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Game Theory and Applications

3rd Joint China-Dutch Workshop
and 7th China Meeting, GTA 2016
Fuzhou, China, November 20–23, 2016
Revised Selected Papers

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Preface

Recently, non-cooperative and cooperative games — particularly cooperative games with coalitional structures, fuzzy non-cooperative and cooperative games, dynamic games, evolutionary games, mechanism design, bargaining games, and auctions — are attracting significant coverage from researchers in many subjects or disciplines such as game theory, operations research, mathematics, decision science, management science, and control theory. Moreover, non-cooperative and cooperative games are successfully applied to various fields such as economics, management, industrial organization, operations and supply chain management, human resources, energy and resource management, biology, and others. In this context, to strengthen the ongoing scientific interaction between the two game theory societies of The Netherlands and China and to promote academic research, exchange, and collaboration among researchers from The Netherlands and China as well as other countries, Fuzhou University of China, Northwestern Polytechnical University of China, University of Twente of The Netherlands, and the Game Theory Subcommittee of Operations Research Society of China hosted the Third Joint China–Dutch Workshop on Game Theory and Applications and the 7th China Meeting on Game Theory and Applications (GTA 2016), which was held during November 20–23, 2016, at Fuzhou University, Fujian, China.

The GTA 2016 received 162 abstract submissions and there were about 180 participants from The Netherlands, USA, UK, Japan, Canada, Russia, and China.

After GTA 2016 in Fuzhou, we prepared the proceedings of GTA 2016 for publication in *Communications in Computer and Information Science* (CCIS) by Springer. Thus, we contacted the experts and scholars attending GTA 2016 and invited them to extend their conference papers for consideration in this publication. Finally, we received and accepted 25 full papers after two rounds of peer review. The 25 papers cover non-cooperative and cooperative games as well as non-cooperative and cooperative games under uncertainty and their applications.

The paper "Repeated Games and Price Wars," written by Ronald Peeters, Hans Peters, Erik Pot, and Dries Vermeulen, discusses collusive equilibria under private and public information and collusive equilibria when market shares form a martingale. The authors show that firms can collude using dynamic price adjustment strategies under the two conditions of public observability and limited volatility of market shares. Particularly, the authors show that collusion can no longer be sustained when the condition of limited volatility of market shares is violated.

The paper "A Game Theory Approach for Deploying Medical Resources in the Emergency Department," by Cheng-Kuang Wu, Yi-Ming Chen, and Dachrahn Wu, proposes a framework for emergency response services that incorporates two game theory models designed to deploy response medical resources when raising three threat advisory levels. The experimental results show that the developed model is feasible, which may provide a method for improving efficiency in emergency department.

The paper "Non-cooperative Monomino Games," authored by Judith Timmer, Harry Aarts, Peter van Dorenvanck, and Jasper Klomp, investigates monomino games, which are two-player games played on a rectangular board with R rows and C columns. The game pieces are monominoes, which cover exactly one cell of the board. One by one each player selects a column of the board, and places a monomino in the lowest uncovered cell. This generates a payoff for the player. The game ends if all cells are covered by monominoes. The goal of each player is to place his/her monominoes in such a way that his/her total payoff is maximized. The aim of this paper is to derive the equilibrium play and corresponding payoffs for the players.

The paper "Bargaining Model of Mutual Deterrence Among Three Players with Incomplete Information," by Yan Xiao and Deng-Feng Li, studies the tripartite bargaining problem of mutual deterrence from the perspective of Rubinstein indefinite bargaining and cooperative game theory. The authors mainly establish a tripartite mutual deterrence bargaining model with unilateral and bilateral incomplete information by introducing incomplete information and defining discount factors. Specifically, the analytical formula is obtained to calculate the Nash equilibrium distribution for each player under incomplete information. The developed model and method may provide a new way for solving multiple mutual deterrence or conflict problems with incomplete information.

The paper "Stakeholders' Behavior Analysis and Enterprise Management Strategy Selection in Chinese Ancient Village Tourism Development," by Wei Fei, investigates how to exploit and protect ancient villages in tourism development, since Chinese ancient villages are an important type of non-renewable tourism resource. The author firstly identifies the stakeholders (i.e., players) who have an interest and play important roles in Chinese ancient village tourism development and protection. Then, the author systematically analyzes the stakeholders' relations, interaction, and importance in the exploitation and protection of Chinese ancient village tourism. Finally, the author elaborates on stakeholders' behaviors and hereby proposes enterprise management strategies for Chinese ancient village tourism.

