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Mini Review

On some problems in economic dynamics are solved using reliable computing experiment

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In this brief overview, we give examples of economic dynamics problems with references to works in which such problems are studied using modern computer technologies, as well as to works that provide a theoretical basis for such studies. Following [1, 657], by reliable computing experiment (RCE) we mean such purposeful computer calculations combined with analytical studies that lead to the strict establishment of new facts (theorems).

Currently, in the context of the digital transformation of the economy, the role of mathematical methods and information technologies is noticeably increasing. One of the most important directions is related to the application of a targeted approach to management and forecasting tasks for socio-economic systems, which makes it possible to find ways and methods to achieve strategic goals, balance goals, and means of achieving them at the level of macroeconomic indicators and determine attainable values of goals.

It should be noted that effective methods and algorithms are developed, as a rule, for fairly simple mathematical models with continuous or discrete time. For more complex models that take into account the aftereffect and combine continuous and discrete dynamics, sometimes called hybrid models (see, for instance [2–7] and references therein), most of the results are quite far from the issues of effective computer implementation. Research conducted at the Department of Information Systems and Mathematical Methods in Economics, Perm State University, makes it possible to fill this gap based on new ideas and approaches using the results of the contemporary theory of functional differential equations (FDEs; see [8]). Those results allow one to develop constructive

methods for the study of various problems of theoretical and applied interest, for example, boundary value problems, control problems, attainability problems, variational problems, and stability problems. Theoretical results give the opportunity of a wide choice of spaces for trajectory and control variables within the unified approach. Results on the solvability for the above-mentioned classes of problems within the framework of the constructive approach are formulated as theorems whose conditions can be verified by using a computer and special computational technologies, for details we refer to the paper [9].

The theoretical basis for the application of RCE to the study of hybrid economic dynamic models is the results of the paper [10]. There the setting of the general linear boundary value problem (BVP) is given, and conditions for the solvability of BVP are obtained. The control problem (CP) with target conditions given by a finite collection of linear functionals is set up and some conditions for the solvability of CP are obtained in the form that allows applying the RCE technology for the study of urgent real-world problems in Economic Dynamics. Questions of computer-aided techniques for studying these problems are discussed.

As noted above, with the given resource constraints, determining the attainable values of the targets is an important task. In the paper [11], for a case of constrained control, the notion of the l -attainability set is introduced, which is a generalization of the classical notion considered in extensive literature. Main relationships that open a way to study this set with the use of computer-aided techniques are derived. Further results of the study of the l -attainability sets to various classes of hybrid models with aftereffects are presented in [12–14].



Economic dynamics models in the form of linear functional differential systems with continuous and discrete times (hybrid models) are considered in [15]. The focus of attention is periodic BVPs with deviating arguments, control problems with respect to general vector-functional, and questions of stability to solutions. For BVPs, some sharp sufficient conditions of the unique solvability are obtained. The attainability of target values is under study as applied to CPs with polyhedral constraints on the control, some estimates of the attainability sets are presented. For a class of hybrid systems, a description of the asymptotic properties of solutions is given.

The applied results use the achievements of the theory and are implemented in the form of software tools for the study and solution of the real economic problems such as forecasting, control, and stability analysis as applied to models of socio-economic development of the regions of the Russian Federation and the Russian Economy as a whole [16].

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