the topic “Development of mathematical methods and algorithms for optimal resource allocation for the balanced growth of a three-sector economic model of a cluster” (state registration number No. 0115PK00763), which was in force in 2015-2017.

The main provisions for the defense.

1. Development of a module “Modelling and planning for optimal allocation of labor and investment resources among sectors” for Economics Sectors MIS;

2. Development of algorithms for searching the synthesizing control for TSEMC. In the offered module for TSEMC, the development algorithms for the following class tasks:

– Development of algorithms for searching the synthesizing control for the linear model of TSEMC in a finite time interval without restrictions on the control values;

– Development of a synthesis control search algorithm for a linear TSEMC model over a finite time interval with restrictions on the control values;

– Development of a synthesis control search algorithm for a non-linear TSEMC model over a finite time interval with restrictions on the control values;

– Development of an optimal stabilization search algorithm for a non-linear TSEMC model on an infinite time interval with restrictions on the control values.

Approbation of scientific work and articles. The scientific results of the work are presented and reviewed in international scientific conferences: IX International Asian School-Seminar “Problems of Optimization of Complex Systems”, Almaty, 2013 (Dr. Sc., Professor V.K. Popkov, Russia); International Scientific Conference "Science, technology and innovative technologies in the prosperous epoch of the powerful state", Turkmenistan, Ashgabat, 2015; International Scientific Conference "Computational and Informational Technologies in Science, Engineering and Education", Almaty, 2015; 36th International Information Systems Architecture and Technology Conference, Poland, Karpacz, 2015; International Scientific Conference "Modern Innovations in Science and Production, Improving the Quality of Education", Ekibastuz Engineering and Technical Institute named after K. Satpayev, Ekibastuz, 2014, 2017; International Scientific Conference of Students and Young Scientists “Farabi World”, Almaty, 2015, 2018; 4th International Scientific and Practical Conference "Modern processes and innovations in science and production", Russia, Kemerovo, Mezhdurechensk, 2015; The 10th International Scientific Conference "Research and Applications of Intelligent Information Systems and Database Systems", Vetnam, Dong Noi, 2018; III International Scientific Conference "Informatics and Applied Mathematics", Almaty, Kazakhstan, September 26-29, 2018.

The thesis was discussed at scientific seminars of the Department of Information Systems and of the Faculty of Information Technologies of the Al-Farabi Kazakh National University.

In the process of carrying out the research 20 scientific works were written. Among them 3 articles were published in journals proposed by the CCES of MES RK:

1. Tussupova K.B. Optimal'noye raspredeleniye investitsiy v trekhsektornoy modeli ekonomiki. Vestnik KazNTU, №5(105), 2014. – С. 431-435.

2. Tussupova K.B. Ekonomikalyk klasterdegi ondirsi salasyn ush sektorly ulgige caikestendiru.KazUTU habarshysy, №5(105), 2014. – Б. 435-441.

3. Z.N. Murzabekov, K.B. Tussupova. Resheniye zadachi optimal'nogo upravleniya dlya nelineynoy modeli trekhsektornogo ekonomicheskogo klastera na konechnom intervale vremeni Vestnik KazNITU, №4(128), 2018. – С. 152-159.

4 scientific articles were published in journals indexed in the Scopus and Thomson Reuters databases:

1. Murzabekov Z., Marek Milosz M., Tussupova K. Modeling and optimization of the production cluster // Proceedings of 36th International Conference on Information Systems Architecture and Technology – ISAT 2015, – Part II.: –Wrocław University of Technology, Poland, 2015**.** Vol. 430. **–** P. 99-108.

2. Murzabekov Z.N., Milosh M., Tussupova K.B.: Resheniye zadachi poiska statsionarnogo sostoyaniya v trekhsektornoy ekonomicheskoy modeli klastera. Actual Problems of Economics, №3(165), 20ч15. – 443-453.

3. Murzabekov, Z., Miłosz, M., Tussupova, K. The Optimal Control Problem with Fixed-End Trajectories for a Three-Sector Economic Model of a Cluster**.** // 10th International scientific conferences on research and applications in

the field of intelligent information and database systems, ACIIDS 2018: – Dong Hoi City, Viet Nam, 19 March, 2018. Vol. 10751 LNAI. – P. 382-391.

4. Marek Milosz, Zainel Murzabekov, Kamshat Tussupova, Saltanat Usubalieva. Optimisation of Discrete Processes with Bounded Control. Journal of Information Technology and Control. Vol. 47, № 4, 2018. – P. 684-690.

13 articles were published in materials of international scientific conferences:

1. Murzabekov Z.N., Tussupova K.B. Zadacha optimal'nogo upravleniya na beskonechnom intervale vremeni v trekhsektornoy modeli ekonomiki. // Trudy IX mezhdunarodnoy aziatskoy shkoly-seminara «Problemy optimizatsii slozhnykh sistem»: – Almaty, Kazakhstan, Institut problem informatiki i upravleniya, 2013. – C. 198-199.

2. Murzabekov Z.N., Tussupova K.B. Zadacha nelineynogo programmirovaniya pri nalichii dvustoronnikh ogranicheniy. // Trudy IX mezhdunarodnoy aziatskoy shkoly-seminara «Problemy optimizatsii slozhnykh sistem»: – Almaty, Kazakhstan, Institut problem informatiki i upravleniya, 2013. – C. 197-198.