The paper "Two Bargain Game Models of the Second-Hand Housing Commence," written by Rui Wang and Deng-Feng Li, discusses the problem of bargaining about final prices of houses for sale on the second-hand house market. Two bargaining models for indefinite and finite periods are established for sellers and buyers. For the indefinite period, the authors derive the complete equilibrium solution of the bargaining game model between the buyers and sellers. Hereby, the game equilibrium solution in the second stage is obtained through imposing some constraints on time. The results show that the game between sellers and buyers depends on the ratio of the discount factor of each seller or buyer.

The paper "Some Relaxed Solutions of Minimax Inequalities for Discontinuous Games," by Xiaoling Qiu and Dingtao Peng, proves the existence of minimax inequalities under some relaxed assumptions by using the KKMF principle or Fan–Browder fixed point theorem and propose the pseu-solution of minimax inequalities. As applications, the authors introduce pseu-Nash equilibriums for n-person non-cooperative games and obtain some relaxed existence conclusions.

The paper "Dynamic Games of Firm Social Media Disclosure," written by Bing Wang, Wei Zheng, and Yan Pan, discusses the game problem of firm social media disclosure. The authors propose a three-stage dynamic game model to analyze the process of social media information disclosure. In the first-stage model, firms disclose social media because of low costs and high incomes so that they get more attention in competition. By introducing investors in the second-stage model, firms disclose exaggeratedly in order to get more benefits from investors in the complete information-static game. In the third-stage model, by introducing the external regulators, the authors propose a repeated game model with incomplete information, which has an equilibrium when the repeated time is sufficient.

In the paper "On Stochastic Fishery Games with Endogenous Stage–Payoffs and Transition Probabilities," Reinoud Joosten and Llea Samuel engineer a stochastic fishery game in which overfishing has a twofold effect: It gradually damages the fish stock inducing lower catches in states high and low, and it gradually causes the system to spend more time in the latter state with lower landings. To analyze the effects of this "double whammy" technically, the authors examine how to determine the set of jointly-convergent pure-strategy rewards supported by the equilibrium involving threats, under the limiting average reward criterion.

The paper "N-Person Credibilistic Non-cooperative Game with Fuzzy Payoffs," written by Chunqiao Tan and Zhongwei Feng, presents n-person non-cooperative games with fuzzy payoffs. Three credibilistic criteria are introduced to define behavior preferences of players in different game situations based on credibility theory. Hereby the authors propose three solution concepts of credibilistic equilibria and prove their existence theorems. Furthermore, the authors propose three sufficient and necessary conditions for computing credibilistic equilibrium strategies.

The paper "Pareto Optimal Strategies for Matrix Games with Payoffs of Intuitionistic Fuzzy Sets," written by Jiang-Xia Nan, Cheng-Lin Wei, and Deng-Feng Li, focuses on developing an effective methodology for solving matrix games with payoffs of intuitionistic fuzzy sets. The authors first propose a new ranking method of intuitionistic fuzzy sets and the concept of Pareto Nash equilibrium solutions of matrix games with payoffs of intuitionistic fuzzy sets. Hence it is proven that Pareto Nash equilibrium solutions of matrix games with payoffs of intuitionistic fuzzy sets are equivalent to the Pareto optimal solutions of a pair of bi-objective programming models, which can be easily solved by using existing multi-objective programming methods.

The paper "Marginal Games and Characterizations of the Shapley Value in TU Games," written by Takumi Kongo and Yukihiko Funaki, discusses axiomatizations and recursive representations of the Shapley value on the class of all cooperative games with transferable utilities (i.e., TU games). Marginal games that are closely related to dual games play central roles in this study. The axiomatizations are based on axioms that are marginal game variations of the well-known balanced contributions property, so that they are interpreted as fair treatment between two players in TU games as the balanced contributions property is. Moreover, the authors propose a general recursive representation that can be used to represent the Shapley value for n-person TU games by those for r-person and (n–r)-person TU games with fixed r being smaller than n.

