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REPORT

By a member of the dissertation committee of the dissertation of SEDAKOV Artem Aleksandrovich on the theme: "Dynamic Network Games", submitted in conformity with requirements for the degree of Doctor of Physico-Mathematical Sciences in Speciality 01.01.09 — Discrete Mathematics and Mathematical Cybernetics.

The thesis of Artem Sedakov consists of 5 technical chapters as well as of Introduction, Conclusions and Bibliography. In the Introduction, the candidate carefully described the motivation of the work, the relation of the work with the state of the art and the main contributions of the thesis.

Chapter 1 considers fairly general cooperative dynamic games of which the cooperative dynamic network games represent a subclass of games. For cooperative dynamic games, the problem of the strong time consistency of such classical cooperative solutions as the core and the Shapley value have been studied. Sufficient conditions guaranteeing their strong time consistency have been formulated. The conditions which guarantee the strong time consistency of an imputation distribution procedure for an imputation from the core have been found in closed form. Interestingly, it may happen that the imputation components are not nonnegative, even if players' stage payoffs are nonnegative along the cooperative trajectory. To mitigate this phenomenon, the author has proposed the scheme of transformation of the characteristic function in the cooperative dynamic game. Furthermore, the relative payments to players according to the proposed procedure remain constant along the cooperative trajectory. All these are very nice results that have important implications far beyond the dynamic network games.

In Chapter 2 some general results of Chapter 1 have been specialized to the cooperative dynamic network games. To understand the essence of the game, the candidate has first investigated dynamic two-stage games in detail in which at the first stage players form a network and at the second stage they

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choose actions determining their payoffs. The author has established conditions on players' payoff functions under which the definition of the characteristic function in the game (in case of full or partial cooperation) according to the von Neumann and Morgenstern approach is reduced to solving a maximization problem. In particular, in the case of full cooperation of players, the conditions guaranteeing the time consistency and the strong time consistency of the cooperative solution have been found. The developed theory for two-stage network games is then extend it to multistage network games. Interestingly, under some conditions, the cooperative strategy profile also becomes a Nash equilibrium. Then, the candidate extends the theory to cooperative repeated network games with shock, in which some random effects affect connections between players.

In Chapter 3, first building on the DeGroot classical model of social influence, Artem Sedakov has proposed a modification of the DeGroot model with two leaders (principals, influence centers). The candidate has established the conditions for the reachability of a consensus and in the cases when a consensus cannot be reached, the candidate has established reachability conditions for a consensus of the majority. Then, in the second part of the chapter, Artem Sedakov has proposed a game-theoretic model with several leaders (players) and influenced agents who cannot control the process. The model is basically a particular case of the linear-quadratic cooperative game. Using the linear-quadratic structure, the candidate has developed cooperative strategies both for open-loop and feedback settings. When the influence coefficients are not known, the candidate has proposed to use the closeness centrality to construct the required coefficients.

In Chapter 4 the candidate considers finite horizon perfect information games where the result of the game is network formation. As equilibrium concepts, the candidate has used a subgame perfect equilibrium, and in the case of its nonuniqueness, an indifferent equilibrium was adapted. In addition, the cooperative dynamic games with uncertain payoffs, i.e., interval payoffs, have been studied. It has been observed that a cooperative outcome may not be realized as the game develops along the prescribed cooperative agreement. Then, as a cooperative solution to the game, Artem Sedakov has introduced the interval Shapley-like value, that satisfies the indifference efficiency property. To realize the interval value, the candidate has introduced an appropriate imputation distribution procedure.

In Chapter 5 the candidate has studied the cost of noncooperation in the class of dynamic games played over event trees. The candidate has analysed in detail the games with a linear-state structure. For such games, many characteristics can be calculated analytically. In particular, this allows to perform a careful analysis of the price of Anarchy. Then, Artem Sedakov has applied the the general results to a pollution control game, where the sensitivity of the price of anarchy to various game parameters has been studied.

Finally, in Conclusions the candidate has summarized the main achievements of the thesis and mentioned the main publications that lead to the thesis. I wished future research has also been discussed but may be this is not required by the standard.

This thesis of Artem Sedakov lays a foundation of the theory of dynamic network games and provides a significant development of this theory as well as numerous applications in

telecommunication, economics, management and social science. The results of the thesis have been presented in important conferences on dynamic games and networks (such as *ISDG*, *GTM*, *GameNets*) and in high-level journals (such as *Applied Mathematics and Computation, Dynamic Games and Applications, Automation and Remote Control, International Game Theory Review, Mobile Networks and Applications*). Most of the publications are indexed by Scopus.

For all the above reasons, I conclude that the dissertation of SEDAKOV Artem Alexandrovich on the theme "Dynamic Network Games" meets the requirements established by Order No. 6821/1 of 1 September 2016, "On the procedure for awarding academic degrees at Saint Petersburg State University", and the candidate SEDAKOV Artem Alexandrovich deserves the award of the degree of Doctor of Physico-Mathematical Sciences in the Speciality 01.01.09 — Discrete Mathematics and Mathematical Cybernetics. Clause 11 of the aforementioned Order by the author of the thesis is not broken.

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29 August 2020.