3. Tussupova K.B. Sozdaniye strukturnoy modeli ekonomicheskogo klastera na osnove trekhsektornoy modeli ekonomiki// Materialy mezhdunarodnoy nauchno – prakticheskoy konferentsii v ramkakh XIII Satpayevskikh chteniy «Povysheniye kachestvo obrazovaniya i nauchnykh issledovaniy», Yekibastuzskiy inzhenerno-tekhnicheskiy institut im. akademika K. Satpayeva: – Ekibastuz, Kazakhstan, 16-17 май, 2014. – C. 415-418.

4. Tussupova K.B. Resheniye statsionarnoy zadachi trekhsektornoy modeli ekonomiki metodom mnozhiteley Lagranzha// Materialy Mezhdunarodnoy nauchnoy konferentsii studentov i molodykh uchenykh «Farabi әlemí»: - Almaty, Kazakhstan, 13-16 aprel', 2015. – C. 188.

5. Tussupova K.B. Modelirovaniye i poisk statsionarnogo sostoyaniya proizvodstvennogo klastera // Materialy IV Mezhdunarodnoy nauchno – prakticheskoy konferentsii «Sovremennyye tendentsii i innovatsii v nauke i proizvodstve»: - Kemerovo, Mezhdurechensk, RF, 8-10 aprel', 2015. – C. 150 – 151.

6. Zainelkhriet N.M., Tussupova K.B., Milosz M., Milosz E. Parametric analysis of the production cluster balance state // Abstracts of papers of the International Scientific Conference “Science, technology and innovative technologies in the prosperous epoch of the powerful state”: – Ashgabat, Turkmenistan, June 11-13, 2015. – P. 219-220.

7. Murzabekov Z.N., Milosh M., Tussupova K.B. Modelirovaniye raspredele¬niya resursov v trekhsektornoy matematicheskoy modeli klastera // International Conference «Computational and Informational Technologies in Science, Engineering and Education»: abstracts, – CITech2015: – Almaty, Kazakstan, 24-27 sentyabr', 2015. Kazakhskiy Natsional'nyy Universitet im. al'-Farabi, 2015. – C. 216-217.

8. Murzabekov Z.N., Tussupova K.B. Optimizatsiya raspredeleniya resursov v trekhsektornoy modeli ekonomicheskogo klastera // Materialy VI

Mezhdunarodnoy konferentsii «Problemy optimizatsii i ekonomicheskiye prilozheniya»: Omskiy Gosudarstvennyy Universitet im. F.M. Dostoyevskogo, – Omsk, RF, 28 iyun' – 4 iyul', 2015. – C. 159.

9. Tussupova K.B. Resheniye zadachi poiska statsionarnogo sostoyaniya v trekhsektornoy ekonomicheskoy modeli klastera // Materialy mezhdunarodnoy nauchno – prakticheskoy konferentsii v ramkakh XIV Satpayevskikh chteniy «Povysheniye kachestvo obrazovaniya i nauchnykh issledovaniy», Yekibastuzskiy inzhenerno-tekhnicheskiy institut im. akademika K. Satpayeva: – Ekibastuz, Kazakhstan, 15-16 may, 2015. – C. 320-321.

10. Tussupova K.B. Problem definition of optimum control of the production cluster // Sbornik trudov mezhdunarodnoy nauchno-prakticheskoy konferentsii «Povysheniye kachestvo obrazovaniya, sovremennyye innovatsii v nauke i proizvodstve», Yekibastuzskiy inzhenerno-tekhnicheskiy institut im. akademika K. Satpayeva: –Ekibastuz, Kazakhstan, 15-16 maya, 2016. – C. 101-103.

11. Tussupova K.B. Chislennyye raschety dlya zadachi optimal'noy stabilizatsii odnasektornoy ekonomicheskoy modeli klastera// Sbornik trudov mezhdunarodnoy nauchno – prakticheskoy konferentsii «Povysheniye kachestvo obrazovaniya, sovremennyye innovatsii v nauke i proizvodstve», Yekibastuzskiy inzhenerno-tekhnicheskiy institut im. akademika K. Satpayeva: –Ekibastuz, Kazakhstan, 15-16 maya, 2017. – C. 175-178.

12. Tussupova K.B. Modeling and optimization of the production cluster // V International Farabi Readings, Materials International Scientific Conference of Students and Young Scientists “Farabi Alemi”: - Almaty, Kazakhstan, 3-13 April, 2018. – P. 19.

13. Murzabekov Z.N., Tussupova K.B. Resheniye zadachi optimal'noy stabilizatsii odnoy nelineynoy sistemy ekonomiki s ogranichennym upravleniyem // Materialy III Mezhdunarodnoy nauchnoy konferentsii «Informatika i prikladnaya matematika», posvyashchennaya 80-letnemu yubileyu professora Biyasheva R.G. i 70-letiyu professora Aydarkhanova M.B.: – Almaty, Kazakhstan, 26-29 sentyabrya, 2018. – C. 332-341.