The paper "Computing the Shapley Value of Threshold Cardinality Matching Games," written by Lei Zhao, Xin Chen, and Qizhi Fang, discusses the computational and complexity issues on the Shapley value in a particular multi-agent domain, which is called a threshold cardinality matching game. The authors show that the Shapley value can be computed in polynomial time when graphs are restricted to some special graphs, such as linear graphs and the graphs having clique or coclique module decomposition. However, it is proven that computing the Shapley value is P-complete when the threshold is a constant.

The paper "Matrix Analysis for the Shapley Value and Its Inverse Problem," by Jun Su and Genjiu Xu, deals with algebraic representation and matrix analysis techniques for computing linear values of cooperative games. The authors propose a matrix approach for characterizing linear values with certain essential properties. Some properties are also described for the Shapley standard matrix, which is the representation matrix of the Shapley value. In addition, the authors examine the inverse problem of the Shapley value in terms of the null space of the Shapley standard matrix.

In the paper "The General Nucleolus of n-Person Cooperative Games," Qianqian Kong, Hao Sun, and Genjiu Xu investigate how to compute and characterize the general nucleolus of n-person cooperative games. To reflect the profit distribution more intuitively on the space of n-person cooperative games, the authors first define the concept of the general nucleolus whose objective function is limited to the players' complaints. Hereby, the authors propose an algorithm for calculating the general nucleolus under the case of linear complaint functions so that an accurate allocation can be obtained to pay for all players. The authors also propose a system of axioms and the Kohlberg criterion to axiomatically characterize the general nucleolus in terms of balanced collections of coalitions. Furthermore, to normalize the different assignment criteria, the authors prove the equivalence relationships among the general nucleolus, the least square general nucleolus, and the p-kernel.

The paper "A Cooperative Game Approach to Author Ranking in Coauthorship Networks," authored by Guangmin Wang, Genjiu Xu, and Wenzhong Li, discusses the problem of author ranking in coauthorship networks from the viewpoint of cooperative games. Three weighted coauthorship networks are constructed from different perspectives and thereby three cooperative games are defined. The core and the Shapley value are chosen as allocation rules for the defined cooperative games. Furthermore, the weighted Shapley value and a new value are proposed as the allocation rules to take into consideration the contribution level of the authors to their papers.

The paper "A Reduced Harsanyi Power Solution for Cooperative Games with a Weight Vector," written by Xianghui Li and Hao Sun, discusses the Harsanyi power solution for cooperative games in which different players may be asymmetric and contribute to different efforts, bargaining powers, or stability in the process of cooperation. The authors use a weight vector to reflect players' asymmetry and hereby define and characterize a reduced Harsanyi power solution for cooperative games with a weight vector, which is relevant to a loss function of dividends. It is proven that the reduced Harsanyi power solution has a linear relationship with the Harsanyi power solution if the loss function takes particular forms.

The college enrollment plan allocation plays an important role in implementing the reform of higher education and adjusting the structure of qualified personnel in China. In the paper "An Allocation Method of Provincial College Enrollment Plan Based on the Bankruptcy Model," Zhen Wei and Deng-Feng Li regard the provincial college enrollment plan allocation as the bankruptcy problem. Hereby a bankruptcy model and an operable bankruptcy rule are proposed to determine the college enrollment plan allocation according to the eight university educational indexes. This study may provide references for Chinese provincial education administrative departments in the college enrollment plan allocation process.

The paper "Edgeworth Equilibria of Economies and Cores in Multi-choice NTU Games," by Jiuqiang Liu, Xiaodong Liu, Yan Huang, and Wenbo Yang, extends the payoff-dependent balanced core existence theorem to multi-choice cooperative games with non-transferable utilities (i.e., NTU games), which implies a multi-choice extension of Scarf's core existence theorem. The study establishes the connection between Edgeworth equilibria of economies and cores of multi-choice NTU games.

The paper "Two-Phase Nonlinear Programming Models and Method for Interval-Valued Multiobjective Cooperative Games," written by Fang-Xuan Hong and Deng-Feng Li, defines the concepts of interval-valued cores of interval-valued multiobjective n-person cooperative games and a satisfactory degree (or ranking indexes) of comparing intervals with inclusion and/or overlap relations. Hereby the interval-valued cores can be computed by developing a new two-phase method based on the auxiliary nonlinear programming models. The proposed method can provide cooperative chances under the situations of interval inclusion and/or overlap relations in which the traditional interval ranking method may not always assure.

