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REPORT

By a Member of the Dissertation Committee for the Dissertation
by Artem Aleksandrovich Sedakov "Dynamic network games"
submitted in satisfaction of the requirements
for the degree of Doctor of Sciences in Physics and Mathematics
(specialization 01.01.09 Discrete Mathematics and Mathematical Cybernetics)

The Dissertation of A.A. Sedakov (presented in full in two languages, Russian and English) consists of Introduction and five chapters. Each of the chapters, besides of general theoretical results, also suggests interesting illustration examples and applications and is concluded by list of the author's contributions obtain in the corresponding chapter.

It gives me a pleasure to submit this report on the Thesis by A.A. Sedakov, due to this impressive and comprehensive work by A.A. Sedakov is of highest quality and represents a summary of a monumental body of work performed by A.A. Sedakov over the past few years that has provided a solid theoretical basis for dynamic cooperative theory and its application to social networks, capital accumulation in economic environment and pollution control in environmental management.

Chapter 1 deals with cooperative dynamic games based on a given noncooperative dynamic game in different scenarios. In particular, the strong time consistency of such cooperative solutions as the core and the Shapley value was studied. Sufficient conditions for the strong time consistency of the core of such games were established. In case when these conditions do not hold, the other sufficient conditions are derived for the strong time consistency of a distribution procedure for a core imputation, which helps to implement the cooperative agreement without a risk that any player decides to break it. Strong time-consistent imputation distribution procedures under a linear transformation of the characteristic function of the cooperative dynamic game is presented. Convergence of iterative transformation rule is shown. Finally, for a special class of cooperative dynamic games with discounting, sufficient conditions are established for the strong time consistency of a distribution procedure for both a core imputation and the Shapley value.

Chapter 2 studies two-stage network games, in which players form an undirected network at the first stage, and then at the second stage, they choose controls based on their objectives in the existing network. Three types of players' behavior are considered: Nash equilibrium, cooperation at both stages, and its mixture, in which cooperation is possible only at the second stage of the game.

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Extensions of the developed theory of two-stage network games to the case of directed networks as well as multistage network games are discussed. To ensure the subgame consistency of a cooperative solution, an imputation distribution procedure is designed explicitly.

Chapter 3 considers a model of a social network with two principals, and the conditions are established for the reachability of a consensus under opinion dynamics defined by a linear stationary system. In the cases when a consensus is not reached, reachability conditions are derived for a consensus of the majority. A generalization of the two principals model to heterogeneous agents is suggested for the set of agents is divided into three disjoint subgroups: agents whose beliefs are directly influenced only by the first principal, agents whose beliefs are directly influenced by both principals, and agents whose beliefs are directly influenced only by the second principal. For such social network the existence of a consensus under the linear dynamics of beliefs is proven.

Chapter 4 provides a model of sequential formation of a network by players as a game with perfect information. As players' payoffs in that game, the Shapley value as well as the solutions to games with restricted communication (the Myerson value, the AT-solution and the centrality rewarding Shapley and Myerson values) are considered. A subgame perfect equilibrium as well as an indifferent equilibrium are derived.

Finally, to study the cost of noncooperation in the class of dynamic games played over event trees Chapter 5 considers a linear-state game played over an event tree for multidimensional state and control variables. Equilibrium strategies, payoffs price of anarchy are found in closed form and illustrated by a pollution control problem.

While I was generally familiar with A.A. Sedakov works, it was a pleasure to me to see them summarized and presented in one comprehensive work of high quality and corresponding to high standard for the field worldwide.

While there is a very little to criticize in this thesis I mention just that it might be more convenient for the readers if at the beginning of each chapter besides of discussion of related literature a subsection with the most related literature should be given, and also directly has to be established what new results are obtained compare with the one obtained in literature. Also, after possible application of the developed theory is announced, the reader might expect to read further what new the obtained result gives for such applications not just in terminology of game theory. Say, on page 84, after "a special class of cooperative dynamic games was studied which finds its application in such areas as, for example, capital accumulation in economic environment or pollution control in environmental management" the reader might expect to read what new the obtained result gives for pollution control. Say, they improve something, they allow the decision maker to do something…. Also, I have noted a few misprints and grammar issues in the text, for example, page 284, "it holds true that" presumably should be "the following relation holds:"

In conclusion, the Thesis "Dynamic network games" by Artem Aleksandrovich Sedakov clearly meets the basic requirements established by Order No. 6821/1 of 1 September 2016, "On the Procedure for Awarding Degrees at Saint Petersburg State University," and exceeds the high standards for Doctor Thesis and Artem Aleksandrovich Sedakov fully deserves to be awarded the

degree of Doctor of Sciences in Physics and Mathematics (specialization 01.01.09 Discrete Mathematics and Mathematical Cybernetics). Clause 11 of the aforementioned Order was not broken by the author of the Thesis.

Sincerely,

Andrey Garnaev

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25 August 2020