In the paper "Models and Algorithms for Least Square Interval-Valued Nucleoli of Cooperative Games with Interval-Valued Payoffs," Wei-Long Li focuses on developing an effective method for computing least square interval-valued nucleoli of cooperative games with interval-valued payoffs, which are usually called interval-valued cooperative games for short. Based on the square excess that can be intuitionally interpreted as a measure of the dissatisfaction of the coalitions, the author constructs a quadratic programming model for least square interval-valued prenucleolus of any interval-valued cooperative game and obtains its analytical solution, which is used to determine the players' interval-valued imputations via the designed algorithms that ensure the nucleoli always satisfy the individual rationality of players. Hereby the least square interval-valued nucleoli of interval-valued cooperative games are determined in the sense of minimizing the difference of the square excesses of the coalitions. Moreover, the author discusses some useful and important properties of the least square interval-valued nucleolus such as its existence and uniqueness, efficiency, individual rationality, additivity, symmetry, and anonymity.

The paper "Interval-Valued Least Square Prenucleolus of Interval-Valued Cooperative Games with Fuzzy Coalitions," written by Yin-Fang Ye and Deng-Feng Li, describes how to compute interval-valued least square prenucleoli of interval-valued cooperative games with fuzzy coalitions. The authors first determine the fuzzy coalitions' values by using Choquet integral and thereby obtain the interval-valued cooperative games with fuzzy coalitions in Choquet integral forms. Then, the authors develop a simplified method to compute the interval-valued least square prenucleoli of

a special subclass of interval-valued cooperative games with fuzzy coalitions in Choquet integral forms. The developed method can always ensure that the lower and upper bounds of the interval-valued least square prenucleolus are directly obtained via utilizing the lower and upper bounds of the interval-valued coalitions' payoffs under some weaker coalition size monotonicity-like conditions.

The paper "Quadratic Programming Models and Method for Interval-Valued Cooperative Games with Fuzzy Coalitions," authored by Deng-Feng Li and Jia-Cai Liu, focuses on developing a quadratic programming method for solving interval-valued cooperative games with fuzzy coalitions. By using the Choquet integral, the interval-valued cooperative games with fuzzy coalitions are converted into the interval-valued cooperative games in which two auxiliary quadratic programming models are constructed to generate their optimal solutions on the basis of the least square method and distance between intervals.

In the paper "Cooperative Games with the Intuitionistic Fuzzy Coalitions and Intuitionistic Fuzzy Characteristic Functions," Jiang-Xia Nan, Hong Bo, and Cheng-Lin Wei present the definition of the Shapley function for intuitionistic fuzzy cooperative games by extending that of the fuzzy cooperative games. Based on the extended Hukuhara difference, the authors derive the specific expression of the Shapley function for intuitionistic fuzzy cooperative games with multilinear extension form and discuss the existence and uniqueness as well as other useful properties.

The paper "A Profit Allocation Model of Employee Coalitions Based on Triangular Fuzzy Numbers in Tacit Knowledge Sharing," written by Shu-Xia Li and Deng-Feng Li, deals with a profit allocation of employee coalitions in tacit knowledge sharing. Due to the existence of uncertain factors, the allocation of profits cannot be accurately estimated and hereby triangular fuzzy numbers are used to express payoffs of coalitions. Taking into consideration the importance of coalitions, a quadratic programming model is constructed to obtain a suitable solution as the profit allocation of employee coalitions. Furthermore, some constraints are imposed on the proposed model so that its optimal solution can always satisfy the efficiency, which implies the pre-imputation of cooperative games with coalition payoffs represented by triangular fuzzy numbers.

We would like to thank the hard work of the academic Program Committee and the Organizing Committee of GTA 2016 as well as all contributors and reviewers, who really understand the meaning of cooperative games. At the same time, we very much appreciate the National Natural Science Foundation of China (NSFC) and the Dutch Organization for Scientific Research (NWO) for their support (No. 71681330662). Particularly, one of the four editors, Prof. Deng-Feng Li, would like to thank his PhD student, Ms. Yin-Fang Ye for her all effort, input, and excellent work for GTA 2016 and for editing the publication.

August 2017

Deng-Feng Li
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